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Large Excess Reserves in the U.S.: A View from the Cross-Section of Banks*

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Abstract

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. These events required major adjustments in banks' balance sheets. We study the evolution of reserve holdings across banks from the fall of 2008 until the middle of 2011 and document how banks' balance sheets changed concurrently. Motivated by the potential implications for monetary policy of operating with a high level of reserves, we focus particular attention on those banks which accumulated large quantities of reserves.

Keywords: bank balance sheets, bank reserves, liquidity, monetary policy, bank capital.

JEL Clasification Numbers: G21, E44, E58.

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1 Introduction

In the final months of 2008, the quantity of bank reserves in the U.S. increased by almost a factor of 20, to more than $850 billion. During the second half of 2009 reserves increased again 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 containing the effects of the financial crisis and the ensuing recession.

On October 1, 2008, the Federal Reserve began paying interest on reserves and no longer sterilized the creation of reserves associated with the various credit programs in place at the time. In late November 2008, the Fed also announced the beginning of 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 Fed launched an expanded asset purchase program. This 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. The 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, totaling $600 billion.

These facts about the origin and evolution of aggregate reserves 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 investigate the distribution of reserves across institutions (i.e., who was holding the reserves?), how the reserves were being introduced and the concurrent changes in other components of banks' balance sheets.

We find that the largest banks in the system held a disproportionate amount of reserves at the peak of the crisis, a period when reserves were being introduced mainly through loans from the Fed. As conditions improved, however, reserves became more evenly distributed. Later in the period, and especially during 2011, U.S. affiliates of foreign banks accumulated significant holdings of reserves.

The banking system as a whole did not appear to substitute reserves for other securities, even though total assets in the system were relatively constant during this time. In fact, securities holdings at insured banks actually increased, as did our measure of short-term liquidity held by banks – which includes reserves.

At the level of individual institutions, we find no evidence supporting the view that the increase in reserves might have created pressure on banks' balance sheets and, through this channel, contributed to a reduction in other components of bank assets, such as loans to the private sector. We also find that from 2010 to 2011, reserves were mostly held by banks with relatively strong capital positions. In principle, then, a significant proportion of the total reserves in the system could have been

transformed into loans without pushing banks against binding regulatory capital constraints.

Some of these findings lead us to think that there are potential consequences of having a large quantity of reserves oustanding. An important line of thinking argues quite differently, that the quantity of reserves is irrelevant if the Federal Reserve pays a near-market interest rate on reserves, as it has since the fall of 2008. In addition, public communication by the Federal Reserve regarding monetary policy actions during the period (such as, for example, Chairman Bernanke's *Washington Post* op-ed piece on November 4, 2010), as well as most academic research, has paid little attention to the behavior of reserves as it relates to monetary policy considerations. The emphasis has instead been on the consequences of Fed actions for the maturity composition of Treasury and mortgage-related securities held by the public.[1] These views notwithstanding, the motivation for our work was a belief that it could be important to investigate the evolution of reserves and their impact on the banking system.

At a minimum, a complete description of the financial crisis and the associated recession requires an examination of how the massive increases in reserves were accommodated on bank balance sheets. In addition, our view is that there are conditions under which the quantity of reserves may matter for the state of the economy and monetary policy, even under a regime of interest on reserves or with zero nominal interest rates. First, a large quantity of reserves makes a strengthening economy more sensitive to ex-post policy errors. Second, absent other changes in the real economy, continuous large increases in the quantity of reserves are likely to eventually have noticeable implications for the banking system and potentially for the aggregate economy. For these reasons, which we discuss in more detail later, policy considerations also serve as a motivation for our analysis of the behavior of reserves, helping to point us toward particular aspects of the cross-sectional distribution of reserves. We acknowledge here, however, that the significance of reserves for policy is still a largely unresolved issue. While our intent is not to settle the issue with this paper, we hope that studying the actual behavior of reserves across banks may help to shed some light on its significance.

The paper is organized as follows. In Section 2 we expand on the policy considerations introduced above, and in Section 3 we describe the data. In Section 4, we discuss the behavior of aggregate reserves and the banking system from a time series perspective. Section 5 investigates the bank-level data on reserve holdings; we focus on the three major waves of increases in aggregate reserves that occurred from 2008 to 2011. Section 6 concludes.

2 Monetary policy considerations

The fact that the Federal Reserve has the ability (as of late 2008) to adjust the interest rate paid on reserves (IOR) clearly alters the nature of reserves as an instrument or indicator of monetary

[1] See for example Gagnon et al. (2011), Hamilton and Wu (2012), Krishnamurthy and Vissing-Jorgensen (2010) and D'Amico and King (2010).

policy. In fact, the prevailing view among monetary economists is that with IOR as an instrument, the quantity of reserves is virtually irrelevant for assessing the stance of monetary policy.[2]

The Fed's ability to adjust IOR indeed suggests that appropriate policy could be used to induce banks to hold the level of reserves supplied by the Fed without producing significant changes in aggregate economic conditions. Thus, a large quantity of reserves is not necessarily an indicator of expansionary monetary policy. Relatedly, to the extent that a fixed IOR (or zero nominal rates) makes reserves a close substitute for very-short-term Treasury securities, central bank purchases of those Treasuries with reserves do not necessarily have an effect on real variables or the price level. However, in both of these dimensions, "irrelevance" occurs only under special conditions which we think do not always apply. The remainder of this section elaborates on these points.[3]

2.1 Falling behind the curve with a large quantity of reserves

Some observers have argued that there is no substantial difference between the monetary policy problem with or without large amounts of excess reserves (see, for example, Dudley, 2011). It seems clear to us that, as is commonly argued, when the central bank is able to accurately time the adjustment of IOR, the quantity of (excess) reserves does not need to have material consequences for the conduct of monetary policy. However, policy is normally conducted under uncertainty about current and future states. Testimony to this is the fact that FOMC members do not always agree about the appropriate time for the Fed to reverse its policy stance. Determining when to adjust monetary policy is a difficult question and hence the possibility of policy being (on occasion) behind the curve is likely to be a real one.

This policy risk, of course, is not limited to a situation with IOR. When targeting a fixed short-term interest rate, the central bank is committed to providing reserves perfectly elastically at that rate. Thus, the risk of falling behind the curve exists regardless of the level of (excess) reserves and regardless of whether or not the Fed pays interest on reserves.[4] In fact, if the interbank market is able to reallocate funding capacity across banks in an almost perfect manner, then the stock of reserves is not likely to matter even when policy is not perfectly timed.[5]

As the behavior of the fed funds rate since the fall of 2007 suggests, frictions appear to play a significant role in the functioning of the interbank market (see, for example, Gertler and Kiyotaki,

[2] Eggertsson and Woodford (2003) have argued influentially that when short-term interest rates are close to their lower bound, the quantity of reserves does not represent a meaningful policy instrument. In their model, the same argument would seem to apply with positive nominal interest rates when the central bank pays interest on reserves at a near-market rate.

[3] For some recent contributions on the issue of monetary policy with interest on reserves see Hornstein (2010), Ireland (2012), and Kashyap and Stein (2011). We discuss Hornstein (2010) and Ireland (2012) in Section 4.3.2. Kashyap and Stein (2011) study monetary policy when the central bank pays interest on reserves and reserve requirements are binding.

[4] See Dudley (2009) on interest rate targeting and the commitment to supply reserves. On the possibility of monetary policy getting behind the curve, see Levin and Taylor (2009) and Plosser (2009, 2011).

[5] As Dudley (2011) writes, "In terms of the ability to expand credit rapidly, it makes no difference whether the banks have lots of excess reserves on their own balance sheets or can source whatever reserves they need from the fed funds market at the fed funds rate."

2010, and Ashcraft et al., 2011). Such frictions are likely to interfere with the reallocation of funding capacity, especially if this funding is to be dedicated to financing long-term loans. If reserves are low and frictions are large, any required reallocation of newly created reserves to banks with profitable investment opportunities may take time, slowing down the economy's adjustment to shocks.[6] Once excess reserves are large, however, and to the extent that those reserves are well spread out across banks, frictions in the interbank market can be more readily circumvented; banks no longer need the Fed and the interbank market to intermediate the process of loan and deposit expansion – banks already hold the reserves they need to expand their activities. As a result, the aggregate economy may be able to react more quickly to changes in economic conditions.

Based on these ideas, we conclude that a system of IOR with massive holdings of excess reserves can increase the "elasticity" of the economy to ex-post policy mistakes (i.e., to unintended delays in policy adjustments), making such mistakes potentially more significant and costly. It is in this sense that a high level of reserves appropriately distributed across banks can present new challenges for the conduct of sound monetary policy (Ennis and Wolman, 2010).[7]

2.2 Reserve increases with a fixed interest rate floor

In principle, increases in the quantity of reserves in a system with IOR (or near-zero nominal interest rates) do not have to translate into changes in short-term rates and, hence, can have little or no effect on prices or quantities. This follows from the fact that reserves as a security are a close substitute for short-term Treasuries. Recent studies of the Fed's large asset purchase programs (see footnote 1) have therefore emphasized the different characteristics of long- and short-term securities. We will discuss here how, even when open market purchases are of short-term securities, the distinctive character of reserves may undermine the logic that suggests that the level of reserves in the system is irrelevant.

Any expansion in bank reserves will come about either through Fed lending or Fed purchases of securities held by the private sector (banks and/or non-banks). Unless the intervention involves the exchange of reserves for securities previously held by banks, the size of banks' balance sheets is likely to increase together with the quantity of reserves. This is because reserves are an asset that can only be held by banks. Securities, instead, can be held not just by banks but also by

[6] As an example, in September 2010 AIG began selling municipal bonds and accumulating cash in anticipation of making an offer in December 2010 for the bonds that the NY Fed held in one of its Maiden Lane vehicles. This story, as reported by Serena Ng in the WSJ (March 21, 2011), supports the idea that financial institutions (in this case AIG) may take time to acquire the cash (liquid funds) to fund certain investments (like buying securities). AIG does not have an account with the Fed and hence cannot hold reserves. But, if it could and if it had in fact owned a large amount of reserves, then it could potentially have made the offer in September, when the decision to buy the securities was initially made.

[7] In a situation with large excess reserves, the fact that the Fed is not an integral part of the credit creation process eliminates one of the Fed's sources of information about the state of the economy. This situation may then call for shifting attention to economic indicators that otherwise play a secondary role. For example, the proportion of required to excess reserves, or short-term changes in aggregate bank lending may be especially useful indicators when conducting monetary policy with high levels of reserves. See Ennis and Wolman (2010) for further discussion of this issue.

non-bank private institutions and the public in general.[8] If the Fed, by conducting open market operations, substitutes reserves for securities in the hands of the private sector on a large enough scale, eventually total assets in the banking system would have to increase. This logic remains valid even if open market operations are restricted to involve only the purchase of short-term Treasury securities.

The resulting expansion of bank assets would have to be consistent with statutory requirements mandating that banks hold a certain ratio of capital to assets. In addition, banks in the U.S. currently pay deposit insurance fees on their assets net of capital. For both these reasons, then, increases in the quantity of reserves outstanding have the potential to increase the regulatory burden imposed on banks, leading banks to take countervailing measures. Depending on how the process of adjustment unfolds, it could inflict either contractionary or expansionary forces on general economic activity.

For example, banks could try to counter the expansion of their balance sheets by reducing their rate of loan origination. Such a response could bring about contractionary effects in the aggregate economy. Alternatively, banks might attempt to shed assets and liabilities by inducing depositors to withdraw currency. The ultimate macroeconomic effects of such a reaction seem harder to disentangle. One possibility, of course, is that the public decides to convert some of the resulting currency holdings into purchases of durable goods, creating expansionary pressures and, potentially, inflation.[9]

The type of effects we have discussed here are speculative. Yet, it seems to us premature and unwise to rule them out. The fact that these effects work mainly through adjustments in the banking system provides additional motivation for our study. Understanding the way banks accommodated the large increases in reserves since 2008 is an integral step in sorting out the implications of such policies more generally.

3 The data

Our cross sectional 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 other thrift institutions, who did not report reserve holdings in their regulatory filings during the period of our study.

[8] Reserves are also distinct from Treasury securities in that they represent a standing commitment by the Fed to create currency; put another way, holding reserves means holding an option, the exercise of which will increase the quantity of currency outstanding. Kocherlakota (2010) discusses the possibility that large quantities of excess reserves could pave the way for a self-fulfilling increase in prices. This scenario is different than, but related to what we discuss in this section.

[9] More generally, the expansion of bank assets (reserves) corresponds to an expansion of non-bank assets (deposits) that can be immediately converted into currency. If open market purchases were to continue indefinitely, it seems likely that at some point the nonbank private sector would choose to adjust its portfolio in order to reduce the proportion of real bank deposits. Standard money-demand considerations suggest that this could require an increase in the price level.

In the second quarter of 2011 there were approximately 2,200 reporting institutions with reserve accounts, 219 of which fall into the uninsured foreign affiliates category.[10] These uninsured foreign affiliates are branches and agencies of foreign banks. They can hold accounts with Federal Reserve Banks, and thus reserves. However, because these foreign affiliates 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 institutions. Thus, most of our analysis below will deal with insured institutions, although we discuss the uninsured foreign affiliates in some detail in the next section. For insured 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.[11]

To complement the Call Report data when we discuss some aggregate measures of banking conditions, we also use data from the Federal Reserve's H.3 and H.4.1 statistical releases, which report on aggregate reserves and other aspects of the Fed's balance sheet. This aggregate data released by the Fed is not derived from the Call Reports. Therefore, judgement is required when relating such data to the aggregates constructed using the Call Reports. For example, the thrift institutions mentioned above do not report their reserve holdings, but those holdings are included in aggregate reserves in the H.3 report. Thus, there will inevitably be a gap between the total reserves accounted for by our cross-sectional data and the reserves in the H.3 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.

Call Report data describes banks' balance sheets on the last day of the quarter. Thus, if there are end-of-quarter effects they would reduce the representativeness of our data in terms of capturing the relevant financial position of the banks. In the appendix, we address this issue by comparing our data with averages of confidential within-quarter reserve data. We conclude that the discrepancy is not significant enough to undermine the content of our exercise.

The timing of reporting is also a potential source of discrepancies between aggregate data produced by the Fed and the aggregates we construct from the Call Reports of individual banks. The Fed's H.3 release, which reports two-week averages of daily figures, will generally differ from the Call Report's end-of-quarter snapshot. We believe this was an issue especially during those periods when total reserves in the system changed significantly from one day to the next, as was the case at the end of the third quarter of 2008.

[10] There are approximately 7,000 banks in the U.S. The 4,800 or so that do not have reserve accounts are small banks who 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.

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

4 Reserves and the banking system across time

In this section we discuss the time series of aggregate reserves, how the sources of reserves varied over time, and how banking system aggregates evolved over our period of study. Some of our discussion of the banking system is meant simply to provide basic background against which to view the behavior of reserves. Other aspects of that discussion are more closely linked to the behavior of reserves, how they interact with other components of banks' balance sheets, and how much they flow across institutions.

4.1 Evolution of total reserves

Prior to the fall 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 September of 2008 this situation changed dramatically. Figure 1 displays the time series for end-of-quarter total reserves as reported on the Federal Reserve's H.3 release. Required reserves over the period in question are also shown in the figure, as well as a decomposition of the aggregate level, which we will discuss later in this section.

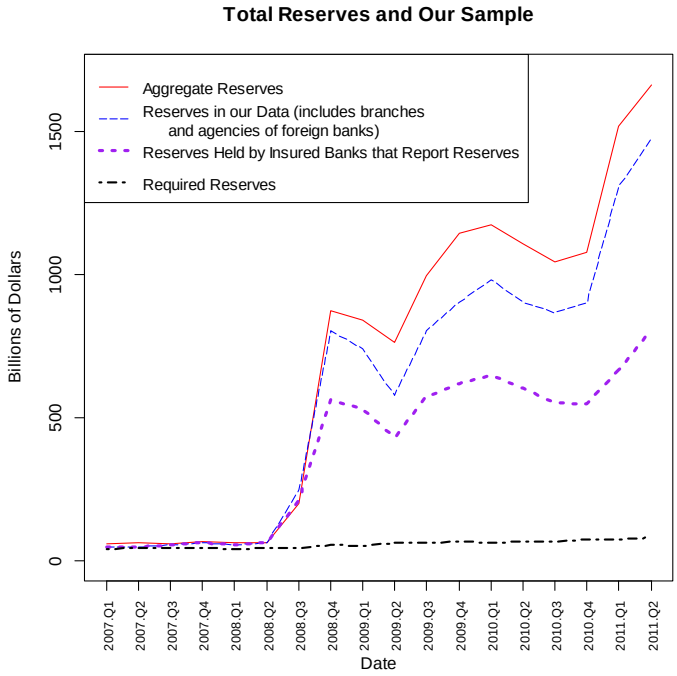

Figure 1

Starting in mid-September 2008 – the time of the Lehman Brothers bankruptcy – the level of reserves increased swiftly, to reach a level of approximately $850 billion by the end of the year. We will call this initial surge in reserves the *first wave* of increases in reserves. As the Fed's credit programs were winding down, the level of reserves actually decreased during the first two quarters

of 2009. The *second wave* of reserve increases came in the last two quarters of 2009, as the runoff of the credit programs no longer compensated for increases associated with the Fed's asset purchase program in place over that period. Total reserves increased by approximately $300 billion in this second wave, to reach a level of about $1 trillion. During most of 2010 the level of reserves fluctuated around that level. In November 2010, the Fed 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.

The initial increase in reserves in September of 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. 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 and this situation remained true for the rest of the period under study.[12] With IOR close to the federal funds rate the costs of holding reserves were significantly reduced. As a consequence, the Fed was able to increase the quantity of reserves to the unprecedented levels seen since January 2009. Keister and McAndrews (2009) explain how the large quantity of reserves can be viewed as an artifact of the credit and asset purchase programs that the Fed undertook starting in late 2008.

Figure 1 also displays reserves held by insured banks in our sample (dotted line) and total reserves in our sample (dashed line).[13] The difference between the dashed and the dotted lines is the total reserves held by uninsured affiliates of foreign banks. Reserve holdings at these institutions increased in the last two quarters of 2008, to reach a level of around $200 billion, and increased another $100 billion in the second half of 2009. But the biggest increase in reserve balances by the foreign institutions came during the Fed's second asset purchase program in the first half of 2011, when they increased their reserve balances by more than half the total size ($600 billion) of the program.

Finally, also notice the gap between total reserves covered in our data and aggregate reserves as reported in the Fed's H.3 data releases. This gap amounted to around $175 billion in the second quarter of 2011. As we explained in the data section, our data does not include some reserve-holding institutions (credit unions and other thrifts) whose balances are included in the H.3 data.

[12] The effective fed 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).

[13] As was mentioned in Section 3, the Fed's H.3 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.

4.2 Sources of reserves

The large increase in reserves took place through two main channels: loans and asset purchases. While the Fed mainly conducted asset transactions with a limited number of counterparties (primary dealers), the credit programs were more widely accessible to the universe of banks. If the interbank market is not a perfect mechanism for the reallocation of reserves, then the way reserves are introduced may affect the dynamics of the distribution of reserves over time. Figure 2 shows reserve balances held by depository institutions at Federal Reserve Banks, together with a decomposition between the part of the stock that can be attributed to loans and the part that can be attributed to asset purchases.[14]

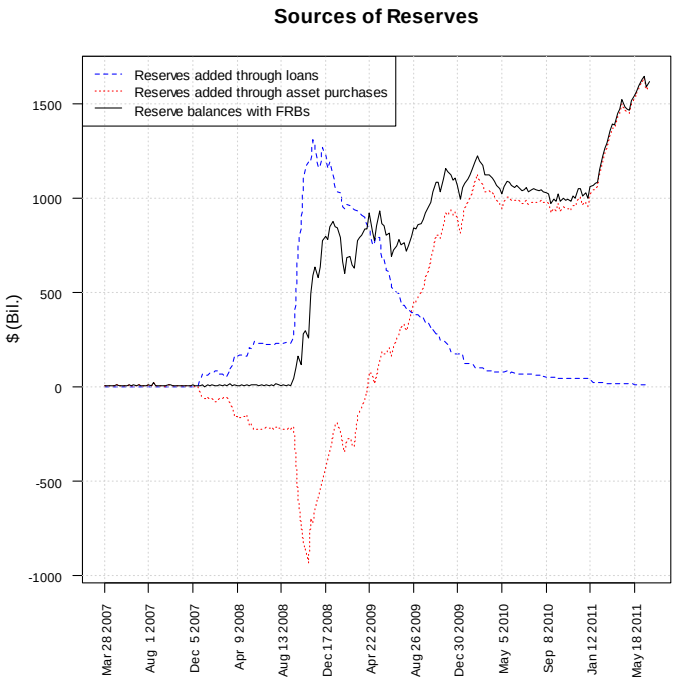

Figure 2

From the end of 2007 until early October of 2008, the Fed's loans to banks were sterilized via open market sales of securities. For this reason, total reserves in the system did not change significantly during that time. Starting in October 2008, with the introduction of interest on reserves, the Fed no longer fully sterilized the reserve creation induced by the credit programs. Hence, the level of reserves in the system increased substantially in a short period of time. The bulk of this initial increase in reserve balances resulted from the Fed's direct loans to depository institutions via the discount

[14] We construct Figure 2 using data from the H.4.1. We calculate reserves added through direct loans as the sum of Term Auction Credit, all Other Loans in Reserve Bank Credit (RBC), and Central Bank Liquidity Swaps. To calculate reserves added through asset purchases we first take all Total Factors Supplying Reserve Funds and subtract reserves added through direct loans. The result is the sum of what we call Other RBC and Other factors. Then we subtract Total Factors Absorbing Reserve Funds (other than reserve balances) from that sum. Note that we are implicitly treating fluctuations in reserves due to Treasury actions as reserves added through asset purchases.

window and the Term Auction Facility, and its indirect loans via liquidity swap lines arranged with foreign central banks (see Figure A1 in the appendix). As we can see in the figure, between October and year-end 2008, total central bank lending increased from less than $300 billion to more than $1 trillion.[15]

Figure 2 also shows that in the beginning of 2009 the stock of reserves that had been added through credit programs started to decrease, and for the remainder of the sample period the main source of reserves became asset purchases. In January 2009, the Fed started to purchase securities, and by mid-April 2009 the stock of reserves added through this channel had turned positive and continued to increase rapidly until March 2010. The last increase in the level of total reserves in the first half of 2011 is entirely accounted for by reserves added through asset purchases.

Between September and December 2008, the Treasury's account experienced a dramatic swing, which can partly explain the sharp movement in the time series for reserves added through asset purchases (Figure 2). The balances associated with the Treasury's Supplementary Financing Program (SFP) went from zero at the beginning of September 2008 to $550 billion at the beginning of November, and then back down to $200 billion by the beginning of 2009. Increases in the SFP account were associated with issuance of Treasury securities, the proceeds of which were deposited at the Treasury's account with the Fed, draining reserves from the system. When the balance in the Treasury's account went down, the reserves went back into the system.

4.3 The banking system balance sheet

The total increase in reserves over our sample period was about $1.5 trillion. With total banking system assets of about $12 trillion in 2011, it seems inevitable that there were important concurrent changes in other components of the banking system's balance sheet. We investigate the nature of those changes here, differentiating between insured domestic institutions and uninsured foreign-related institutions.

4.3.1 Uninsured affiliates of foreign banks

Uninsured foreign institutions' reserves increased by a factor of more than 1000 from the middle of 2008 to the middle of 2011, going from $571 million on June 30, 2008, to $667 billion on June 30, 2011 (see Table 1).[16] Relative to total reserves, uninsured foreign institutions' reserves increased

[15] While currency in circulation increased rapidly in the last quarter of 2008 and the first half of 2009, the increase is not very significant relative to the other factors absorbing reserves. It is possible that some of the banks taking direct loans held some of the funds obtained in the form of cash, or used the funds to pay out to depositors who then kept cash in their pockets. We are subtracting this increase in cash in circulation from the reserves added through asset purchases, but perhaps it would be more appropriate to subtract at least some of that increase (not the level, though) from reserves added through direct loans. This alternative adjustment would not make a big difference in the numbers. It is important to realize that reserve balances with FRBs do not include vault cash. Vault cash is included in Currency in Circulation and hence we subtracted it from Total Factors Supplying Reserves Funds when we subtracted Factors Absorbing Reserves.

[16] This can also be seen as the distance between the dashed and dotted lines in Figure 1.

from 6.3 percent to more than 40 percent. Relative to uninsured foreign institutions' assets, their reserves rose from less than 0.03 percent to more than 30 percent over the same period. Total assets in these foreign related institutions rose by less than 2.5 percent during the period in question, so the increase in reserves was accompanied by a significant reduction in the *levels* of some other asset categories.

Table 1. Balance sheets of uninsured affiliates of foreign banks

Time Period	Reserves	Net Due from Rel'd DIs	Other ABS	Loans and Leases	Other Trading Assets	All Other Assets	Reserves
	(measured as % of assets)						($ million)
2008 $Q2$	0.03	37.44	2.64	27.33	10.58	21.99	571
2008 $Q4$	11.45	26.16	3.82	30.23	12.02	16.32	235,183
2009 $Q2$	7.28	35.48	3.50	28.35	9.02	16.38	141,260
2010 $Q4$	18.24	30.89	2.13	24.91	7.35	16.47	349,016
2011 $Q2$	31.01	21.31	1.91	23.41	6.20	16.17	666,819
$\Delta(08Q2, 08Q4)$	11.42	−11.28	1.18	2.91	1.44	−5.66	234,612
$\Delta(08Q4, 09Q2)$	−4.16	9.32	−0.32	−1.88	−3.00	0.06	−93,922
$\Delta(09Q2, 10Q4)$	10.96	−4.58	−1.37	−3.44	−1.66	0.10	207,756
$\Delta(10Q4, 11Q2)$	12.77	−9.58	−0.22	−1.50	−1.15	−0.31	317,803

Table 1 summarizes the transformation in foreign institutions' balance sheets. The table contains information on selected asset categories as a percent of assets for five quarters: the second and fourth quarter of 2008, the second quarter of 2009, the fourth quarter of 2010, and the second quarter of 2011. The second quarter of 2008 corresponds to a period immediately prior to the large initial increase in reserves, and the second quarter of 2011 marked the end of the Fed's second asset purchase program. We chose the three intermediate dates because they demarcate distinct phases in the transformation of uninsured foreign institutions' balance sheets. The asset categories in the table, in addition to reserves, are the categories that bore the brunt of the change in reserves. Between the second and the fourth quarter of 2008, reserves increased by more than 11 percent of assets, and there was almost a perfect offset in these institutions' deposits at other related institutions ("Net due from related depository institutions"). Between the fourth quarter of 2008 and the second quarter of 2009, reserves fell by more than 4 percent of assets, and there was a more than offsetting increase in deposits at related institutions. In the period between the second quarter of 2009 and the fourth quarter of 2010, reserves rose by 11 percent of assets, with the offsetting reductions coming primarily from deposits at related institutions (4.58 percent) and loans (3.44 percent), and to a lesser extent from trading assets other than Treasuries and Agencies, and non-mortgage ABS. Finally, between the end of 2010 and the end of the second quarter of 2011, which corresponds to the Fed's second asset purchase program, reserves increased by almost 13 percent of assets, and the

offset came overwhelmingly from deposits at related institutions, loans, and other trading assets.

The balance sheet changes displayed in Table 1 can help explain why uninsured foreign institutions might have increased their reserves so much. In late 2008, many foreign institutions with large dollar assets experienced difficulty in rolling over short-term dollar funding (Goldberg et al., 2010, and Fleming and Klagge, 2010). It seems plausible that one way these institutions would have responded was to draw down their U.S. affiliates' deposits with the parent company, purchase dollars and build up reserve accounts with the Fed, creating a pool of precautionary dollar balances.

The increase in reserves from mid-2009 to late 2010 does not obviously lend itself to such a clean explanation. One element in explaining the increase must be the decline in market interest rates that occurred over this period: with the Fed 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, dollar funding concerns may have again become relevant. In addition, in April 2011 a change in the FDIC premium for deposit insurance lowered the effective return on reserves for insured institutions. With the Fed's asset purchases driving up aggregate reserves, it was predictable for them to flow disproportionately to the uninsured institutions.

It may be tempting to associate the behavior of foreign institutions' reserve holdings in 2008 and 2009 with the swap lines the Fed provided to foreign central banks; drawdowns of those lines rose from $62 million on September 17, 2008, to more than $582 billion on December 24, 2008, before gradually declining to pre-Lehman levels over the course of 2009 (see Figure A.1 in the appendix). It is indeed the case that the swap lines were used to fund lending to foreign banks (with the lending decisions made by foreign central banks). However, it was not necessarily the case that this lending generated reserves at the foreign institutions being discussed here.

The mechanism behind the swap drawdowns was that when a foreign central bank made a dollar loan to a bank in the foreign country, the reserves would initially appear on the books of a bank with a reserve account in the U.S. Certainly, if the borrowing foreign institution itself had a reserve account with the Fed, and hence was part of our dataset, then the swap line drawdowns could be directly associated with increases in their reserve holdings.[17] In other cases, a correspondent bank would be involved. Some of the foreign institutions in our data could have acted as correspondents, which would also be consistent with a link between their reserve balances and the swap line drawdowns. But it is also possible that U.S. money center banks played this correspondent role, in which case the link would be weakened.

At its peak in January 2009, outstanding dollar lending originated in swap lines was close to $500 billion, but reserves held by foreign institutions with Fed accounts were only around $200 billion.

[17] If the institution had collateral pledged with the Fed, it was also eligible to borrow directly from the Fed. In fact, foreign institutions were major participants in the Term Auction Facility, which lent significant amounts to banks between 2008 and 2010 (see Benmelech, 2012, for details). For this reason, among others, changes in reserve balances of these institutions do not rely on the existence of the swap lines.

This disparity makes clear that a significant portion of the reserves that originated in swap lines ended up on the balance sheets of U.S. institutions. Either the U.S. institutions were correspondents of foreign banks or they conducted transactions with foreign institutions which resulted in a transfer of reserves to the U.S. banks.[18]

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 2010, they are capable (in principle) of rapidly decreasing their balances. These institutions hold significant quantities of both loans and securities, and presumably they are sensitive to economic conditions and market interest rates in choosing their reserve positions.

4.3.2 Insured depository institutions

For the group of domestic insured institutions in our dataset, we plot in Figure 3 aggregate values for some of the main components of their balance sheets. We see that total assets were growing until the third quarter of 2008 and after that stalled. This is also true for aggregate loans. In contrast, aggregate deposits continued growing at roughly the same rate in the entire period covered by our study. Notably, at the same time that reserve balances held by banks were increasing considerably (see Figure 1), so were bank holdings of securities (aggregate securities and capital are measured on the right axis in Figure 3) – in aggregate, reserves did not substitute for securities on the asset side of banks balance sheets.

It is also interesting to see in Figure 3 that aggregate bank capital continued growing steadily during the full period, with some slight acceleration immediately following the peak of the crisis. Combined with the behavior of aggregate deposits and assets, we can conclude that total bank liabilities stopped growing after the third quarter of 2008 and, in fact, bank liabilities not accounted for by deposits actually decreased during and after the crisis.

The Fed's lending programs had a direct impact on the subcategory "Other borrowings" of the component "Other borrowed money" (OBM) on the liability side of banks' balance sheets (as reported in the Call Report filings). This is where any loan from the Fed would be accounted for. Banks actually report a narrower component called "Other borrowing with a remaining maturity of one year or less," which, given the standard maturity of the loans provided by the Fed, is where most (if not all) central bank lending would be included. We call this subcategory OSTB (other short-term borrowings), for brevity.

[18] Additionally, 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. Our data does not allow us to incorporate foreign affiliates when we aggregate U.S. insured banks at the holding company level, as we do below. In principle, however, reserves in foreign affiliates could be transferred to a related U.S. bank relatively quickly if the parent company decides to do so. In the fourth quarter of 2010, Deutsche's domestic insured institutions reported reserves of about $15 billion, and its uninsured affiliate reported reserves of about $25 billion.

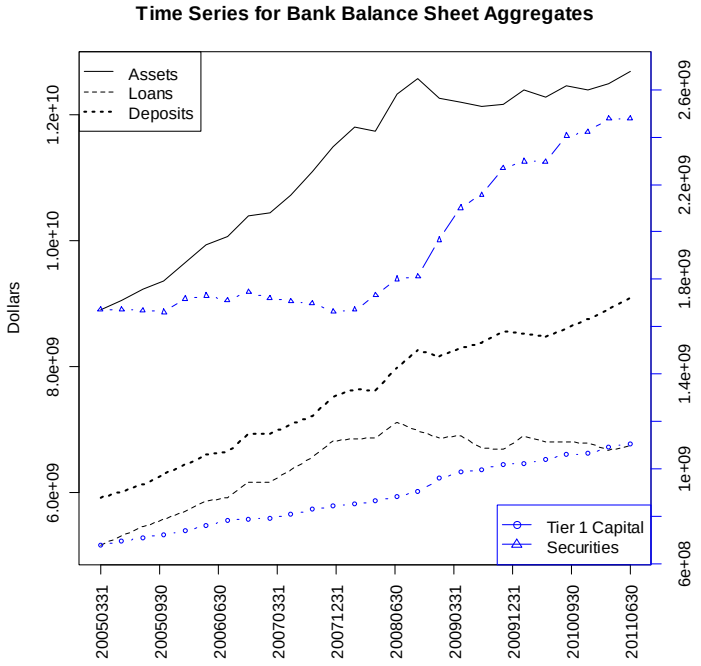

Figure 3

Figure 4 plots the sum of OSTB across all insured institutions in our dataset, together with the time series for reserves created through loans, net of the liquidity swaps, which we constructed using the Board of Governors H.4.1 (see footnote 14). In the figure, we can see that total OSTB increased significantly during 2008 and then decreased during 2009, just as Fed lending was winding down. In interpreting this figure, it is important to keep in mind that some foreign bank affiliates, which do not file a detailed Call Report and hence are not included in our aggregate measure of OSTB, in fact had access to the Fed's credit programs (see footnote 17). This is why Fed lending can sometimes be higher than aggregate OSTB.[19] Also, it is clear from the pre-2008 data that OSTB includes various types of borrowings, not just Fed lending. The main point here is that changes in OSTB during years 2008 and 2009 are likely to be closely associated with changes in the level of activity in the Fed's lending programs that were in place during that period. Additionally, the picture is consistent with Fed lending substituting to some degree for interbank borrowing; as Fed lending increased by around $450 billion in the second half of 2008, banks' total short-term borrowing increased by no more than $210 billion.

The other major subcategory of OBM on the liability side of banks' balance sheet is "FHLB advances;" i.e., loans to banks from the Federal Home Loan Banks System. Commercial banks often use FHLB advances as a back-up source of liquidity. In fact, during the second half of 2007, the FHLB system increased its lending to banks through advances by 36.7 percent (Ashcraft, et al.,

[19] Foreign affiliates report OBM, but not the subcategory OSTB. Still, Fed lending to these institutions is included in OBM. Between the second and fourth quarters of 2008, foreign affiliates' OBM increased $137 billion. Insured institutions' OSTB increased $69 billion over these same two quarters.

2010). During this period, FHLBs were able to issue debt at favorable rates and then lend to banks also at more favorable rates than the ones that banks could obtain elsewhere. As the crisis deepened, however, the funding advantage of FHLBs eroded and total advances grew more modestly during the first three quarters of 2008. In the fourth quarter of 2008, total FHLB lending started to decline and did so consistently for the rest of the sample period (see Figure 4).

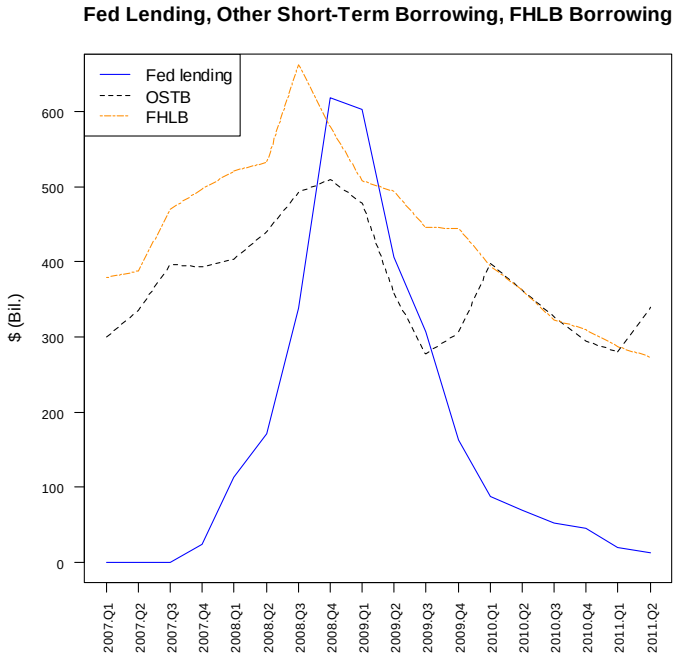

Figure 4

To the extent that interest-bearing reserves are (close to) a perfect substitute for short-term low-risk securities, under normal conditions an increase in aggregate reserves brought about by Fed policies might be offset by a reduction in banks' holdings of short-term low-risk securities. Of course, the events in the fall of 2008 were far from normal and it seems likely that they would have induced an increase in banks' demand for liquid assets. However, as conditions slowly returned back to a more normal state, we would predict that the substitution effects between reserves and other low-risk liquid assets would tend to become more evident. More generally, to the extent that reserves are a very close substitute for other low-risk liquid assets, it may not be particularly revealing to look at reserves in isolation – doing so would be akin to studying the behavior of $20 bills instead of total currency outstanding. Rather, one would like to look at a more aggregate measure of bank liquidity, which we do next.

In Figure 5, 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 year or less to maturity), and net repo and fed 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 5 fed 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 entire banking system, instead of idiosyncratic shocks to certain banks that could be accommodated by reducing lending to other banks in the system. Foreign affiliated institutions do not report short-term securities. For those institutions, the dashed line in Figure 5 plots a measure of liquidity that instead uses U.S. Treasury securities and U.S. government agency obligations as the measure of liquid securities.

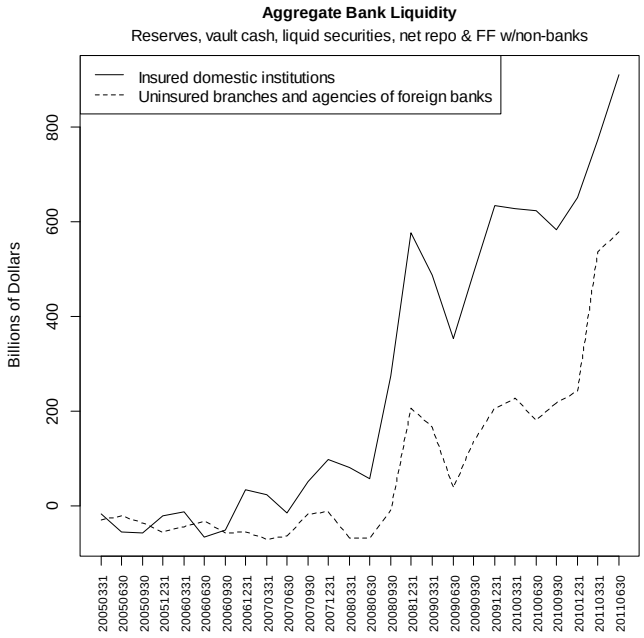

Figure 5

According to Figure 5, prior to the crisis, aggregate liquidity in the banking system was actually negative in some quarters: 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 presumably increased significantly. However, in subsequent quarters financial market conditions tended to normalize and still the quantity of liquid assets remained high – increasing with both of the Fed asset purchase programs. We interpret Figure 5 as showing that 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). Importantly, the increase in liquidity occurred at

both insured domestic institutions and uninsured foreign-related institutions.[20]

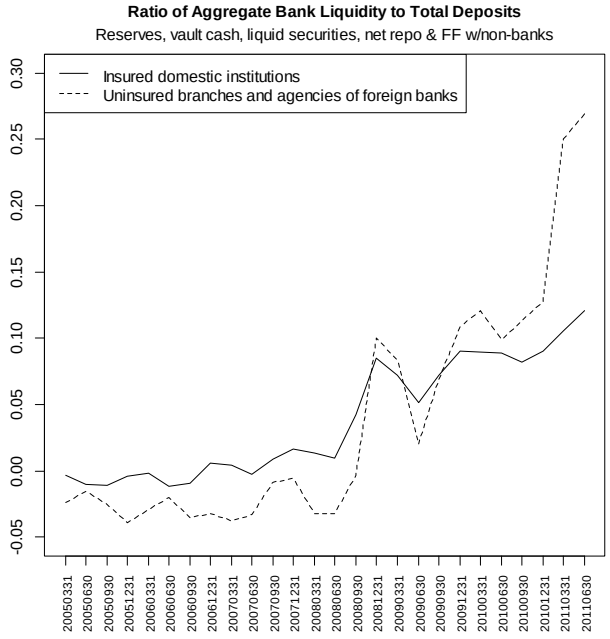

Figure 6

Figure 6 provides a slightly different perspective on aggregate liquidity, plotting ratios of the measures in Figure 5 to total deposits at the two types of institutions. Macroeconomic models with money and banking often posit a technology whereby reserves are an input into the production of deposits. These models tend to focus one's attention on the ratio of liquid assets to deposits. There are two points about Figure 6 worth noting here. First, it reinforces the message of Table 1, that there was a dramatic balance sheet transformation at the foreign related institutions: the ratio of their liquid assets to deposits went from being negative to almost 30 percent. 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 2011. Second, for insured domestic institutions, the increase in liquidity relative to deposits was dramatic in late 2008, but relatively modest since then. In other words, while Figure 5 already showed that domestic banks were not simply substituting reserves for other liquid assets, Figure 6 shows that the increases in liquidity after 2008 were accompanied by almost proportional increases in deposits.

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 (2012). The last two papers are explicitly concerned with monetary

[20] 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. As suggested by the discussion in Section 2, the extent to which the increase in reserves matters depends in large part on the extent to which banks matter. This is an obvious point of contact between our paper and the literature on the lending channel of monetary policy transmission (see, for example, Kashyap and Stein, 1994).

policy when interest is paid on reserves, and thus deserve some 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. 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, in the last two years 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 has fluctuated in a relatively narrow range.

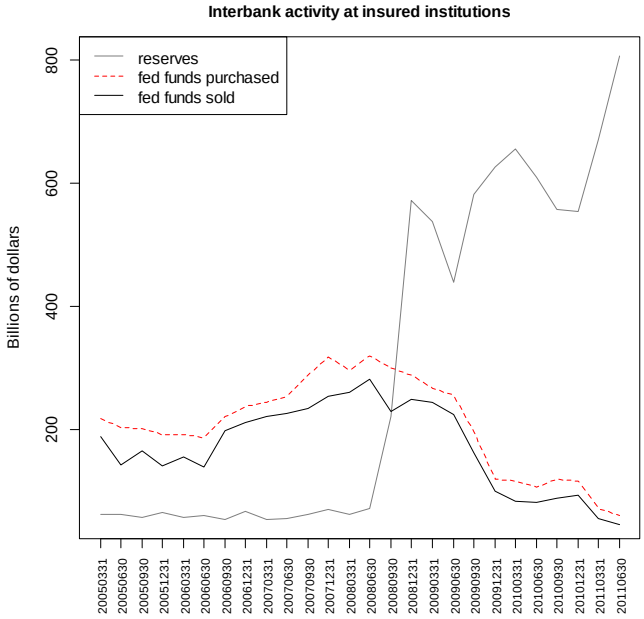

Figure 7

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 fluctuated somewhat. Ireland's model predicts that the ratio of reserves to deposits would comove negatively with the difference between market rates and IOR. Using weekly data from the Fed's H.15 and H.8 statistical releases, covering January 2009 through June 2011, the correlation between the 3-month T-bill rate and the ratio of aggregate reserves to deposits was -0.74. Note that with weekly data it is not possible to compute this correlation using only insured institutions.[21]

[21] Kashyap, Rajan, and Stein (2002) emphasize the role of liquid assets not only in supporting 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). Certainly that phenomenon played some role in banks' willingness to hold higher liquidity in late 2008 and early 2009. However, in the later periods of our sample lending growth was practically nonexistent (see Figure 3) and therefore cannot explain the increase in liquidity at banks.

In the papers mentioned above, there is no role for an interbank market because banks are homogeneous. In reality, individual banks hold liquidity in the form of deposits with other banks or short-term loans to other banks. By paying interest on reserves at a near-market rate and dramatically increasing the quantity of reserves, the Fed changed the calculus of banks' liquidity management. Banks that previously economized on holding reserves and then borrowed in the fed funds market when needed no longer face a significant cost of, instead, holding a high level of precautionary reserves. It stands to reason then that the volume of activity in the fed funds market would have declined, and Figure 7 bears this out. Among the insured institutions in our sample, trading in the fed funds market fell from around $300 billion in the second quarter of 2008 to around $50 billion in the second quarter of 2011.

4.4 Reserve concentration

The high concentration of assets in the banking system suggests that reserve holdings may also be highly concentrated. Figure 8 plots the percentage of total reserves of U.S. insured banks held by the top 10 and top 100 banks by assets (at each point in time) on the left axis, and the level of insured-bank reserves on the right axis.

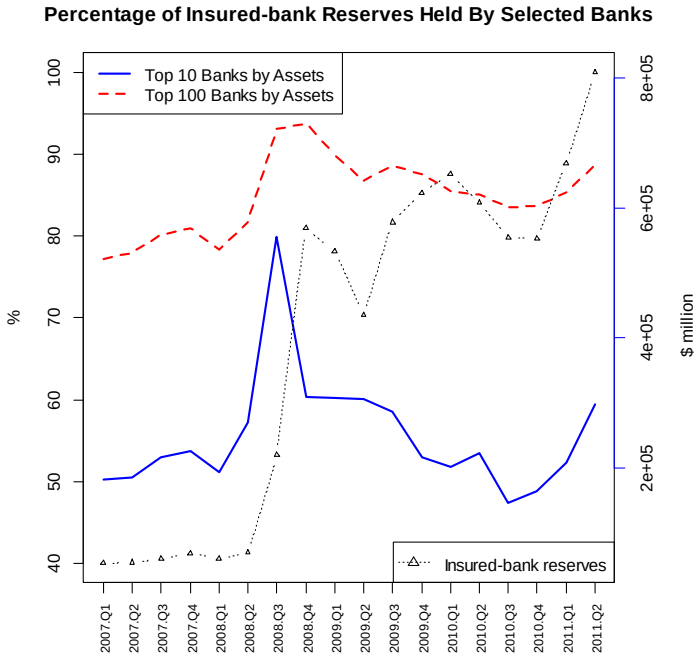

Figure 8

The 10 largest banks tend to hold roughly half of the reserves (and 55 percent of the assets – see Figure A2 in the appendix) 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 (see Figure A.2).

We can see in Figure 8 that the percentage of reserves held by the 10 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 8). Starting in the third quarter of 2010, it appears that the top 10 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.

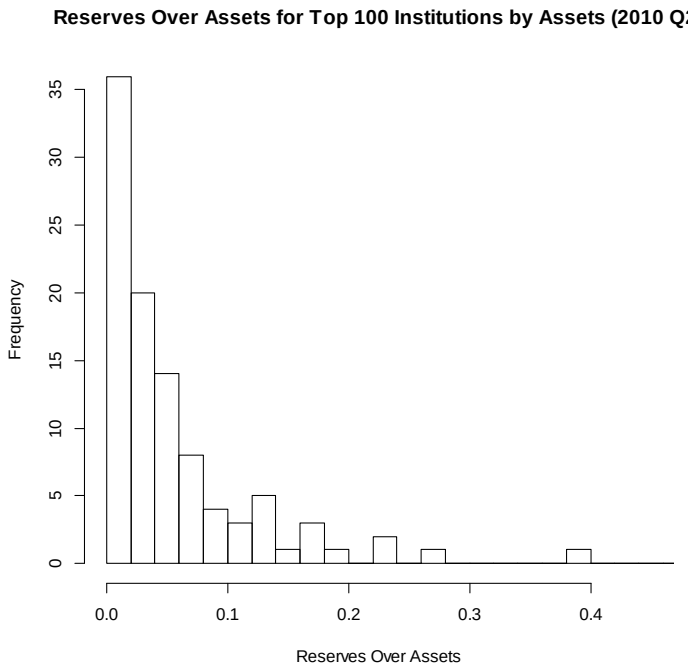

Figure 9

According to Figure 8, large institutions held a large portion of total reserves. But, were reserve holdings across institutions proportional to assets? Figure 9 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 variation in the ratio of reserves to assets across institutions. We turn our attention to this variation in Section 5.

4.5 Gross flows of reserves

We define as gross flows of reserves the sum across all institutions of the absolute change in reserves from one quarter to the next. Figure 10 displays the time series for the change in total reserves in insured institutions in our sample, together with the gross flows of those reserves. If the only changes in bank-level reserve holdings were due to the change in total reserves, then the two lines would be identical. In the third and fourth quarters of 2008 this was approximately the case: the gross flow of reserves was quite close to the change in total reserves. This pattern does not suggest a significant flow of reserves across institutions during the peak of the crisis. Instead, reserves flowed mainly from the Fed to banks. A strained interbank market might have contributed to this situation. Another contributing factor may be that the lending programs were broadly accessible to banks, and in particular to those banks that wanted to hold reserves. Effectively, given the Fed's interventions, reserve flows across banks did not need to be large during this initial period of reserve creation.

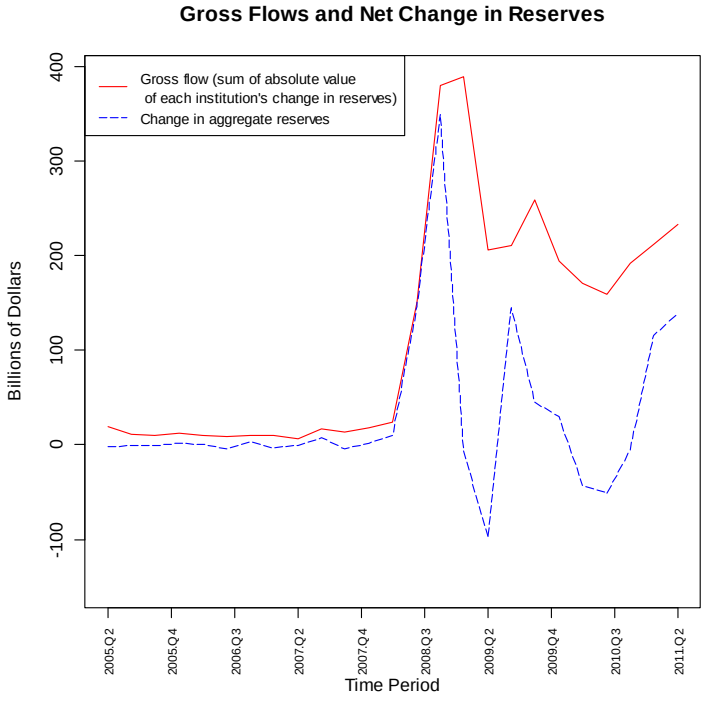

Figure 10

Subsequently, however, the changes in total reserves were generally small relative to the gross flows. Figure 11 shows that while the gross flows were large, since the third quarter of 2009 they did not rise relative to the level of reserves; for each period "t," the figure plots the gross flow from $t-1$ to t divided by the level of reserves at t. We can see in the figure that gross flows relative to reserves increased significantly in the initial periods of the crisis. In fact, such a change happened even before the large increase in the level of reserves during the third and fourth quarters of 2008. Starting in late 2007 several Fed programs were put in place. Also, the Fed sterilized the effects

of those programs on the level of reserves until September or October of 2008. Sterilization meant that the Fed absorbed reserves from some institutions who eventually, then, needed to acquire new reserves to continue acting as agents for counterparties of the Fed's open market operations. All these reserves-based transactions likely account for the increase in relative gross flows in the second half of 2007 shown in Figure 11. Furthermore, note that after the first quarter of 2009, gross flows fell dramatically relative to the stock of reserves, and by mid-2011 these relative flows were well below pre-crisis levels.

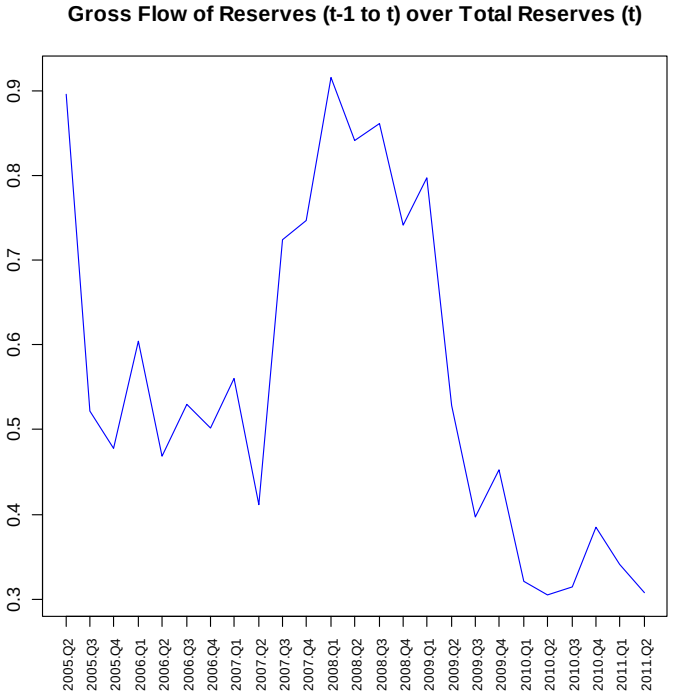

Figure 11

In evaluating the gross flows data, it is important to understand the factors that lead to these flows. We have already discussed Fed behavior: if the Fed is changing the total stock of reserves or is turning over that stock (as, for example, with short-term repos), then gross flows will naturally be created. However, the turnover effect is likely to be reflected mostly in high-frequency data, and not so much in the quarterly numbers studied here. Gross flows also result from interbank payments that are a natural part of the business of banking. These flows are likely to be most relevant at very high frequencies, such as intraday. Finally, gross flows result from institutions choosing to rebalance their portfolios. If the Fed keeps the total stock of reserves high and banks begin to increase their lending, then large gross flows would likely ensue.

When the banking system functions with low levels of reserves, it is not surprising that reserves move across institutions fairly intensively (with high velocity). Reserves are scarce and need to be reallocated to those banks that need them the most. Figure 11 shows that before the crisis roughly

half of the reserves changed hands from one quarter to the next. When the system functions with high levels of reserves, presumably this pressure for reallocation is weaker. Along these lines, we saw in Figure 7 that activity in the fed funds market declined by more than 75 percent from its peak in the second quarter of 2008 to the second quarter of 2011. Fed funds trading reallocates reserves, and it indeed declined significantly as the quantity of reserves increased. Yet Figure 11 shows that gross flows in 2011 were still more than 30 percent of the level of existing reserves, and gross flows exceeded net flows by about $100 billion (Figure 10). Figures 10 and 11 together underscore the fact that at any point in time *an individual bank* can hold whatever level of reserves it wishes. And, during the period under study here there were, in fact, substantial fluctuations in reserve holdings across banks from quarter to quarter.[22]

5 Increases in total reserves: Three waves

As we discussed in section 4.1, from 2008 to 2011 there were three distinct periods when the total level of reserves increased by a significant amount (see Figure 1). Here we discuss how these waves of reserves were distributed across banks and were accommodated on banks' balance sheets. Our analysis will focus on insured institutions, which file a more complete Call Report. Recall, however, that a substantial quantity of reserves flowed to uninsured foreign affiliates, especially during the third wave (see section 4.3.1).

For the first wave, which took place at the height of the crisis, we will discuss the distribution of reserves across banks and the relationship between reserves and other components of banks' balance sheets. For the second and third waves, we also examine the relationship between reserve holdings and bank capital. We close the section with a discussion of the relationship between reserve holdings and banks' loan interest income in the context of the third wave.

5.1 First wave: Fed lending in late 2008

5.1.1 Distribution of reserves

To represent the distribution of reserves in the cross section of banks, we construct a plot *similar* to a Lorenz curve for reserves. Figure 12 presents those curves for the last two quarters of 2008. Instead of ranking banks by reserves on the horizontal axis, they are ranked by assets, and the horizontal axis measures fraction of assets, not fraction of banks.[23] As is clear from the figure, the largest banks held a disproportionately high amount of reserves at the peak of the crisis.

[22] One factor contributing to the high level of gross flows has been the increased volatility of Treasury balances at the Fed. From January 2007 through June 2008, the average absolute weekly change in Treasury balances was $720 million. In contrast, from January 2010 through June 2011 that number was $21 billion (Source: H.4.1).

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

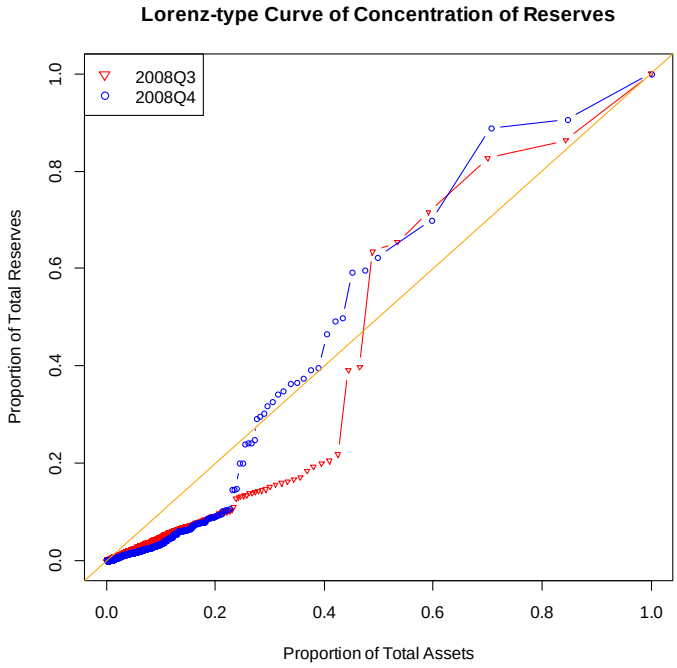

Figure 12

In the curve that corresponds to the end of the third quarter of 2008 we see two institutions that hold a disproportionate amount of reserves relative to assets. These institutions were 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). These are both banks that primarily provide services to other financial institutions. It is likely that during the peak of the financial crisis State Street and BONY faced significant uncertainty about their needs for payment-related liquidity, which would explain why they were holding a disproportionately large amount of reserves at the time.

5.1.2 Banks' balance sheets

Understanding how the introduction of reserves was accommodated by individual banks is complicated. The impact of the increase in reserves on the size and composition of a bank's balance sheet depends on various factors. First, it depends on how the reserves are initially introduced, via central bank loans or via open market operations. Second, it depends on whether the bank is acting as a direct counterparty of the Fed (by taking a loan or buying/selling securities) or just as a provider of banking services to non-bank counterparties of the Fed. Each particular situation results in different implications for the bank's balance sheet.

When a bank takes a loan from the Fed, initially this results in an increase in reserves on the asset side of the balance sheet and an increase in short-term borrowing on the liability side. If these changes were the only ones associated with the central bank loan, then the size of the bank's balance sheet would increase. However, if the bank accessed Fed credit to be able to fund a pre-existing

position, then reserves would be used immediately and the balance sheet of the bank would remain the same, with Fed lending replacing some other liability used for funding the pre-existing asset position.[24] Of course, the reserves will be deposited in some other bank account and hence would result in an increase in deposits and reserve holdings for that other bank.

When the Fed undertakes an open market operation and buys securities from the private sector, it may or may not absorb assets previously held by banks. If the securities were held by banks, then the Fed is swapping one banking asset for another, and the size of those banks' balance sheets would remain unchanged. In this case, the securities holdings of the banks would decrease. Alternatively, if the Fed buys securities from non-bank investors, then the trade tends to induce an increase in the balance sheets of banks where the investors hold accounts. In principle, this trade would create an increase in deposits and assets at those banks as they increase their reserves. However, if the investors sold the securities to obtain liquidity that they were then planning to use for some other payments, the increase in reserves would be reflected on the balance sheets of the banks where the payments are sent. These banks would experience an increase in reserves and in deposits.

Table 2. Correlation coefficients of reserve changes with other components of banks' balance sheets. First wave, large banks.

	$\Delta A/A$	$\Delta D/A$	$\Delta S/A$	$\Delta Lq/A$	$\Delta Lq^*/A$
Correlation coef. of $\Delta R/A$	0.3649	0.4070	-0.1960	0.8751	0.8432
Standard error[25]	0.0871	0.0839	0.0966	0.0235	0.0290
Corr. coef. of $\Delta R/A$; top reserve changers	0.1770	0.2274	-0.3526	0.8615	0.8459
Standard error	0.2222	0.2176	0.2009	0.0592	0.0653

During the first wave of increases in total reserves, the Fed's lending programs played a predominant role. If most of the banks that acquired loans from the Fed were keeping the reserves on their balance sheets, then the changes in reserves at individual institutions would be highly correlated with the changes in their total assets. If instead banks that ended up holding the reserves received them from clients in the form of deposits, then the changes in reserves would be highly correlated with the changes in deposits. Table 2 concentrates attention on the top 100 banks by assets and presents the correlation coefficient between the changes in individual banks' holdings of reserves and the changes in other components of their balance sheets. We express all quantities relative to assets to adjust for the large dispersion in bank size even among the top 100 banks. We calculate the correlation coefficient for the entire sample (100 banks) and for those banks whose reserves increased by more than 0.5 percent of the aggregate change in reserves for the 100-bank sample. We view the

[24] Note that the OSTB category may not necessarily increase, since borrowing from the Fed may be substituting for other short-term liabilities included in OSTB.

[25] We compute standard errors for the correlation coefficients using the formula $se_r = \left(1 - r^2\right) / \sqrt{n-1}$, where r is the estimated correlation coefficient and n is the sample size.

behavior of this latter group as more likely to reveal the association between significant changes in reserves and other components of banks' balance sheets.

There is a moderate correlation – around 0.4 – between changes in reserves (R) and changes in assets (A) and deposits (D) at the large banks.[26] However, for the top reserve changers these correlations are cut in half, whereas the correlation between changes in reserves and changes in securities holdings (S) is noticeably higher (and negative) suggesting that these institutions may have been substituting reserves for (less liquid) securities. Indeed, the strongest correlation is between changes in reserves and changes in the short-term liquidity measure referred to earlier (Lq), which is consistent with the finding discussed in Section 4 and demonstrates a tendency for banks to increase their short-term liquidity as they increased their holdings of reserves. At the individual bank level, it is also interesting to consider a liquidity measure that includes balances due from other depository institutions (Lq^*); the correlations are similar for this broader measure. Taken together, the negative correlation with securities and negligible correlation with assets make clear that banks with the largest increases in reserves were not simply borrowers from the Fed who held the reserves without making other changes to their balance sheets.

5.1.3 Banks' balance sheet capacity

Since reserves must be held by banks, the remarkable increase in the stock of reserves could have put pressure on banks' balance sheet capacity. 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 mechanism for adjustment. To the extent that the leverage ratios of banks were 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 might have actually been contractionary.

To get a sense of how operative this channel was during the first wave of increases in reserves, Figure 13 plots the leverage ratios for the largest 100 banks against their changes in total assets net of reserves.[27] Furthermore, we split the sample into two subsamples, 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 adding reserves was contractionary, then those banks that increased their reserve holdings significantly would show a positive correlation between their leverage ratio and the change in their assets net of reserves; banks that increase their reserves and have a low leverage ratio would have to adjust by decreasing some other asset, and hence would show a decrease in their assets net of reserves. As Figure 13 shows, there is little evidence of such a relationship during the first wave of increases in

[26] In all cases, we looked at the scatter plots of the data and verified that the lack of correlation is not the result of a few outliers, nor of the existence of a strong non-linear relationship in the data.

[27] The leverage ratio here is measured as the ratio of capital to assets, following the definition used in the Call Reports. To account for outliers, we eliminate all banks that had an increase in total assets greater than 50% between the third and fourth quarter of 2008.

reserves. We conclude that reserves did not systematically reduce scarce balance sheet capacity at banks, and thus did not crowd out other kinds of banking assets, such us loans and leases.[28]

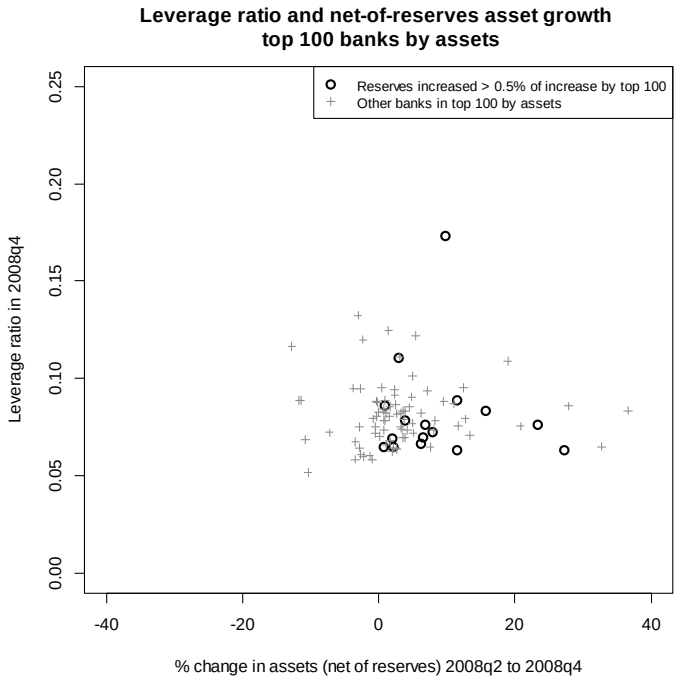

Figure 13

5.2 Second wave: Asset purchases in 2009

5.2.1 Distribution of reserves

During this period, 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 (that is, the Lorenz-type curve moved to be above the 45 degree line during this period). As we saw in Figure 12, at the end of 2008 banks holding the bottom 20 percent of assets held less than 10 percent of reserves. 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 in the figure) 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 Fed conducts open market operations with only a very small set of counterparties may tend to create some concentration of reserves in large institutions when the open market operations are large. Since by mid-2010 the quantity of reserves had not been growing for some time, this force towards

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

concentration of reserves in large banks was no longer operative, allowing the reserves to become more evenly distributed.[29]

5.2.2 Banks' balance sheets

As with the first wave, we investigate in Table 3 how the changes in reserves at individual banks correlate with changes in other components of their balance sheets during the second wave of increases in reserves. Again the correlation between changes in reserves and changes in liquidity is high, especially for the narrower measure of liquidity that excludes interbank balances. For the top reserve changers, the regression coefficient of the change in liquidity on the change in reserves is close to one (0.93). Together with the fact that their holdings of securities tend to decrease (changes in reserves are negatively correlated with changes in securities), this suggests that banks that increased their holdings of reserves also reduced their holdings of longer-term securities, but not their holdings of short-term securities (since the former but not the latter are included in our liquidity measure). Indeed, the regression coefficients of change in securities on change in reserves are 0.02 for short-term securities, and -0.36, and significant, for long-term securities.

Table 3. Correlation coefficients of reserve changes with other components of banks' balance sheets. Second wave, large banks.

	$\Delta A/A$	$\Delta D/A$	$\Delta S/A$	$\Delta Lq/A$	$\Delta Lq^*/A$
Correlation coef. of $\Delta R/A$	0.3286	0.1664	-0.2857	0.8714	0.7899
Standard error	0.0897	0.0977	0.0923	0.0242	0.0378
Corr. coef. of $\Delta R/A$; top reserve changers	0.3896	0.1154	-0.5476	0.8630	0.7327
Standard error	0.1769	0.2057	0.1460	0.0532	0.0966

The correlations of changes in reserves with changes in assets is somewhat higher than in the first wave (Table 2) but still not very strong. Finally, there is virtually no correlation between changes in reserve holdings and changes in deposits at individual institutions. Together these correlations paint a picture of the asset purchases during the second wave as, to a large extent, removing securities from bank balance sheets (given the strong negative correlation between changes in reserves and securities). The positive correlation of changes in reserves with changes in assets, but not with changes in deposits, suggests that some banks were borrowing in order to hold reserves.

5.2.3 Banks' balance sheet capacity

Again, for institutions that increased reserves a significant amount, we find no clear evidence that the change in assets other than reserves was positively correlated with the leverage ratio (see Figure

[29] 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.

A.3). Similarly to what we found for the first wave (Figure 13), pressure on the balance sheet capacity of banks did not appear to play a significant role during this period of increasing total reserves.

5.2.4 Bank capital requirements

In principle, holding high levels of reserves provides 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 is costly and can take time. 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).

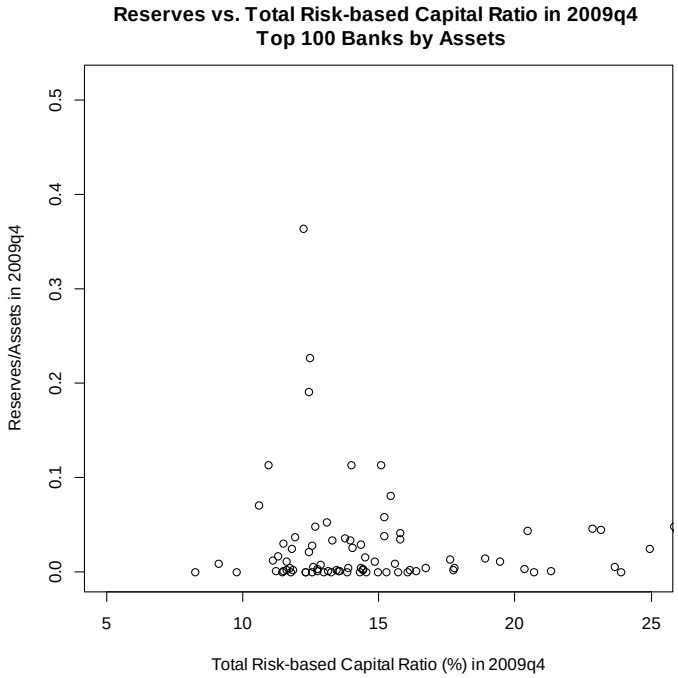

Figure 14

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 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.[30]

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

For the 100 largest (insured) banks, Figure 14 plots the ratio of reserves to assets on the vertical axis and the risk-based capital ratio for each bank on the horizontal axis. The Figure shows that there were a number of banks with fairly high capital ratios (above, say, 12 percent) that were also holding significant levels of reserves.[31]

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 measures 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 (see appendix). The top 100 banks held $505 billion of reserves, and we calculate that $480 billion were loanable reserves. We also calculate a more conservative measure of loanable reserves that takes into account that U.S. regulators are in the process of raising capital requirements, and banks may have changed their behavior in anticipation thereof. Even with our more conservative measure, $322 billion of reserves could be considered loanable. In summary, while binding capital requirements are likely to limit the ability of certain banks to transform reserves into loans, it is clear from Figure 14 and our measure of loanable reserves that in late 2009, several banks would have been able to lend a significant portion of their reserves without facing binding capital constraints.

5.3 Third wave: Asset purchases in 2010-2011

5.3.1 Distribution of reserves

Figure 15 shows Lorenz-type curves (see also the discussion of Figure 12) 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 2010-2011 Fed asset purchase program was just starting.

[31] To be considered well-capitalized, a bank must have a total capital ratio of at least 10 percent.

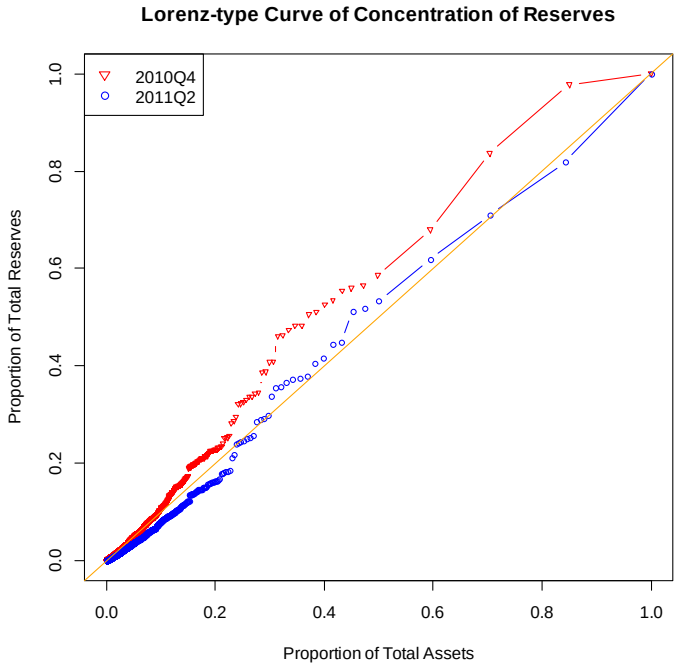

Figure 15

5.3.2 Banks' balance sheets

It is interesting to note (see Table 4) that during this period, (large) banks that increased their reserve holdings the most also tended to increase their assets and their deposits. Furthermore, these banks did not systematically adjust their securities holdings as they increased their reserves. In this respect, the third wave of increases in reserves seems different than the previous two.

Table 4. Correlation coefficients of reserve changes with other components of banks' balance sheets. Third wave, large banks.

	$\Delta A/A$	$\Delta D/A$	$\Delta S/A$	$\Delta Lq/A$	$\Delta BLq/A$
Correlation coef. of $\Delta R/A$	-0.0011	0.0191	-0.2806	0.8557	0.7161
Standard error	0.1005	0.1005	0.0926	0.0269	0.0490
Corr. coef. of $\Delta R/A$; top reserve changers	0.6011	0.4848	0.0042	0.8666	0.8310
Standard error	0.1597	0.1912	0.2500	0.0622	0.0774

The fact that banks increased their deposits and assets along with their reserve holdings is consistent with a situation where the Fed was purchasing securities from the non-bank private sector and the sellers were increasing their bank deposits. Banks thus experienced an increase in deposit liabilities and reserve assets.

5.3.3 Banks' balance sheet capacity

Just as for the first two waves of increases in reserves, we do not find evidence that balance sheet capacity was a significant constraint for banks that were increasing their individual reserve holdings during the first half of 2011. If anything, Figure 16 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. This pattern appears also in Figure 13, which relates to the second half of 2008. We consider these facts a clear indication that balance sheet capacity was not a major concern for banks holding large portions of the newly created reserves.

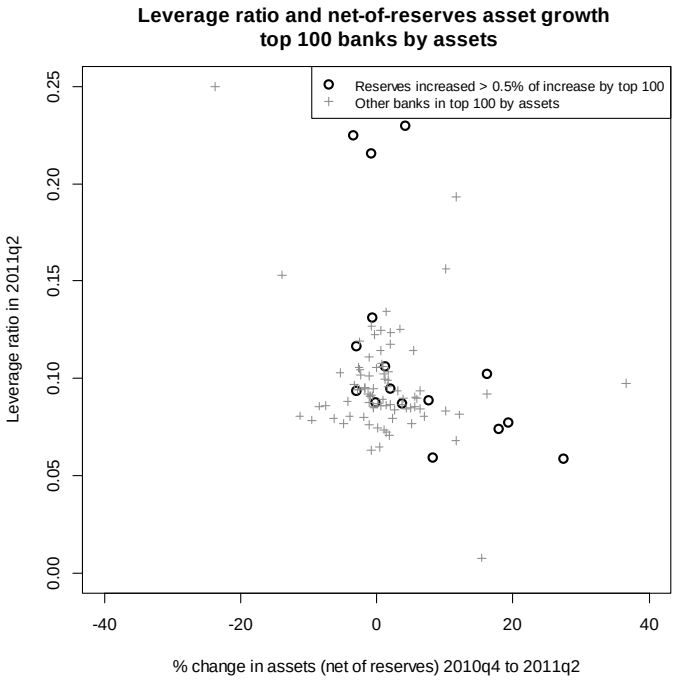

Figure 16

5.3.4 Bank capital requirements

Figure 17 plots again (as in Figure 14 for the second wave) the risk-based capital ratio on the horizontal axis and the ratio of reserves to assets on the vertical axis for the subsample of the 100 largest banks in the second quarter of 2011. The figure shows that not all banks holding high reserves were poorly 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, $628 billion of the $675 billion of reserves held by these banks were loanable given existing capital requirements, and $439 billion were loanable using the more conservative calculation. In summary, by the end of the second quarter of 2011 a significant proportion of the reserves held by large banks could be quickly transformed into loans without pushing banks against their minimum regulatory capital levels.

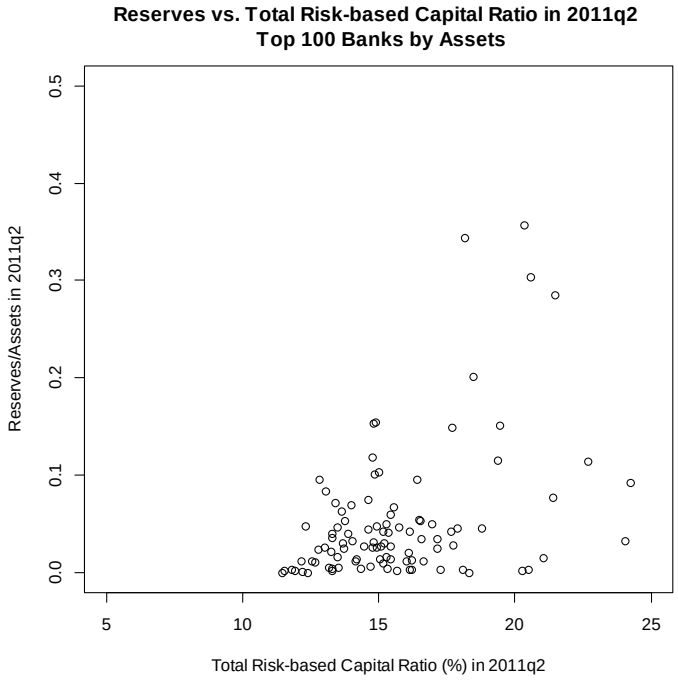

Figure 17

Figure 17 also shows that large banks in general had higher capital ratios in 2011 than at the end of 2009 (see Figure 14). Additionally, from Figure 8 we know that they held more reserves. For these two reasons, and as our measures of loanable reserves clearly indicate, the potential for large banks to create loans funded with reserves increased considerably between 2009 and 2011.

5.3.5 Banks' 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, which suggests that any potential benefits from holding reserves were not sufficient to compensate for the unfavorable rate-of-return differential. By the end of 2008, when the Fed was paying interest on reserves at 25 basis points and had stopped narrowly targeting the fed funds rate, the decision of any given bank to hold reserves had changed dramatically. The majority of the time between late 2008 and the end of our sample period, the interest rate on Treasury bills was actually below 25 basis points. For a bank choosing how to allocate its liquid assets, this became an obvious reason to favor reserve holdings over Treasury bills. Because the T-bill return is available to all, this shift in the rate-of-return differential affected all insured banks equally. However, the rates of return on lending opportunities vary across banks and also affect the opportunity cost of holding reserves. The question then arises whether banks that accumulated fewer reserves during the third wave were

experiencing an unusually high return on their lending activities.[32]

Table 5. Distribution of rates of return on loans across banks
(annualized, in percentage terms)

	Min.	1st Quart.	Median	Mean	3rd Quart.	Max.	Stdev.
Level 2011	2.12	4.68	5.09	5.46	5.68	13.24	1.66
Change 2010 to 2011	−2.01	−0.28	−0.12	−0.07	0.07	2.12	0.50

We approximate each bank's rate of return on loans with its ratio of loan interest income to total loans, averaging over the first two quarters of 2011. The first row of Table 5 summarizes the distribution of the return on lending across banks. There is substantial heterogeneity in these rates of return, which is not surprising given the heterogeneity in lending strategies across banks in the U.S.; for example, the returns in the first row of Table 5 do not correct for risk. By differencing the data we can control for fixed variation in strategies across banks. Differencing also gives us an approximate measure of the change in each bank's rate of return on lending. The second row of the Table shows that the change in returns from the first half of 2010 to the first half of 2011 exhibits miniscule variation across banks in comparison to the level of returns.

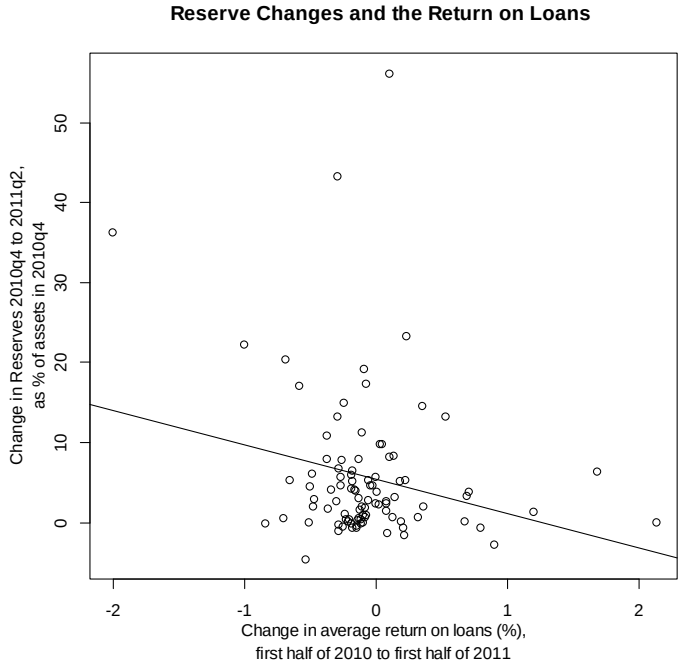

Figure 18

Without much idiosyncratic variation in returns, it is difficult to determine whether banks experiencing especially good lending opportunities tend to reduce their reserve holdings: during the

[32] Of course, one could also ask this question about the first two waves. However, unusual economic conditions during those periods make it especially difficult to identify a relationship between reserve holdings and lending opportunities.

relevant period in our study (the third wave), large changes in lending opportunities simply did not occur. While aware of this limitation, we nonetheless examine in Figure 18 the relationship between the top 100 banks' change in loan interest income and their change in reserves over assets. There is a negative relationship, with reserves falling by 4.3 percent of assets for a 100 basis point increase in the return on loans. Unfortunately, as the figure makes clear, the relationship is only marginally significant; furthermore, the relationship fades as the sample is extended beyond the top 100 banks.

6 Conclusion

We see the research described in this paper as shedding light on the cross-sectional implications of the dramatic increase and continued high level of bank reserves in the United States. Ultimately one would like to understand the effects that large quantities of reserves can have on economic outcomes. Relatedly, as we discuss in Section 2, the fact that banks are holding plentiful excess reserves raises new and important questions for policymakers. Our empirical investigation provides many elements that can inform the debate on these issues. Recent experiences in Europe, Japan and the U.K. could also be studied productively along the same lines.

Our analysis has focused on the 100 largest insured banks, which hold most of the assets and most of the reserves in the system. However, we also provide information about the whole banking system when the issue demands it. The population of banks in the U.S. is large and heterogeneous. Even among our subsample of large banks the heterogeneity is quite significant. Notwithstanding this obstacle, our analysis has uncovered five notable patterns in the data.

First, we observed an increase in the level of total liquidity in the banking system concurrent with the increase in aggregate reserves over the period of our study. With the Fed 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, in the form of excess reserves.

Second, foreign-related institutions (i.e., uninsured U.S. branches and agencies of foreign banks) played a significant role in determining the way that the banking system absorbed the changes in aggregate reserves during the period of our study. In fact, in the second quarter of 2011 these institutions, numbering around 200, held more than 40 percent of the total amount of reserves in the system.

Third, we do not find evidence that the increase in reserves put pressure on insured banks' balance sheet capacity and induced banks to reduce lending. Fourth, after the height of the financial crisis had passed, reserves were not concentrated in banks with low capital ratios as the Federal Reserve increased aggregate reserves by undertaking large asset purchase programs. For most of the large banks in our sample, the lion's share of their reserves could have been converted into loans without creating any substantial pressure on their capital ratios.

Finally, the way the Fed increased reserves – i.e. the way the asset side of the Fed's balance sheet

changed – was reflected in the cross-section of bank balance sheets. When the increase in reserves came from central bank lending at the height of the crisis, banks that absorbed the largest quantities of reserves did not expand their assets or deposits consistently. When the increase in reserves later came from asset purchases, banks with the largest increases in reserves also generally expanded their assets. Furthermore, this correlation between increases in reserves and increases in assets was stronger for the second asset purchase program. Our interpretation is that the first asset purchase program (in 2009) involved a mix of removing securities from bank and non-bank balance sheets, whereas the second asset purchase program primarily removed securities from non-bank balance sheets, replacing them with bank deposits and thereby increasing reserves for the banks accepting those deposits. Regardless of whether reserve increases occurred through lending or asset purchases, those increases initially resulted in a greater concentration of reserves at large banks.

We also consider the impact of changes in rates of return on individual bank decisions associated with reserves. In principle, idiosyncratic variation in lending opportunities could be informative for policy considerations. Referring back to section 2, if IOR were to remain low as aggregate lending conditions improved, then banks would presumably attempt to move out of reserves and into higher-yielding loans and securities. For policymakers, it would be valuable to know how acute a response to expect, and how fast it is likely to unfold; this information would help guide decisions about when and how fast to raise IOR. While we do find some evidence that banks with improved lending opportunities tend to reduce their reserves, the idiosyncratic variation in banks' rates of return present in our data seems too small to use as compelling quantitative guidance for how the banking system would respond to an increase in aggregate returns if IOR were held fixed.

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A Appendix

A.1 Other figures

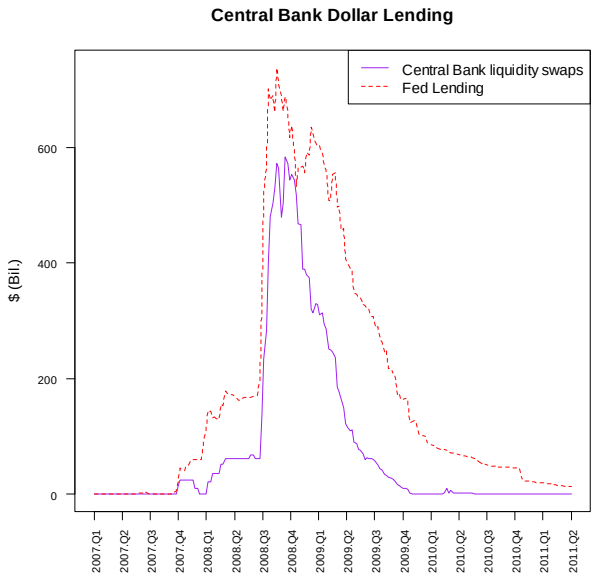

Figure A.1

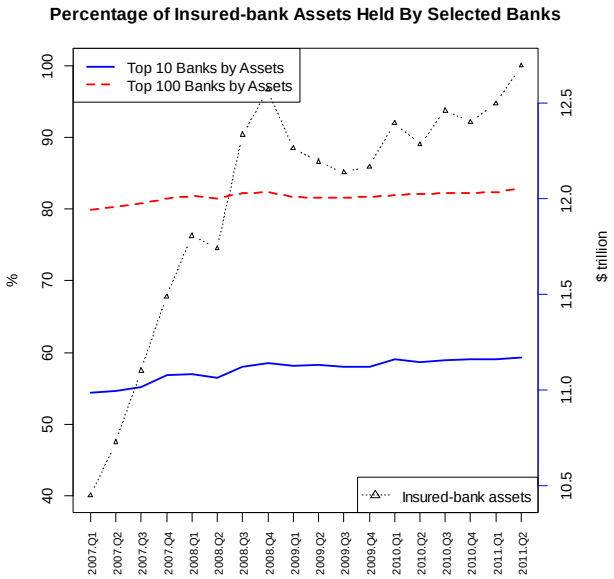

Figure A.2

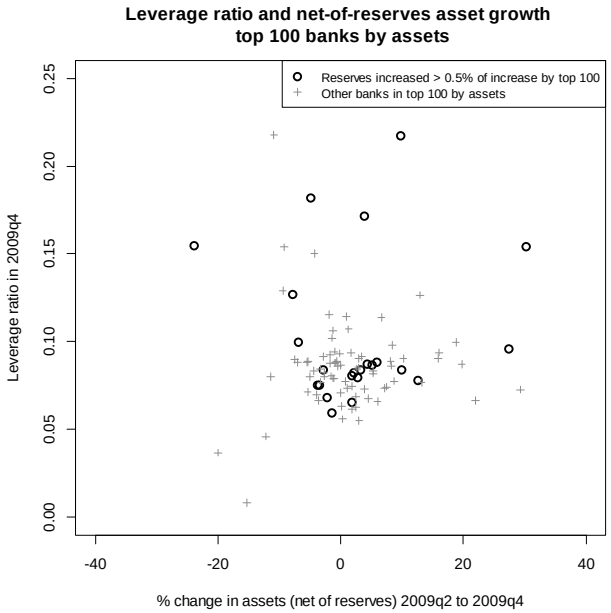

Figure A.3

A.2 Integrating aggregate and cross-sectional data

Aggregate reserve balances with Federal Reserve Banks are reported in the Fed'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.[33] 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 individual bank can be estimated using Call Report deposits and the Fed'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 Fed 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 Fed'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 has been trending down 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.

A.3 Representativeness of end-of-quarter data

The Call Reports, our basic data source, summarize banks' balance sheet positions at the end of the quarter. It is natural to suspect that individual banks' reserve balances also fluctuate within the quarter, and potentially in a significant manner. In some parts of this paper, we take the end-of-quarter position to represent a bank's medium-term decision with respect to its asset holdings (not just an end-of-quarter event). To get a sense of how good an approximation this working assumption is, for the top 75 banks by assets we report summary statistics for the difference, as a percentage of assets, between average reserve holdings during a quarter and end-of-quarter holdings in that same quarter (labeled $D(i,t)/A$). For the first quarter of 2009 and the fourth quarter of 2010, Table A.1 displays quintiles based on ascending values of $D(i,t)/A$ for two subgroups of the top 75 banks by

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

assets: the top 25 and the rest.[34] We can see from the table that for many banks the difference between average reserves within the quarter and reserves at the end of the quarter is not large as a percentage of assets.

Table A.1. Percent deviation of average within-quarter reserves from end-of-quarter reserves

First quarter, 2009			
Top 25 banks by assets		Top 26-75 banks by assets	
Rank	$D(i,t)/A$	Rank	$D(i,t)/A$
5	-0.85	10	-0.18
10	-0.02	20	0.00
15	0.60	30	0.13
20	1.30	40	1.38
Fourth quarter, 2010			
Top 25 banks by assets		Top 26-75 banks by assets	
Rank	$D(i,t)/A$	Rank	$D(i,t)/A$
5	-1.69	10	-3.13
10	-0.45	20	-0.82
15	-0.09	30	-0.12
20	0.02	40	0.26

As a reference, aggregate reserves in the top 75 banks at the end of the fourth quarter of 2010 were around 4.1 percent of assets. The bottom panel of Table A.1 tells us that in the fourth quarter of 2010 at least 15 of the top 25 largest banks experienced a reallocation of assets due to changes in reserves positions within the quarter of less than 2 percent of assets. For the same period the reallocation in the 26th to 75th largest banks is less than 3 percent of assets for at least 30 of the 50 banks in that group. It is also notable in the top panel of the table that the reallocation was significantly smaller for the 26th to 75th largest banks in the first quarter of 2009.

Table A.2. Deviation of 2010q3 reserves from 2010q4 reserves, as percentage of 2010q4 assets

Top 25 banks by assets		Top 26-75 banks by assets	
Rank	$D(i,t)/A$	Rank	$D(i,t)/A$
5	-1.643	10	-0.67
10	-0.3466	20	-0.0044
15	0.4312	30	0.0323
20	1.8291	40	1.743

[34] The numbers in Table A.1 are based on confidential data and were provided to us exactly as they appear in the Table, by the Statistics Division of the Federal Reserve Bank of Richmond.

Table A.2 is an analogous summary of the changes in reserves from one quarter to the next. These numbers are a useful benchmark for interpreting Table A.1. The changes from quarter to quarter in reserves are roughly comparable to those within the quarter.

It seems likely that, during the period under consideration, some banks were able to borrow in the overnight repo market at rates lower than IOR, then deposit the proceeds at the Fed, and in this way obtain an interest differential. This phenomenon was much discussed in the financial press following the April 2011 change in FDIC insurance premiums. When banks borrow in the repo market and increase their balances with the Fed, they fully anticipate that the reserves will be used the next day to cancel the repo transaction. In that sense, those reserves are not available for funding. This kind of repo transaction, however, likely is less predominant on the last day of the quarter, when banks want to control their reported leverage ratios as much as possible. Such repo transactions may drive some of the difference between averages during the quarter and end-of-quarter numbers reported above, but the difference is not necessarily a problem for our purpose to the extent that end-of-quarter numbers are more representative of the actual liquidity available to banks to fund lending or the purchase of new securities. This reasoning, of course, relies on the likely presupposition that the reserves unloaded by some banks at the end of the period are more evenly distributed in the system and hence constitute a smaller bias in our data.

In summary, we believe that potential end-of-quarter adjustments were probably not significant enough to undermine the value of our data as being representative of banks' desired reserve position.[35]

A.4 Calculating total loanable reserves

Capital requirements in the U.S. 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). Since transforming reserves into loans on the asset side of the balance sheet does not change this ratio in any material way, the leverage ratio is not a relevant limiting factor in the ability of banks to lend out reserves.

The tier 1 capital ratio is the ratio of tier 1 capital to risk-adjusted assets.[36] The risk charge for reserves is lower than the risk charge for loans. Hence, transforming reserves into loans results in an 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.[37] As with tier 1 capital, a bank with a relatively low total capital ratio (such that approaching the

[35] Fedwire data provides information about reserve flows at an even higher frequency. However, this data is dominated by intraday payments and seems less informative about the issues we are concerned with here.

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

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

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. Currently, a "well-capitalized" bank must have 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:

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

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 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, 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.