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

Huberto M. Ennis Alexander L. Wolman

Research Department
Federal Reserve Bank of Richmond

June 1, 2011

Abstract

Bank reserves in the United States increased dramatically at the end of 2008 and have undergone another dramatic increase since November 2010. Reserves can be held only by financial institutions, mainly banks, with accounts at the Federal Reserve. For this reason, the increase in reserves has required a major adjustment in banks' balance sheets. From the perspective of monetary policy the expansion in reserves is unprecedented, although it has also coincided with the introduction of interest on reserves, which has changed the nature of reserves as assets of the banking system. We study reserve holdings across banks since the fall of 2008. With an eye toward understanding the implications for monetary policy of operating with a high level of reserves, we evaluate banks' ability to convert reserves into loans should lending conditions improve. We find that a significant proportion of the reserves can be considered "loanable" in the sense that they are held by banks with sufficient capital to increase lending without confronting binding capital requirements.

1 Introduction

In the final months of 2008, the quantity of bank reserves in the U.S. increased by more than a factor of ten. Reserves fluctuated between 0.97 and 1.2 trillion dollars through 2010. In November 2010 the Federal Reserve announced a new

*We would like to thank participants at the Bob King Conference and a seminar at the Bundesbank for helpful comments and Tim Hursey for excellent research assistance. The views in this paper do not represent the views of the Federal Reserve Bank of Richmond, the Board of Governors of the Federal Reserve, or the Federal Reserve System. *Authors' email addresses*: huberto.ennis@rich.frb.org; alexander.wolman@rich.frb.org.

program of asset purchases for $600 billion, resulting in a significant further increase in the level of reserves. These and other facts about the behavior of aggregate reserves are well-known. Much less attention has been devoted to the distribution of reserves across banks; how was the initial large increase in reserves distributed, and how has the distribution of reserves subsequently evolved? We address these and other related questions. We also investigate the characteristics of banks that hold the reserves with an eye toward understanding the implications for monetary policy of operating with a high level of reserves.

An important line of thinking argues that the quantity of bank reserves is irrelevant if the Federal Reserve is able to pay a near-market interest rate on reserves, as it has since the fall of 2008.[1] The Fed's ability to adjust the interest rate it pays on reserves (i.o.r.) indeed means that appropriate adjustments can convince banks to "sit on" whatever level of reserves the Fed supplies.[2]

This logic is valid provided the Fed is able to time the adjustment of the i.o.r. in an (almost) perfect manner. However, monetary policy is 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 i.o.r. As long as the Fed is targeting a fixed short-term interest rate, the Fed 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.[3]

However, large quantities of (excess) reserves in the banking system may exacerbate the potential problems associated with untimely policy adjustment. With i.o.r. and a high level of reserves, banks do not 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. In Ennis and Wolman (2010) we argued that, therefore, the current massive holdings of reserves by banks may have changed the "elasticity" of the economy to an ex-post policy mistake (i.e., delay), making such a mistake more significant and costly. In this sense, the high levels of reserves present new challenges for the conduct of timely monetary policy.[4]

[1] See for example Hall and Woodward (2009).

[2] Our language is loose here. What we mean is that for any level of reserves, there exists some level of i.o.r. such that banks will be content to hold those reserves without any other adjustments to their balance sheets. Otherwise, attempts by all banks to shed reserves will result in some combination of an increase in currency outstanding, an increase in the quantity of deposits, and an increase in the price of assets other than reserves.

[3] 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).

[4] 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 new 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,

Some observers have argued that there is no substantial difference between the workings of the banking system with or without large amounts of excess reserves (see, for example, Dudley, 2011). This view relies in large part on the premise that the interbank market is able to reallocate funding capacity across banks in an almost perfect manner.[5] Frictions in the interbank market are likely to interfere with the reallocation of funding capacity, especially if this funding is to be dedicated to financing long-term loans. As the behavior of the Fed funds rate since the fall of 2008 suggests, frictions seem to play role in the functioning of the interbank market (Gertler and Kiyotaki, 2010). Whether those frictions are large enough to cause a material difference between situations with high and low reserves remains an open question.

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 already well spread out across banks in the banking system, the aforementioned reason for delays is no longer present and the economy can react more quickly to changes in economic conditions. Based on this logic, we study the distribution of reserves across banks in recent years, emphasizing the relationship between banks' reserve holdings, components of their balance sheets, and other bank characteristics.

The payment of interest on reserves has made reserves a relatively close substitute for short-term Treasuries and other short-term securities on banks' balance sheets. It is therefore relevant to ask whether the increase in reserves since 2008 ultimately represented a substitution of reserves for other liquid assets on bank balance sheets. Or, did banks maintain a high level of total liquid assets even after the strains in financial markets subsided? We answer this question by taking a particular stand on how to define liquid assets. However, the rest of our analysis mainly concerns reserves and not liquid assets, because reserves are unique in that they (a) carry zero interest rate risk, (b) represent a means of settlement, and (c) can only be held by banks and other financial institutions with Federal Reserve accounts.

If reserves did not simply substitute for other liquid assets on banks' balance sheets, there may nonetheless be mitigating factors that limit policy risks asso-

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 a more detailed discussion of this issue.

[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."

[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 (21 March 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.

ciated with the large quantity of reserves. The degree of those risks and how they could materialize will depend on how the reserves are distributed across the banking system and on the characteristics of banks that are holding reserves. Suppose that reserves are concentrated in institutions with binding regulatory capital requirements. In that case, banks would have limited ability to quickly expand lending or purchases of longer-term securities, and there would likely be a low degree of risk associated with the large stock of reserves.

We find that reserves did not simply substitute for other forms of liquidity on banks' balance sheets, and that reserves are not highly concentrated in banks that face binding capital requirements. Our measure of aggregate liquid assets held by banks more than doubled at the end of 2008 and has not fallen appreciably. At the level of institutions, there is little evidence that individual banks actively substituted reserves for other liquid assets. With regard to capital, we find little evidence that banks holding high levels of reserves tend to be banks with low levels of capital.

Below, we document these and many other facts about the distribution of reserves, and in the process substantiate the concerns raised earlier: the difficulties in verifying and predicting the state of the economy, and the resulting possibility of ex-post delays in adjusting i.o.r. suggest that a large quantity of reserves may create additional risks for monetary policy.

The Fed's November 2010 policy announcement, which we referred to above as involving a potential increase in reserves of $600 billion or around 60 percent, has received a tremendous amount of attention in the press. Most of that attention, and most of the Fed's own communication on the subject (for example Chairman Bernanke's op-ed piece on November 4, 2010), has avoided describing this action in terms of its effects on reserves. Instead, the discussions have emphasized the short-term effects on the yield curve of what is essentially a swap of short-term government liabilities (interest-bearing reserves) for long-term government liabilities (interest-bearing Treasury securities). Academic research on the Fed's earlier program of asset purchases has shared this focus.[7] The driving motivation for our empirical investigation is not this short-term effect of large assets purchases by the Fed. Rather we are interested in the potential implications, as economic conditions evolve, of having a large quantity of reserves on bank balance sheets.[8]

We begin below with some background on the behavior of aggregate reserves and the various Fed programs that affected the quantity of reserves starting in the fall of 2008 (prior to that point, the effect of credit programs on reserves was offset by sales of securities and by the Treasury's Supplementary Financing Program). Next we provide a basic description of how the large increase in

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

[8] Note that although the Fed's short-term plans will likely imply an increase in reserves, over the long term it is not clear whether the level of reserves will remain high. At any time the Fed could choose to reduce the quantity of reserves by selling securities in its portfolio. In 2010 the Fed also announced plans for a Term Deposit Facility, and for expanding its capacity to conduct reverse repurchase agreements. These tools can be used to drain reserves, as long as the associated interest rates are set at appropriate levels.

reserves was reflected in the distribution of reserves across banks. Aside from helping us understand the terms on which banks are holding the large levels of excess reserves, this information is integral to a complete account of the recent financial crisis and the ensuing policy response. We investigate where the large injections of reserves initially resided (in which segments of the banking system) and how reserve holdings evolved to what looks like a relatively stable distribution today.[9]

Next we address the substitution of reserves for other liquid assets, and the relationship between banks' capital positions and their reserve (ratio to assets) holdings. Finally, we turn to the characteristics of institutions holding relatively high and low ratios of reserves to assets; by studying these institutions we hope to be able to learn something about the circumstances under which banks as a whole would attempt to shed reserves - which would require adjustments in asset returns, goods prices, or the quantity of currency held by the public.

2 Aggregate reserves and Fed policy since 2008

Prior to the autumn of 2008, the total quantity of 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. An initial increase in aggregate reserves of $134 billion occurred from mid-September 2008 – the time of the Lehman bankruptcy– to mid-October. Then, from mid-October until the beginning of 2009, reserves increased a further $721 billion, to $900 billion. From early 2009 until the end of 2010, reserves fluctuated in a range between $670 billion and $1.25 trillion, and required reserves did not account for more than 9.3 percent of total reserves. Figure 1 displays time series for required reserves and excess reserves over the period in question.[10]

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 to pay interest on all reserve balances held by depository institutions, and since mid-November 2008 the interest rate paid on reserves (IOR) has been essentially equal to the target for the Federal Funds rate.[11] With IOR close to the federal funds rate most costs of holding reserves are eliminated. Thus, the Fed was able to increase the quantity

[9] As we stress below, stability of the distribution of reserves does not imply that reserves are "stuck" at particular institution; a stationary distribution is consistent with nontrivial gross flows of reserves, and that is indeed what we find.

[10] Because our bank-level dataset ends with the fourth quarter of 2010, the pictures of aggregate reserves also end with that date.

[11] The effective fed funds rate has generally been below IOR. It is widely believed that this reflects the fact that the GSEs 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 Bech and Klee (2009).

of reserves to the high 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 programs and asset purchases that the Fed has undertaken since late 2008.

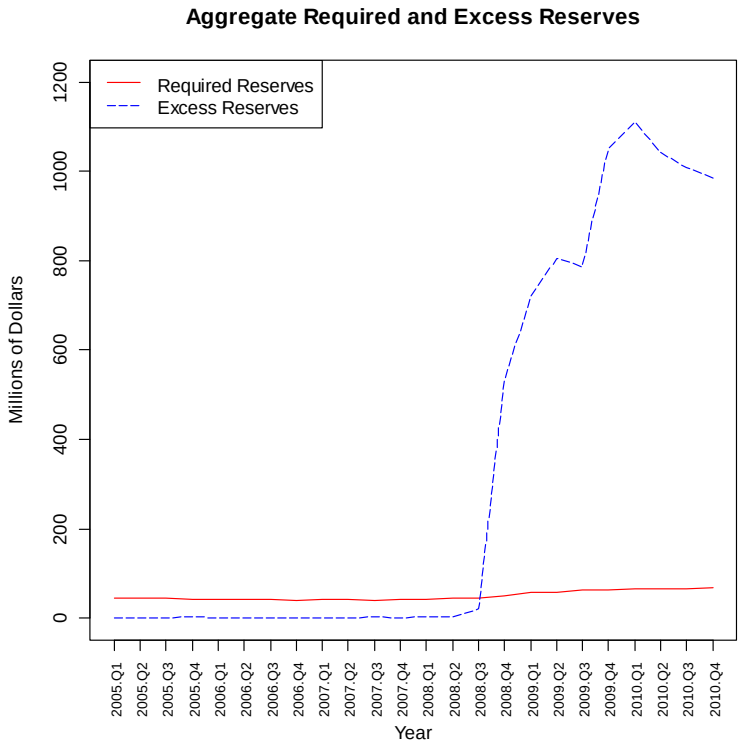

Figure 1

2.1 Sources of reserves

The large increase in reserves took place through two main channels: loans and asset purchases. While the Fed mainly conducts asset transactions with a limited number of counterparties (primary dealers), the programs that the Fed used to loan reserves were more widely available to the universe of banks. If the interbank market is not a perfect channel for the reallocation of reserves, then the way reserves were introduced might have affected the allocation and the dynamics of the distribution of reserves over time. We will assess this possibility using our cross-sectional data below.

Our conjecture is that newly injected reserves only slowly find their way through the system to banks that hold them in the medium term as part of their desired portfolio. Especially after major interventions like the ones taking place in the last quarter of 2008 and the first quarter of 2009, it may take time

for banks to fully adjust their balance sheets. The speed of such adjustment is likely to be linked to the way that the reserves are introduced into the system.[12]

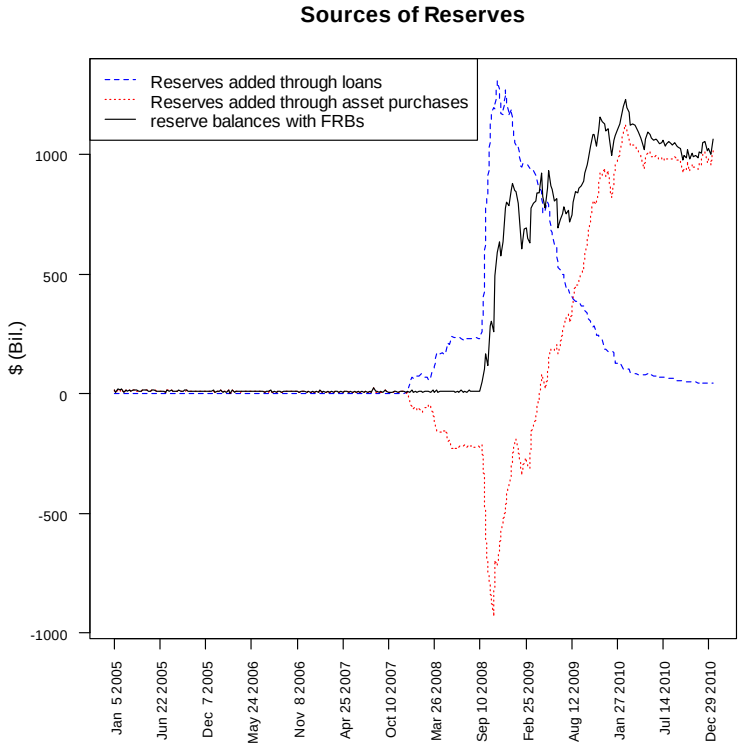

Figure 2

As a response to the crisis, during the first part of 2008, the Fed made sterilized loans to banks – offsetting the effect on reserves by open market sales of securities. Reserves did not change in any significant amount during that time. In October 2008, with the introduction of interest on reserves, the level of reserves in the system increased substantially in a short period of time. The bulk of this initial increase in reserve balances was the consequence of Fed loans to depository institutions via the discount window and the Term Auction Facility, and indirect loans via the liquidity swap lines with foreign central banks (see Figure A1 in the appendix). Indeed, between October and year-end 2008 total central bank lending increased from less than $300 billion to more than $1 trillion (see Figure 2).[13] By the beginning of 2009 and during the entire year,

[12] The issue discussed here also arises when considering alternative strategies for reducing the level of reserves outstanding. In fact, in preparation for the eventuality of having to absorb large quantities of reserves, the Fed expanded its list of counterparties for reverse repurchase agreements in September 2010.

[13] We construct the figure using data from the Board of Governors Table H.4. We calculate

the main source of reserves became asset purchases (instead of loans). In fact, while the level of reserve balances increased further and stayed at high levels during 2009, total central bank lending trended down to reach very low levels by the end of year.[14]

The way that reserves are introduced into the system may also directly influence the state of banks' balance sheets. Securities purchased (and sold) by the Fed, for example, could be absorbing assets that were held by the non-bank private sector or by the banking system itself. If the securities were held by the non-bank private sector, the Fed swapped assets previously held by non-bank entities for an asset that can only be held by banks (reserves), increasing the banking system's balance sheet. In this way, securities purchases could put pressure on banks to control the expansion of their balance sheet as they get closer to binding leverage ratios. Using the cross-sectional data, we will investigate this and related issues further in Section 3 below.

The sub-category "Other borrowings" in the category "Other borrowed money" of banks liabilities (as reported in the Call Report filings) is a natural component to look at when exploring these issues. This sub-category is where loans from the Fed are accounted for. In particular, banks report "Other borrowing with a remaining maturity of one year or less" where most (if not all) central bank lending is included.[15] Figure 3 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 Table H.4 (see footnote 13). In the figure, we can see that total OSTB increased significantly during the year 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 had access to Fed lending. However, due to lack of data availability, their liabilities are not included in the total for OSTB reported in the figure. Also, it is clear from the pre-2008 data that OSTB includes various types of borrowings, not just Fed lending. The main message from this figure then, is just that changes in OSTB

Reserves added through direct loans as the sum of Term Auction Credit, all Other Loans in Reserve Bank Credit, and Central Bank Liquidity Swaps. To calculate Reserves added through asset purchases we 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. We subtract from this Total Factors Absorbing Reserve Funds (other than reserve balances). Implicitly then, we are treating fluctuations in reserves due to Treasury actions as Reserves added through asset purchases.

[14] 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. But this alternative adjustment would not make a big difference in the numbers. It is important to realize that reserve balances with FRBs does not include vault cash. Vault cash is included in Currency in Circulation and hence we subtracted it from Factors Supplying Reserves when we subtracted Factors Absorbing Reserves.

[15] We call this sub-category OSTB (other short-term borrowings) for brevity.

during 2008-2009 are likely to be associated with the changes in Fed lending that took place during that period.

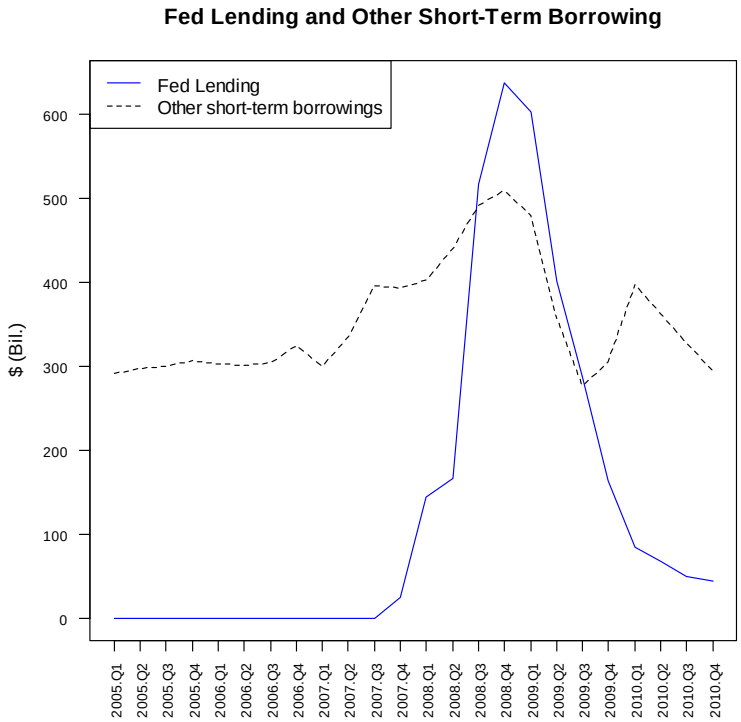

Figure 3

The other major sub-category of "Other borrowed money" on the liability side of banks' balance sheet is "FHLB advances;" i.e., loans from the Federal Home Loan Banks. Banks use FHLB advances as a back-up source of liquidity. It is well known that loans from the FHLBs were heavily used during the period under consideration here (Ashcraft, et al. 2010). FHLB loans involve transfers of reserves, but the link between FHLB borrowings and end-of-quarter reserve holdings is not obvious. The issue deserves careful study but we do not (yet) pursue it here.

3 Distribution of reserves across banks

Our 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, the Call Reports, which are our primary data source. Our study does not cover credit unions and some thrift institutions;

they do not report reserve holdings in their regulatory filings. In the most recent quarter there were approximately 2200 institutions with reserve accounts, 219 of which fall into the uninsured foreign affiliates category.[16]

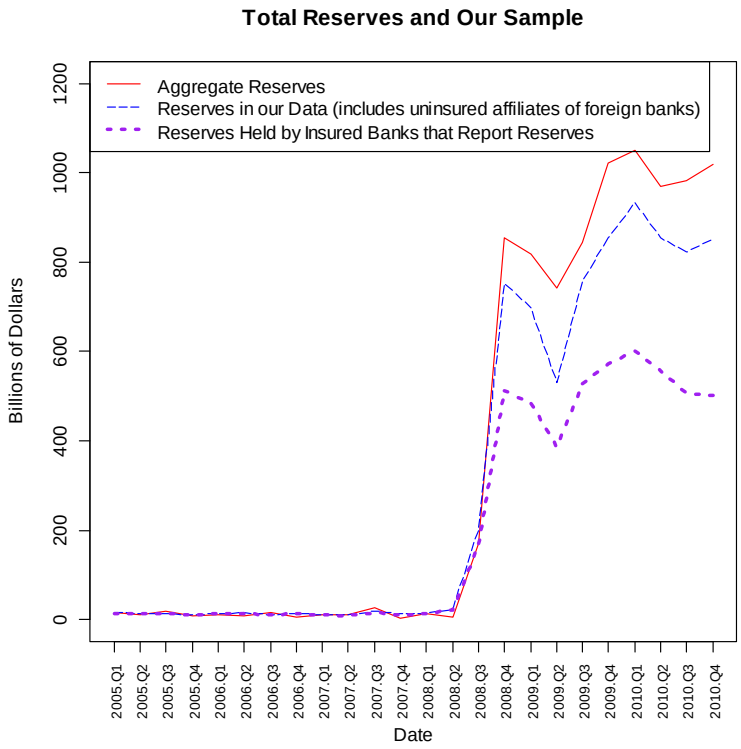

Figure 4

Figure 4 displays time series for aggregate reserves reported on the Federal Reserve's H.3 release (solid line), reserves held by insured banks in our sample (dotted line), and total reserves in our sample (dashed line).[17] The difference between the dashed and the dotted line is the total reserves in uninsured affiliates of foreign banks. In 2010q4, total reserves were $1.02 trillion; domestic banks in our sample held $502 billion, and uninsured affiliates held $350 billion. Thus,

[16] There are approximately 7000 banks in the U.S. The 4800 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 five percent – so we are not too concerned about this source of mismeasurement.

[17] The Fed's H.3 release typically does not cover the last day of the quarter. For this reason, such data can show some inconsistencies with the data in the Call Reports – our main data source. This is especially a factor during those 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.

there is a gap of approximately $165 billion between reserves covered in our data and aggregate reserves reported by the Fed' H.3 report. We conjecture that this gap is accounted for by reserve holdings of credit unions and those thrifts institutions not included in our data set.

To construct the time series for total reserves held by insured banks in our sample, we aggregate across those banks the entry "balances due from federal reserve banks" of the call reports, which includes required clearing balances. For comparison with the H.3 release we subtract from aggregate balances the total value of required clearing balances as reported in the Fed's H.4 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 used the call report item "balances due" to proxy for the reserve position of individual banks at each point in time.

Cash in the vaults of depository institutions is not included in our measure of total reserves. However, vault cash can be used to satisfy reserve requirements. Hence, to compute excess reserves for an individual bank one needs to subtract required reserves net of vault cash (used to satisfy required reserves) from total reserve holdings. We will make this adjustment when necessary throughout the paper.

3.1 Foreign bank affiliates

Like domestic depository institutions, uninsured affiliates of foreign banks may hold reserve accounts with the Fed. However, they have distinct characteristics and file a less-detailed report than generic "banks," so we will treat them separately in our analysis. Note that insured domestic bank subsidiaries of foreign banks are included with domestic depository institutions.

Foreign institutions' reserves have increased by a factor of almost 600 from the middle of 2008 to the present, going from $571 million on June 30, 2008 to $349 billion on December 31, 2010.[18] Relative to total reserves, foreign institutions' reserves increased from 5.2 percent to 34 percent. Relative to foreign institutions' assets, their reserves rose from less than 0.03 percent to more than 18 percent over the same period. Thus the increase in reserve balances has entailed a dramatic balance sheet adjustment for foreign institutions. Furthermore, total assets in foreign related institutions actually fell eight percent during the period in question, so the increase in reserves has been accompanied by a significant reduction in the LEVELS of some other asset categories.

[18] This can be seen as the distance between the solid and the dashed lines in Figure 4.

Table 1. Foreign institutions: selected asset categories (% of total assets)

	RCFD0090	RCFD2154	RCFDC036	RCFDC122	RCFDC419	
	Reserves	Net due from related depository institutions	Other asset-backed securities	Loans and leases, net of unearned income	Other trading assets	All other assets
2008Q2	0.03	37.44	2.64	27.32	10.58	21.98
2008Q4	11.45	26.16	3.82	30.23	12.02	16.37
2009Q2	7.28	35.47	3.50	28.38	9.01	16.34
2010Q4	18.24	30.91	2.13	24.90	7.35	16.51
Change 2008Q2 to 2008Q4	*11.42*	*-11.28*	*1.18*	*2.91*	*1.44*	*-5.61*
Change 2008Q4 to 2009Q2	*-4.17*	*9.31*	*-0.32*	*-1.85*	*-3.01*	*-0.03*
Change 2009Q2 to 2010Q4	*10.96*	*-4.56*	*-1.37*	*-3.48*	*-1.66*	*0.17*

Table 1 summarizes the transformation in foreign institutions' balance sheets. The Table contains information on selected asset categories as a percent of assets for the periods 2008q2, 2008q4, 2009q2 and 2010q4. The first of these periods is immediately prior to the large increase in reserves, and 2010q4 is the last period covered by our data. We chose the two intermediate periods because they demarcate distinct phases in the transformation of foreign institutions' balance sheets. The asset categories in the table, in addition to reserves, are the categories that bore the brunt of the increase in reserves. In the first subperiod, reserves increased by more than eleven percent of assets, and there was almost a perfect offset in the foreign institutions' deposits at other related institutions ("Net due from related depository institutions"). In the second subperiod, reserves fell by more than four percent of assets, and there was a more than offsetting increase in deposits at related institutions. Finally in the third subperiod, reserves rose by eleven percent of assets, with the offsetting reductions coming primarily from deposits at related institutions (4.56%) and loans (3.48%), and to a lesser extent from trading assets other than Treasuries and Agencies, and non-mortgage ABS.

The balance sheet changes displayed in Table 1 can help explain why 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 in the home office, 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 the present does not lend itself to such a clean story. 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.

It may be tempting to associate the behavior of foreign institutions' reserve holdings in the first two subperiods with 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. 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 would tend to be associated with increases in their reserve holdings.[19] 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. This disparity makes clear that a significant portion of the reserves that originated in swap lines ended up on the balance sheets of US institutions. Either the U.S. institutions were correspondents of foreign banks or they made transactions with foreign institutions which resulted in a transfer of reserves to the US banks.

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.[20]

[19] If the institution had collateral pledged to the Fed, it would also have been eligible to borrow directly from the Fed, for example using the Term Auction Facility. For this reason, among others, changes in reserve balances of these institutions do not rely on the existence of the swap lines.

[20] Sometimes a banking corporation appears to have both U.S. insured affiliates and uninsured affiliates. An example of this is Deutsche Bank, which has both insured U.S. banks and uninsured U.S. affiliates. 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 2010Q4, Deutsche's domestic insured institutions reported reserves of about $15 billion, and their uninsured affiliate reported reserves of about $25 billion.

3.2 Reserves in the cross section

For most of our analysis below we will restrict attention to insured banks and 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.[21] The holding of reserves across institutions is likely to be associated with the size of the institution. Figure 5 plots the percentage of total reserves of U.S. insured banks held by the top ten and top 75 banks by assets (at each point in time). We can see that the percentage of reserves held by the top ten banks increased significantly at the end of 2008 when the level of reserves was increasing rapidly. This is also true for the top 75 banks. It is interesting to see that initially (in 2008q3) the top 10 banks are the main drivers of the increase in the proportion of reserves held by the top 75 banks. From 2008q4 onwards, however, the banks in the top 75 group which were not in the top 10 group increase their reserve holdings more markedly (as shown by the increasing distance between the solid and the dashed lines in Figure 5).

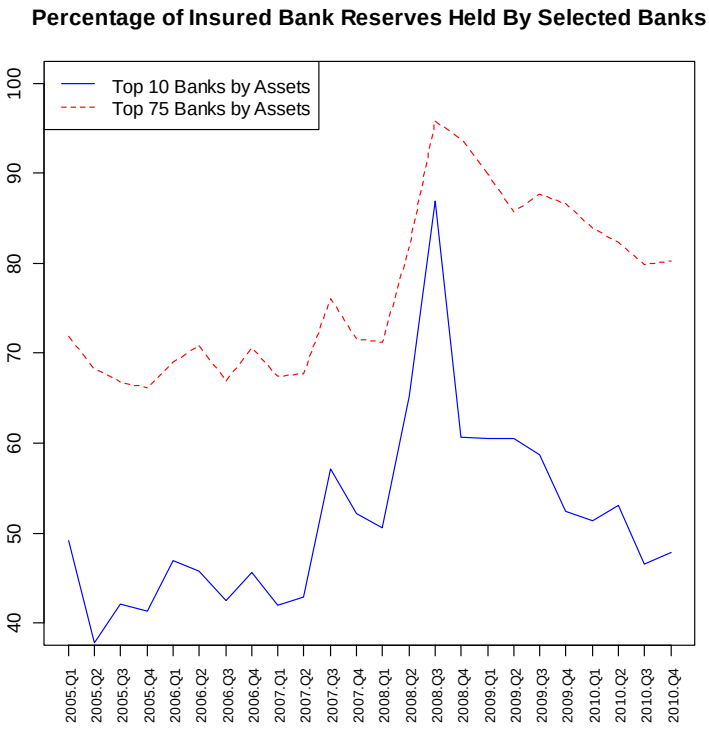

Figure 5

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

According to Figure 5 then, large institutions hold a large portion of total reserves. But, are reserve holdings across institutions proportional to assets? The first panel of Figure 6 displays the histogram of the ratio of reserves to assets for 2010q3 and shows that there is in fact a wide variation in this ratio across institutions. As shown in the second panel of Figure 6, significant variation is also present within the largest 75 holding companies, which account for approximately 80 percent of assets. This pattern suggests that it is generally inappropriate to use a representative bank (normalized by assets) as an abstract representation of the U.S. banking system.

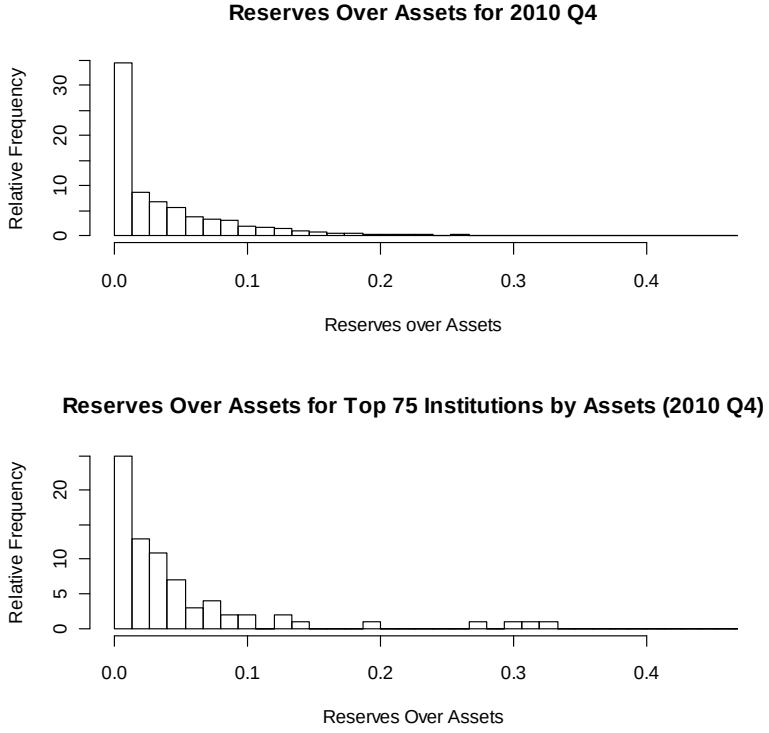

Figure 6

Figure 7 presents the evolution of reserve holdings as a percentage of total assets for the largest seven banks in the system as of December 2007.[22] There appear to be two distinct strategies followed by these banks. While Citi, Bank of America, and HSBC held more than 6 percent of assets in reserves during the period, the rest of the banks stayed at lower levels, around 2 percent of assets.

[22] Wachovia was the fourth largest institution but was acquired by Wells Fargo in the third quarter of 2008, before the large system-wide increase in reserves. For this reason, we do not include it in the figure.

However, Wells Fargo seems to be moving closer to the first group in the more recent quarters and HSBC's holdings are more volatile than the rest.

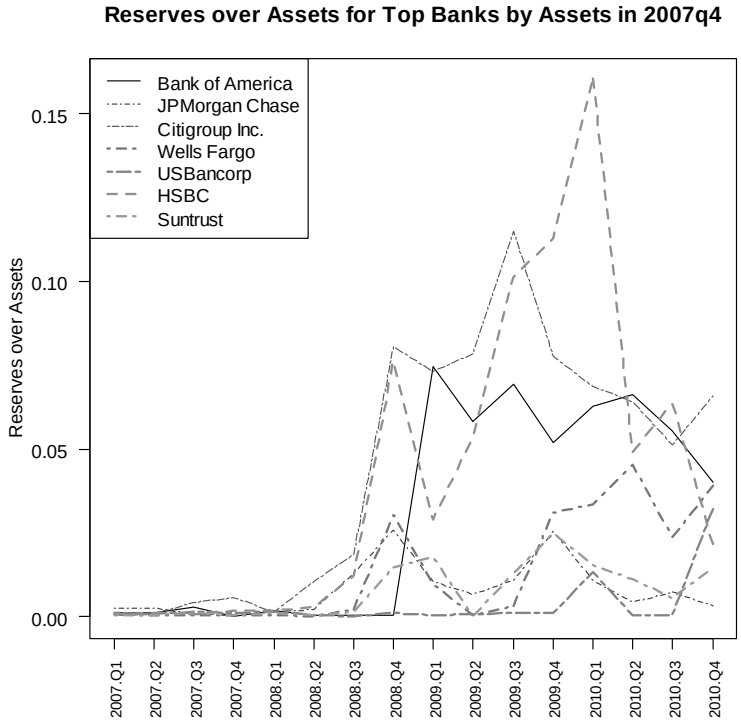

Figure 7

Figures 8 and 9 provide information about how the distribution of reserves across banks of different sizes has evolved over time, and in particular how the large increase in reserves was initially distributed across banks and then how the distribution subsequently evolved. Figure 8 covers 2008q3 and 2008q4, the two quarters in which the initial increase in reserves occurred, and the only quarters in which Fed lending was neither a minor factor nor rapidly declining. Figure 9 covers the two most recent quarters, 2010q3 and 2010q4. Each line in these figures represents something *similar* to a Lorenz curve for reserves. Instead of ranking banks by reserves on the horizontal axis, they are ranked by assets, and the horizontal axis measure fraction of assets, not fraction of banks.[23]

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

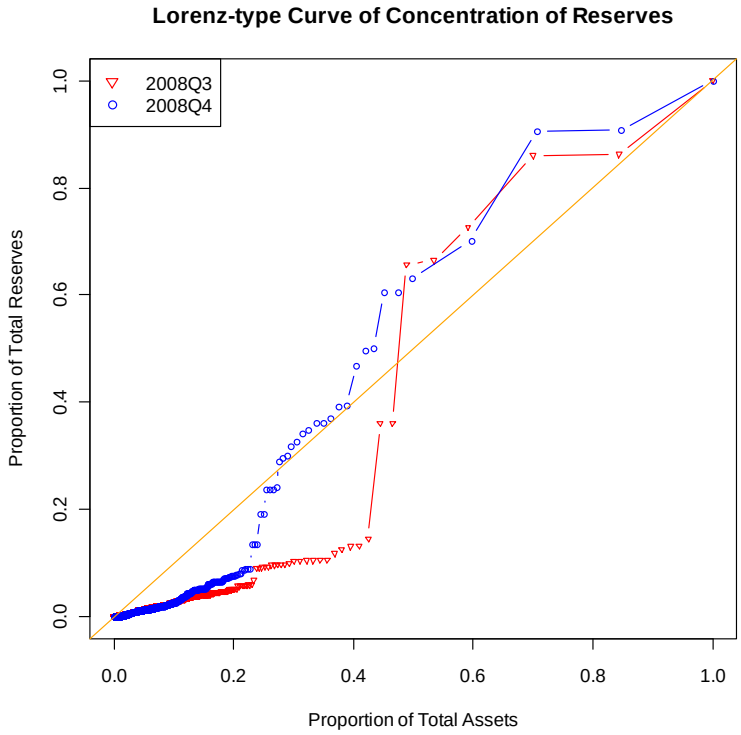

Figure 8

Comparing Figures 8 and 9, we see that the concentration of reserves has changed significantly between these two periods. As was suggested by Figure 5, the largest banks held a disproportionately high amount of reserves at the peak of the crisis. The figures also show that the four largest banks account for roughly 50 percent of assets and that some large changes in their reserve positions had significant effects on the distribution of reserves relative to assets. Consistent with the broad picture of changes in concentration, note that at the end of 2008 banks holding the bottom 20 percent of assets held less than ten percent of reserves, whereas by late 2010 this same group of banks held approximately 25 percent of reserves.

It is interesting to note that prior to the large increase in reserves (not in the figures), 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 demand deposits. In this sense, although the level of reserves is much higher, the distribution of reserves among small banks has moved back closer to its pre-crisis state.

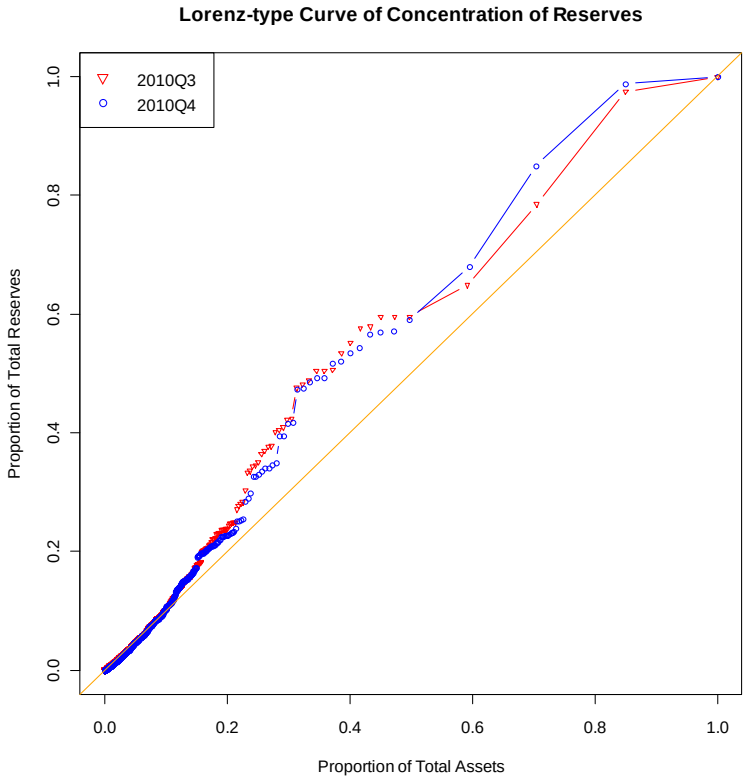

Figure 9

The differences between the Lorenz-type curves in Figure 8 and those in Figure 9 are likely to be associated with two factors. First, in the last two quarters of 2008 large quantities of reserves were just being created and introduced into the system. Potentially, the banks that initially received the new reserves did not immediately get rid of them, leading to the more "unbalanced" distribution displayed in Figure 8. Second, the state of the economy was very different in the periods plotted in the two figures. During the peak of the crisis (corresponding to Figure 8) some banks may have had greater incentives to accumulate reserves than others. Both these factors likely contributed to the more unbalanced distribution of actual and desired reserve holdings in the second half of 2008.

The first factor mentioned above is based on the idea that: (1) only a subset of banks played a major role as Fed counterparties during the crisis and (2) banks' balance sheet adjustments occur only gradually. The fact that the interbank market was severely strained during the crisis probably contributed to making the adjustment more gradual. The way that the reserves are introduced would also play a role in this interpretation. As pointed out in the discussion of Figure 2, the large increases in reserves at the end of 2008 came

about through Fed lending programs and liquidity swap lines. In principle, this way of introducing reserves tends to create a more dispersed initial distribution of reserves than when the Fed conducts asset purchases with a limited set of primary dealers. Notwithstanding this force for a more dispersed distribution, Figure 8 suggests some noticeable concentration of reserves at the top (i.e., in large banks).

Table 2. Correlation of reserves/assets across periods:
level (top right) and change (bottom left)

	08q4	09q1	09q2	09q3	09q4	10q1	10q2	10q3	10q4
08q3	0.33	0.27	0.26	0.26	0.26	0.25	0.22	0.24	0.19
08q4		0.72	0.56	0.51	0.48	0.45	0.40	0.38	0.42
09q1	−0.33		0.76	0.68	0.60	0.54	0.50	0.48	0.47
09q2	−0.27	−0.18		0.84	0.75	0.67	0.63	0.60	0.56
09q3	0.03	0.02	−0.12		0.83	0.74	0.68	0.65	0.60
09q4	0.02	−0.10	0.01	−0.22		0.79	0.74	0.69	0.67
10q1	0.03	0.08	−0.01	0.00	−0.31		0.91	0.85	0.80
10q2	−0.11	0.02	0.02	−0.06	−0.02	−0.20		0.91	0.85
10q3	0.01	−0.00	−0.03	0.02	−0.05	−0.04	−0.15		0.89
10q4	0.10	−0.14	−0.09	−0.07	0.10	−0.12	−0.08	−0.26	

While Figures 8 and 9 provide some information about how the distribution of reserves evolved over time relative to the distribution of assets, those figures can only hint at how reserves evolved at the level of individual institutions. Table 2 displays correlations between one period and the next for the ratio of reserves to assets at each bank. The entries on the top right are correlations of levels, and the entries on the bottom left are correlations of growth rates. From Figures 8 and 9 we learned that reserves became more evenly distributed across assets in the later periods. Table 2 shows that the later periods have also been characterized by greater stability of reserves at particular institutions. However, as we will see below, there are in fact significant flows of reserves across institutions. The growth-rate correlations, shown below the diagonal in Table 2, are generally either zero or negative. This evidence, while hardly conclusive, does not seem to support the view that banks gradually adjust their reserves to a target level.

3.3 Changes in reserves and the balance sheet

Understanding how the introduction of reserves was accommodated by individual banks is complicated. The impact of the increase in reserves on the size of a bank's balance sheet and its components potentially depends on how the reserves are initially introduced, as we discussed before. The bank may be a direct counterparty of the Fed (by taking a loan or selling securities) or it may just be the provider of banking services to a non-bank counterparty of the Fed. Each case 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 OSTB 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 buys securities from the private sector, it may or may not absorb assets previously held by the banking system. If the securities were held by banks, then the Fed is swapping one banking asset for another and the size of the banking system's balance sheet would stay unchanged. Alternatively, if the Fed buys securities from non-bank investors, then the trade tends to induce an increase in banks' balance sheets, since the Fed is swapping an asset that can be held by anyone for an asset (reserves) that can only be held by banks. In principle, this trade would create an increase in bank deposits and bank assets in the form of reserves.

To get a better sense for how the introduction of reserves was accommodated by banks, we go back to the data presented in Figure 7 and identify the four largest quarter-to-quarter increases in reserves (not divided by assets) among the top banks in the system. The first four rows of Table 3 deal with these changes. Two of the changes happened during the period where the main source of reserves was central bank lending (as identified in Figure 2) and two of the changes happened in the period where asset purchases were the main driver of the increasing level of reserves. We can see that, in general, the change in reserves was not offset by changes in other liquidity, and assets for the bank did not increase as much as reserves, nor did other short term borrowings (which include loans from the Fed). The bottom rows represent two other prominent changes in reserve positions by two of the top banks, as suggested by Figure 7.[25] Again, we see that increases in assets do not account for the increases in reserves, nor do other liquidity changes offset the reserve increases. Notably, OSTB did change significantly for JPMC during the third quarter of 2009, but this is probably not associated with borrowing from the Fed since the lending programs were actually winding down by that time.[26]

[24] Note that "Other short-term borrowings" may or may not increase, since borrowing from the Fed may be substituting for other short-term borrowings or for liabilities other than OSTB.

[25] There were two other large changes not included in the Table, for Wells Fargo and JPMC, both in the last quarter of 2008, around the time when these two banks acquired large troubled banking organizations (Wachovia and WaMu, respectively). We did not include them in the table as the main changes in their balance sheet were driven by other factors. Bank of New York Mellon also had a large increase in its reserves position during the third quarter of 2008 but, being mainly a clearing bank, we decided to leave it out of the table.

[26] More detailed data on the recipients of Fed lending during the period (through the Term Auction Facility and the Discount Window) is now publicly available and could be used to analyze how the main users of Fed lending facilities accommodated the new loans in their

Table 3. Large changes in individual bank reserves

	Change in Reserves	Change in Assets	Change in Liquidity	Change in Other ST Borrowings
BofA 2008q4 to 2009q1	127.73	16.92	114.24	17.69
Citi 2008q3 to q4	82.38	28.90	61.70	32.18
Citi 2009q2 to q3	48.94	23.78	40.88	-19.76
Wells 2009q3 to q4	33.24	89.20	33.98	1.08
JPMC 2009q3 to q4	24.36	-39.73	13.01	16.98
HSBC 2008q3 to q4	11.73	-0.39	11.19	0.88

More generally, we can ask whether banks of all sizes were increasing the size of their balance sheets as they increased their reserve holdings. Figure 10 presents some evidence that suggests this was not the case. To construct the figure we form four groups of banks, according to the value of their change in reserves divided by assets from Q3 to Q4 of 2008. Each group contains 20% of the banks. The first group includes all banks with a change in reserves relative to assets between the first and the third decile of the distribution. The second group includes all banks between the third and the fifth deciles, and so on for the other two groups so that in total we include all banks between the 10th and 90th percentiles when ranked by their change in reserves relative to assets. We then compute the percentage change in assets for each bank and summarize the distributions that condition on each of the four quantiles. In the figure, the horizontal axis measures the change in reserves as a percentage of assets. The four vertical lines correspond to the 20th, 40th, 60th and 80th percentiles of the change in reserves as a percentage of assets– the midpoints of each bin. The points plotted on the vertical lines represent quintiles and the median for the percent change in assets within each group. The distribution of changes in reserves over assets is right-skewed – the 70-90 quantile is far removed from the 10-70 quantiles. However, even for groups of banks with very different changes in reserves (relative to assets) the distribution of the percent change in assets is similar. In other words, Figure 10 suggests that those banks that increased their reserves the most during the fourth quarter of 2008 did not systematically increase their assets the most.

balance sheet. We leave this analysis for future research.

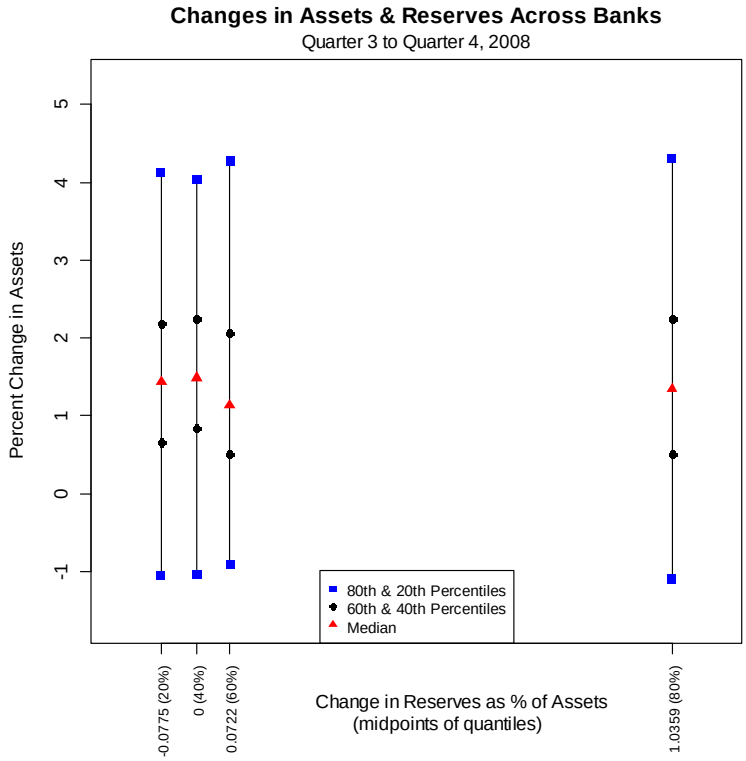

Figure 10

Similarly, we can ask whether those banks that increased their reserve holdings at the end of 2008 also increased their level of total deposits. This would be the case, for example, if banks were using Fed loans to substitute for other sources of funding, in which case the bank holding the reserves would be the one holding the account of the borrowing bank's previous creditor. Figure 11 displays some evidence of a positive relationship between changes in reserves and changes in deposits during that period: banks with a relatively large increase in reserves as a percentage of assets (the 70-90 quantile) had a distribution of deposit changes higher than other banks.

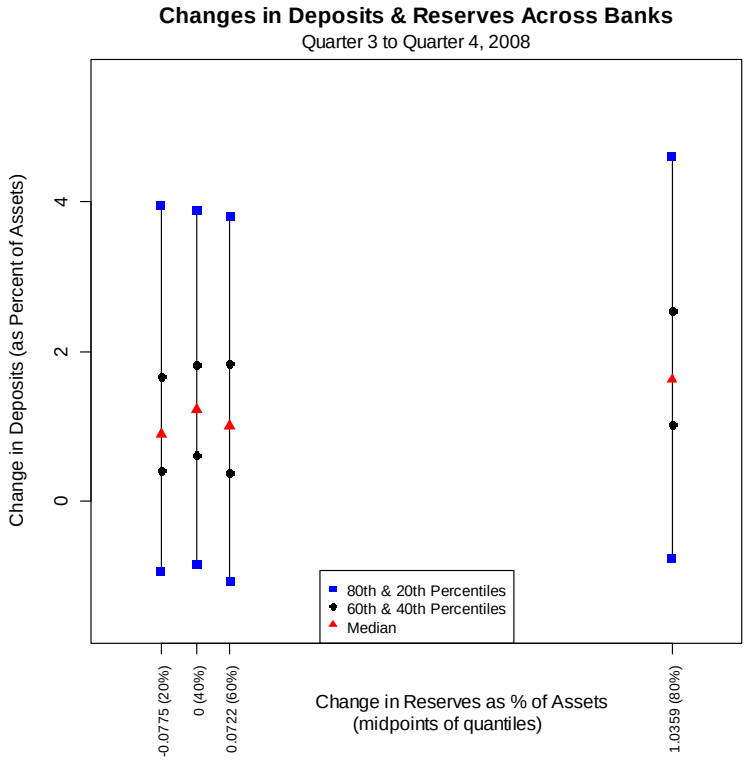

Figure 11

One limitation to Figure 11, and other similar figures, is that they weight all banks equally. Figure 12 restricts attention to the 100 banks that had the largest increases in reserves in 2008q4.[27] The figure plots the cumulative change in deposits against the cumulative change in reserves for 2008q3 to q4, with institutions ranked in descending order by their change in reserves. The total increase in *both* deposits and reserves for these institutions was close to $300 billion. However, among the 15 banks with the very biggest increases in reserves the relationship between deposit changes and reserve changes is weaker.

[27] We exclude Wells Fargo because its balance sheet approximately doubled with the purchase of Wachovia.

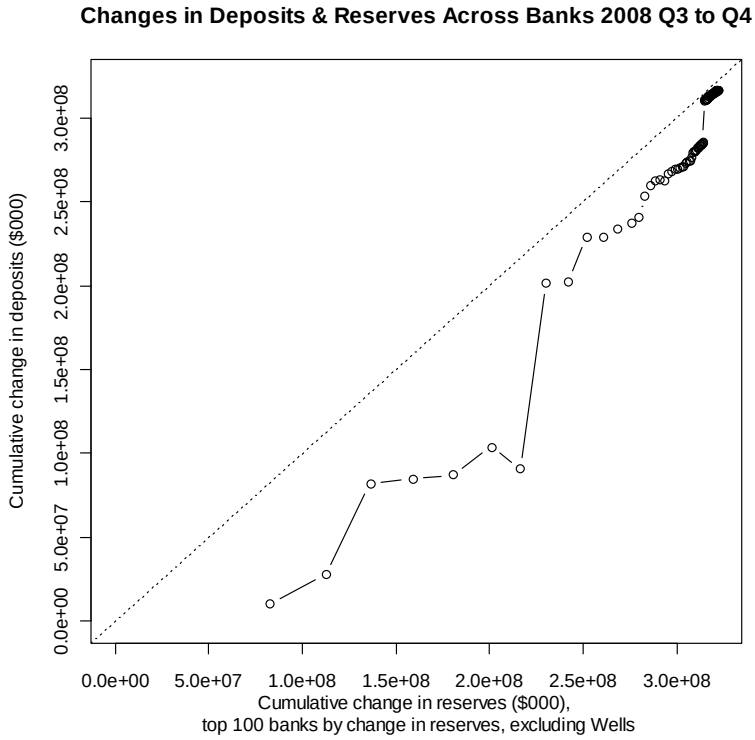

Figure 12

Given that changes in assets are not tightly linked with the changes in reserves, for some institutions the change in reserves may have been offset by a change in securities, leaving total assets unchanged. This fact would call for a negative correlation between changes in reserve holdings and changes in securities holdings. Figure 13 shows that there is no strong evidence for such a pattern in the data, but again this figure treats all banks the same, regardless of size. With Figure 12 showing that reserves and deposits moved together in aggregate for the 100 banks that increased reserves the most, it seems unlikely that reserves primarily substituted for securities at those institutions. Figure 14 confirms that substantial substitution only occurred at a small number of institutions.

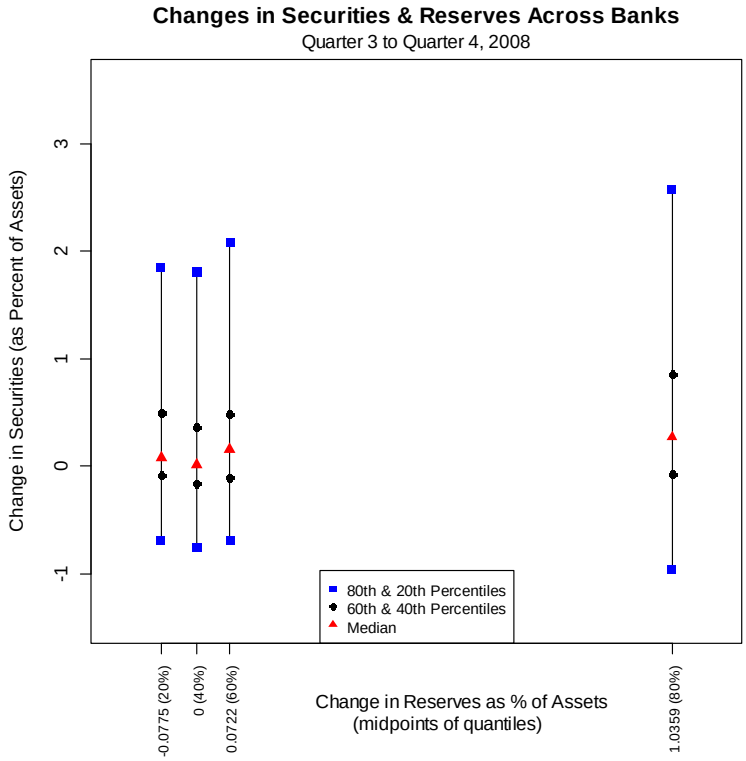

Figure 13

The picture painted by these figures is not easy to interpret. Banks that had a significant increase in their reserves position (relative to assets) did not increase their total assets more than other banks. This would suggest that some other component of the asset side of the balance sheet must have decreased. However, according to Figures 13 and 14, it is not the case that securities play that compensating role. At the same time, there is some evidence that banks that increased their reserves position significantly also increased their deposits. These deposits could reflect the fact that customers of the reserve-holding bank had previously been lenders to other banks. When the borrowing banks switched to Fed facilities for their funding, they paid off private loans, causing an increase in deposits and reserves at their (nonbank) lender's bank.

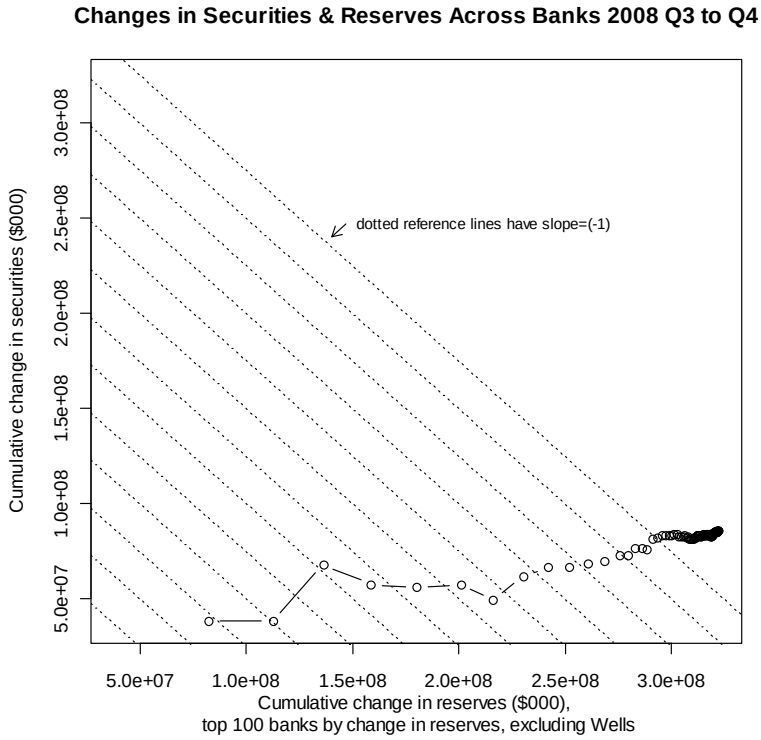

Figure 14

After the initial period of increases in reserves based on Fed lending in late 2008, the introduction of reserves has been accomplished through asset purchases. This is of course the case in the program of asset purchases set to end in June 2011. During the second and third quarter of 2009, the total amount of reserves increased significantly. The main channel for the increase in reserves in that period was also asset purchases, which makes it comparable to the current situation. As we have explained, if the Fed is purchasing most of the securities from banks in exchange for reserves, then there should be a negative correlation between reserves and securities holdings on bank balance sheets during these periods of large increases in reserves. Figure 15 shows that there is some tenuous evidence of a negative correlation in the middle periods of 2009 among all banks. However, Figure 16 shows that among those banks experiencing the biggest increases in reserves, very few reduced their securities holdings as much as they increased their reserves. Presumably then, the Fed was absorbing securities not just from the banking system but also from other private holders.

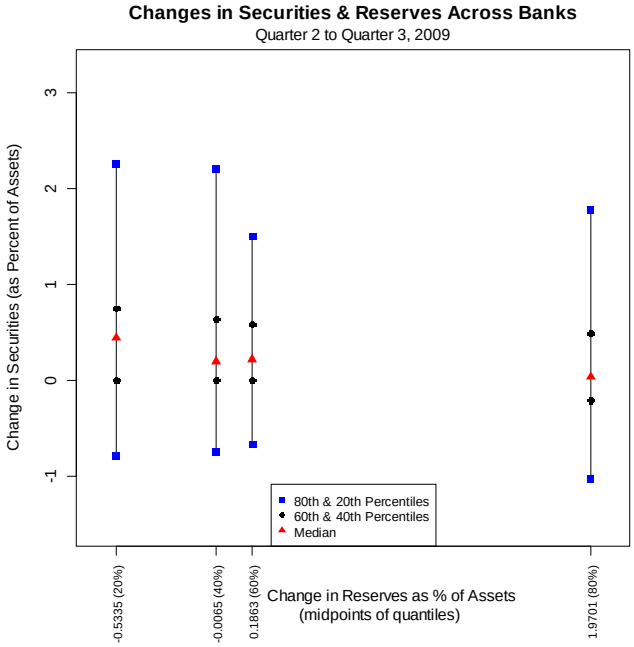

Figure 15

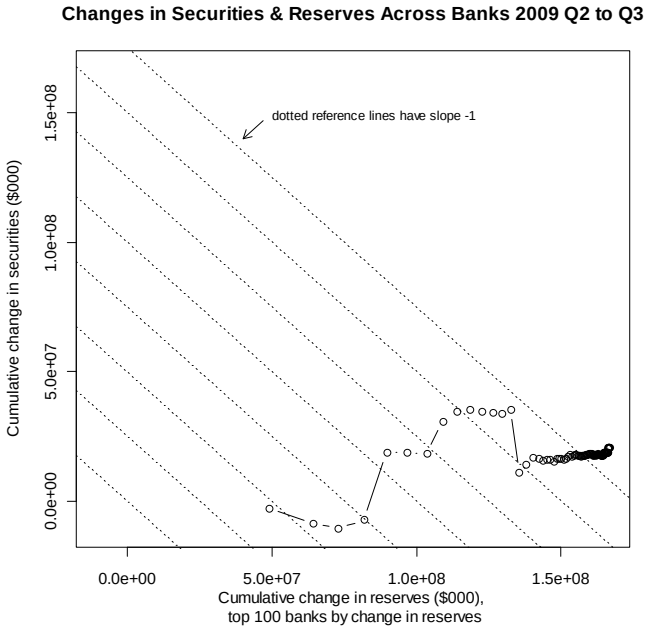

Figure 16

Figure 17 hints at a positive relationship between changes in reserve holdings and in deposits. There is indeed a fairly tight relationship between reserve changes and deposit changes for the 12 banks with the largest increases in reserves (see Figure 18). When we consider the top 100 absorbers of reserves the relationship is weaker than in 2008. In sum, the evidence suggests that private holders reduced their securities positions and increased their bank deposits as a result of the Fed's first round of asset purchases.

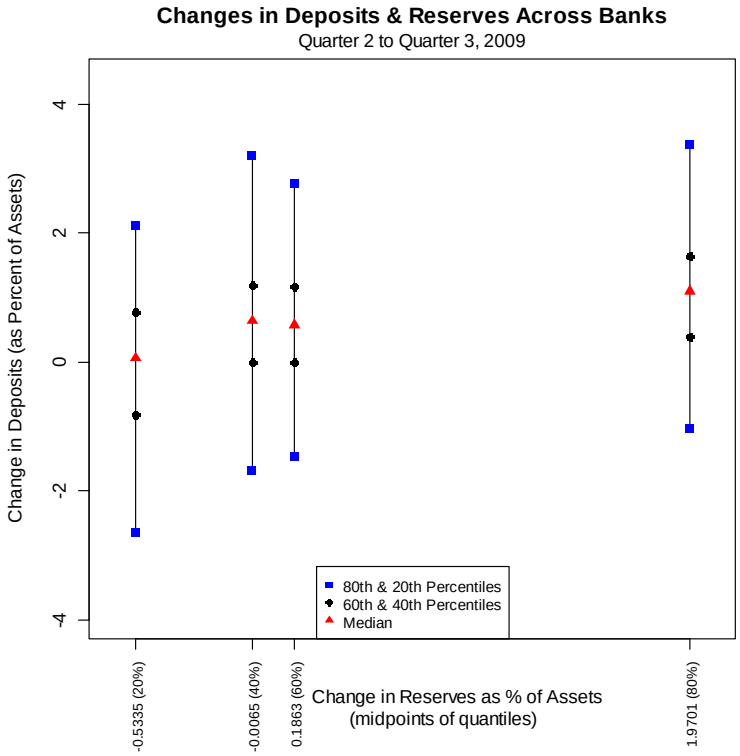

Figure 17

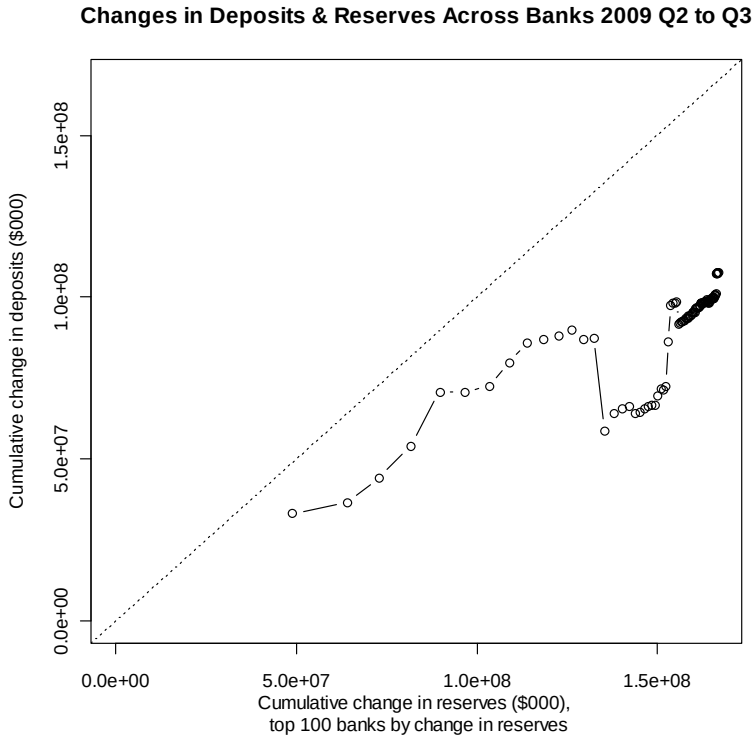

Figure 18

3.4 Gross Flows

Going back to Figure 8, one could alternatively think that the uneven distribution of reserves was the result of a deliberate choice by some banks to accumulate disproportionately large quantities of reserves during the crisis. Under this interpretation, market transactions actually reallocate reserves quite effectively. Figure 19 displays the time series for the change in total reserves, together with the gross flow of reserves, defined as the sum of each institution's absolute change in 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 2008q4 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 (2008q3 and 2008q4). A strained interbank market might have contributed to this situation. Also though, the fact that the lending programs were broadly accessible to banks, and in particular to those banks that wanted to hold reserves, surely implied that reserve flows across banks did not need to be large during this initial period of reserves creation.

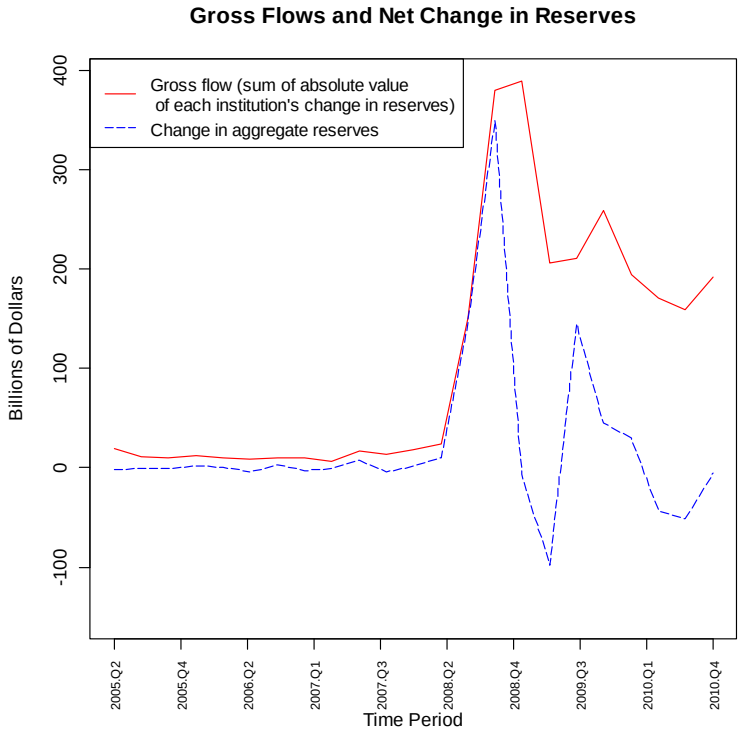

Figure 19

Subsequently, however, the changes in total reserves have generally been small, but the gross flows have remained large (though not nearly as large as in 2008q4). The larger gross flows since 2008 could indicate that higher levels of reserves tend to induce proportionally larger flows. Figure 20 plots gross flows "normalized" by the level of reserves. We can see in the figure that gross flows relative to reserves actually increase significantly during the crisis. In fact, such a change happened even before the large increase in the level of reserves during the third and forth quarter of 2008. Starting in mid 2007 several Fed programs were implemented that tended to redistribute reserves across the system. Also, the Fed sterilized the effects of those programs on 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 are likely to underlie the increase in adjusted gross flows in the second half of 2007shown in Figure 20. Furthermore, note that after the first quarter of 2009, gross flows fell dramatically relative to the stock of reserves, and by mid 2010 they lay well below precrisis levels. In the last two quarters of 2010 there was a moderate increase in gross flows relative to reserves.

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 repo), 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 the intraday frequency. 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 may ensue. Whether the increase in the second half of 2010 represents the leading edge of this phenomenon remains to be seen.

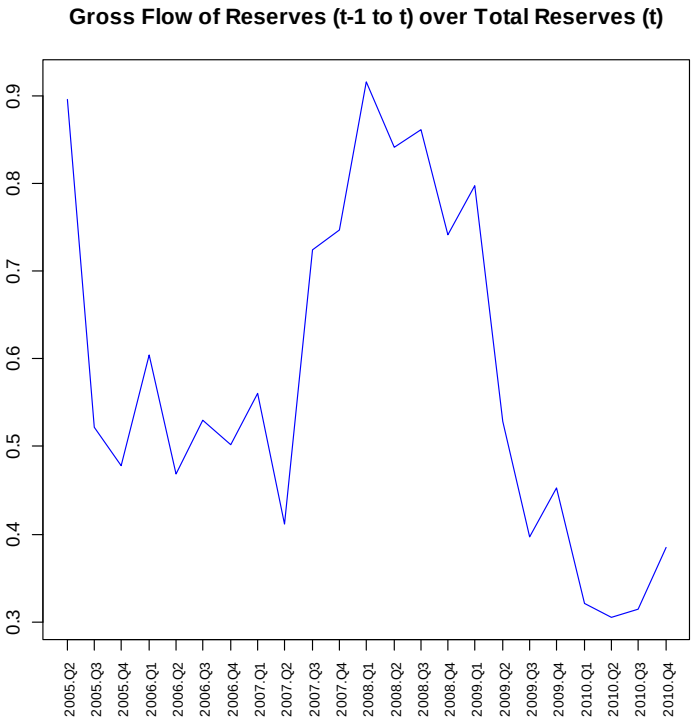

Figure 20

When the banking system functions with low levels of reserves, it is not surprising that reserves move across institutions with high velocity. Reserves are scarce and need to be reallocated to those banks that need them the most. Figure 19 shows that before the crisis roughly half of the reserves change hands from one quarter to the next. When the system functions with high levels of reserves, presumably this pressure for reserves reallocation is weaker. Yet Figure 20 shows that gross flows in 2010 were still over 30 percent of the level of

existing reserves. Contrary to what one might conclude based on the convergence *of distributions* suggested by Figure 9, it is not the case that reserves have reached their final destination after a gradual adjustment period. Keister and McAndrews (2009) emphasize that in the short run banks have no choice but to hold the reserves created by the Fed; Figures 19 and 20 underscore the fact that *an individual bank* can hold whatever level of reserves it wishes, and that, in fact, there are substantial fluctuations in reserve holdings across banks.[28]

3.5 Higher frequency reserve changes

The Call Reports, our basic data source, summarize banks' balance sheet positions at the end of the quarter. Given the nontrivial gross flows presented in Figure 19, it is natural to suspect that individual banks' reserve balances also fluctuate within the quarter, and potentially in a significant manner.

In some of the interpretations we provide in 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).[29] 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 2009q1 and 2010q4, Table 4 displays quintiles based on ascending values of D(i,t)/A for two sub-groups of the top 75 banks by assets: the top 25 and the rest.[30]

[28] This line of reasoning leads to the question, what if all banks attempt to decrease their reserves? In principle they could reduce total deposits, in the process transforming reserves into currency held by the public. Alternatively, banks' attempt to reduce reserve holdings could actually lead to the creation of new deposits and an adjustment of economy-wide rates of return so as to make banks willing to hold the reserves supplied by the Fed.

[29] It is the case that some banks have been able to borrow in the overnight repo market at rates lower than IOR, deposit the proceeds at the Fed and thereby obtain an interest differential. This phenomenon was much discussed in the financial press following an April 1, 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 prominent 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, 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 for funding lending or the purchase of new securities. This reasoning, of course, assumes 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.

[30] The numbers in Table 3 were provided to us exactly as they appear in the Table, by the Statistics Division of the Federal Reserve Bank of Richmond.

Table 4. Percent deviation of average within-quarter reserves from end-of-quarter reserves

2010q4			
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

2009q1			
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

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. Aggregate reserves were 4.1% of assets for the top 75 banks in 2010q4, but there was some significant concentration, as illustrated by the second panel of Figure 6. Table 4 tells us that for the top 25 largest banks the reallocation of assets due to changes in reserves positions within a quarter amounts to less than 2% of assets for all but five cases, and for the 25th to 75th largest banks the reallocation is less than 3% of assets for all but ten cases. It is notable that this reallocation was significantly smaller for the second group in 2009q1, as shown in the bottom panel of the table. In the appendix, we provide a similar table for the changes in reserves from one quarter to the next. These numbers are a useful benchmark to assess information in Table 4. The changes from quarter to quarter in reserves are roughly comparable to those within the quarter. In other words, end-of-quarter adjustments do not appear to undermine the value of our data as being representative of banks' desired reserve position.[31]

A recurrent theme throughout this section, and in the rest of the paper, is the speed at which reserves get reallocated in the system. We have seen that reserves gross flows are nonnegligible and that, while the differences between end-of-quarter and averages are not very large, they are certainly not zero. The speed of reallocation is also an issue when interpreting the Lorenz-type curves in Figures 8 and 9, since the uneven distribution of reserves during the peak of the crisis (as reflected in Figure 8) may reflect either gradual reallocation of reserves or banks reacting differently to the crisis. In the former case the desired distribution of reserves deviates from the actual distribution, whereas

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

in the latter case the desired distribution itself displays the dispersion seen in the data. Similarly, banks (in)ability to quickly reshuffle reserves affects the relationship between the manner in which reserves are introduced and the observed end-of-quarter reserve distribution. We generally take the view that although reallocation of reserves does take place, actual holdings are likely to be influenced by transitional movements and the type of interventions the central bank uses to alter aggregate reserves.

The idea that adjustments to individual banks' balance sheets is likely to take some time is also important for understanding why we believe that a banking system holding a large quantity of reserves will be able to react more rapidly to improvements in general economic conditions. If banks are not holding the necessary liquidity to finance new loans, it may take them a few weeks (or even months) to arrange the appropriate funding sources to back the long-term loans. But when banks are "sitting" on a large stock of reserves, funding is no longer an issue, and hence loans can be made more promptly.

4 Reserves as a form of liquidity

To the extent that interest-bearing reserves are now a perfect substitute for short-term low-risk securities, we would expect that the increase in aggregate reserves brought about by the Fed was eventually offset by a reduction in banks' holdings of short-term low-risk securities. We say eventually, because in the fall of 2008 there was clearly a shock to the demand for liquid assets. The point here is that if reserves are a perfect substitute for other liquid assets, then it may not be interesting to look at reserves in isolation – doing so would be akin to studying the behavior of $20 bills instead of total currency outstanding.

Figure 21 displays the time series for a measure of aggregate liquidity (reserves + other cash + short-term securities) held by banks. We view this measure as a reasonable proxy for low-risk assets on a bank'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. The initial increase in liquidity corresponds to a period (fall 2008) where there was a large increase in the demand for liquid assets. Thus, not much can be inferred from the initial increase in the quantity. However, in subsequent quarters financial market conditions normalized, and the quantity of liquid assets remained high. We interpret Figure 21 as showing that once financial conditions normalized, banks did not substitute reserves for other forms of liquid assets.

At the level of individual banks, we again do not find that there was meaningful substitution of reserves for other liquid assets. There is a strong positive correlation across banks between changes in reserves and changes in the liquid asset measure used in Figure 21 – this holds for all periods in the sample. Table 5 shows that from 2008q2 to 2010q2, banks with a greater increase in reserves also tended to have higher increases in liquidity, although there was also a larger coefficient of variation for change in liquidity among the banks with the largest increases in reserves.

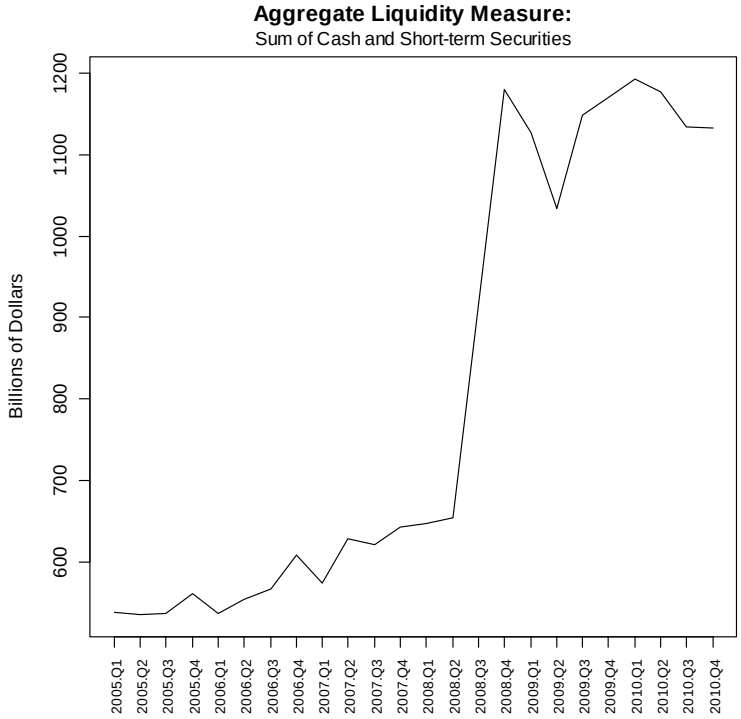

Figure 21

Table 5. Changes in Liquidity and Reserves from 2008Q2 to 2010Q2

	Change in liquidity ($000)		
Quintiles of change in reserves	mean	variance	CV
1	-14822	5.43×10^{10}	-3.66×10^{6}
2	6104	2.15×10^{9}	3.52×10^{5}
3	18511	3.70×10^{9}	2.0×10^{5}
4	37415	6.63×10^{9}	1.77×10^{5}
5	1.49×10^{6}	7.1885×10^{13}	4.81×10^{7}

It is clear then that banks increased their overall level of liquidity, and did not simply substitute reserves for other liquid assets. Even with historically normal levels of reserves, the high level of liquidity would represent an increased ability to quickly react to changes in economic activity. And reserves represent the most liquid of assets, amplifying this ability to react.

5 Reserves and capital across banks

We have established that banks did not simply use reserves to substitute for other liquid assets on their balance sheets. In other words, banks are currently holding high levels of liquidity. Our working hypothesis is that banks holding liquidity are in a better position to fund new loans or securities purchases when profitable opportunities arise. While attracting new depositors may take time and resources, liquidity that is already on the balance sheet can immediately be used for funding higher-return assets. From this perspective, it is also natural to expect that reserves will be the "first out the door" source of funding; in the ranking of liquid assets, reserves are effectively at the top.

In principle, then, 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 if its level of capital is not sufficiently high (see, for example, Van den Heuvel, 2002).

In light of these considerations, it is important to assess the extent to which banks hold capital that would allow them to "convert" excess reserves into loans or other risky assets. It is a well-known empirical regularity that smaller U.S. banks tend to hold higher capital ratios. As a first pass at the data, we therefore look at only the 75 largest banks by assets. Within this group there is no systematic, long standing relationship between size and capital. Figure 22 plots the risk-based capital ratio on the horizontal axis and the ratio of reserves to assets on the vertical axis for this sub-sample of large banks in the fourth quarter of 2010. The figure shows that not all banks holding high reserves tend to be poorly capitalized, and that in fact there are many large banks with both high levels of reserves and high capital ratios.[32]

Based on the figure alone, it is difficult to quantify banks' immediate ability to expand lending, as implied by their reserve holdings and capital ratios. While binding capital requirements are likely to limit the ability of certain banks to transform reserves into loans, Figure 22 suggests that several banks can indeed lend out their reserves without facing a capital constraint. To get a sense of how prevalent this situation is, we compute below an aggregate measure of loanable reserves that adjusts for the fact that each bank's new lending has to be consistent with satisfying its capital requirement.

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

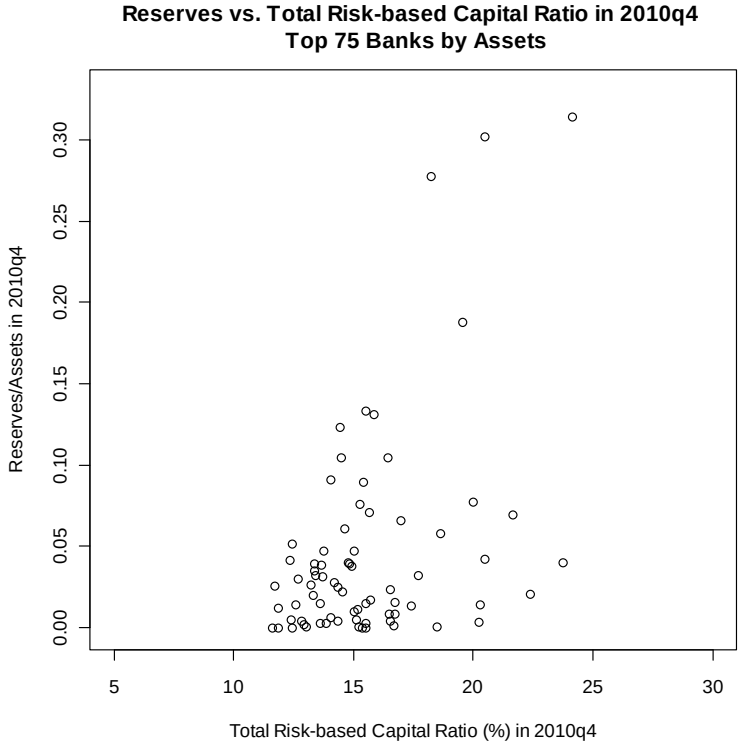

Figure 22

5.1 Total loanable reserves

Capital requirements in the US 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.[33] 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

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

over risk-adjusted assets.[34] As with tier 1 capital, a bank with a relatively low total capital ratio (such that approaching the regulatory minimum becomes a concern), will tend to limit its expansion of credit, even when funding could be readily provided with the holdings of excess reserves.

In summary, some of the potential lending capacity associated with holding excess reserves should be "discounted" to the extent that those reserves are being held by banks with (effectively) binding capital constraints. Determining at what levels of capital ratios the requirements become effectively binding is, of course, a difficult task. 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 each bank's lending capacity is 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% and a total capital ratio higher than 10%. Using this criterion, we compute for each quarter in our data set the following measure of loanable reserves for all insured banks in the sample:

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

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%. 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%. 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.

It is clear now that capital ratios are going to increase in the near future, especially for large banks. For this reason, we also compute a more conservative measure of loanable reserves for the last quarter in our dataset, 2010q4. To compute this alternative measure, we based our estimates on the Basel III proposal and fix the tier 1 capital ratio to 8.5% and the total capital ratio at 10.5%. We use these ratios for all but the top 25 banks. For the larger banks (the top 25 by assets) we increase the tier 1 capital ratio to 10.5% and the total capital ratio to 12.5%. There is still significant uncertainty with respect to the capital requirements that will be imposed on large banks in the U.S. We use these ratios as a way to obtain a relatively conservative measure of loanable reserves.

Figure 23 plots our measure of loanable reserves $LR(t)$ together with total (excess) reserves $ER(t)$ across time, where:

$$ER(t) = \sum_i \left[R_i(t) - R_{iR}(t)\right]^+.$$

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

The figure shows that in the fourth quarter of 2010 about 96% of reserves could be converted into loans without pulling banks into poorly-capitalized territory.

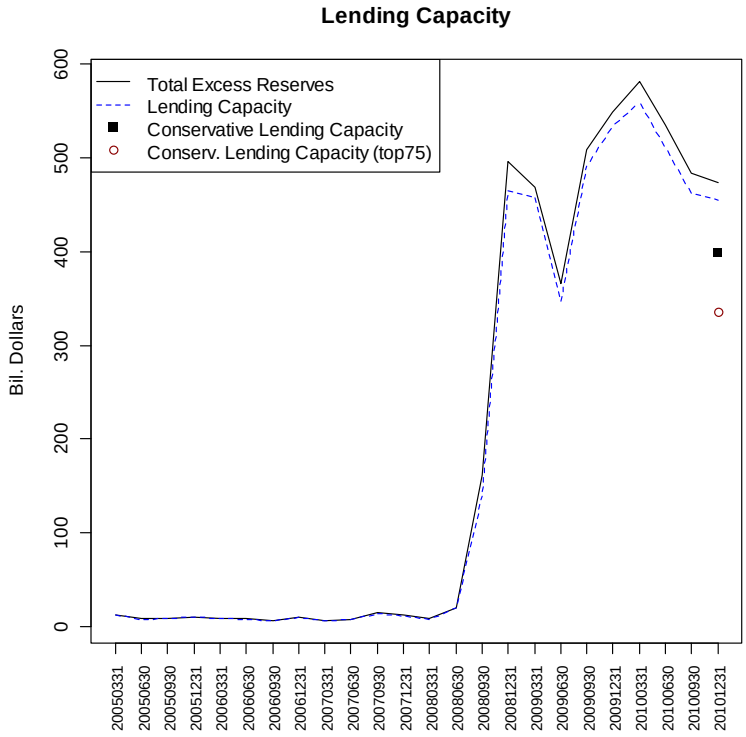

Figure 23

We also indicate with an (isolated) black square in Figure 23 the value of our more conservative measure of loanable reserves for the fourth quarter of 2010. Even when we use extremely high capital requirements (by historical standards) the total amount of loanable reserves is still around $400 billion, more than 80% of the total excess reserves available in insured banks.

Figure 24 plots the conservative measure of loanable reserves for the top 75 banks by asset size in the fourth quarter of 2010 (large open circles) and the actual excess reserves held by each of those banks (small solid circles). We can see from the figure that several banks are capital constrained but the majority of them are not. Furthermore, it is clear from the figure that capital constraints do not reduce the loanable reserves of the top 75 banks to levels that would preclude a large (and potentially sudden) increase in bank credit. Finally, the isolated (open) circle in Figure 23 aggregates the lending capacity of these 75 largest banks and it accounts for about 70% of the total excess reserves held by insured banks.

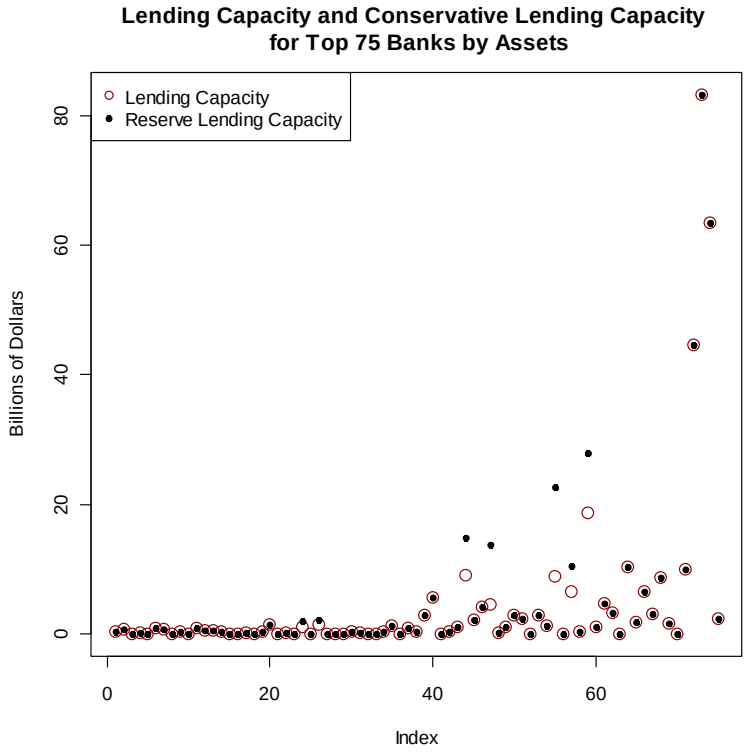

Figure 24

Of course, the kind of massive aggregate shifts we are considering here could not occur without triggering some major price and interest rate adjustment. Tracking the effects of such a move would require a more structural study of the equilibrium forces driving this movement. The point of the figure is to show that there is a large amount of reserves that could potentially be used to fund new bank credit. Understanding what factors could induce banks to attempt such a transformation is clearly important for monetary policy considerations. Below we investigate the characteristics of banks holding reserves as a first step in gaining such an understanding.

One caveat to the calculations provided here is that by limiting our analysis to Call Report data we consider capital holdings only at the level of the bank subsidiaries in a bank holding company. We do not include the level of capital at the bank holding company, which of course is a relevant factor for determining the ability of a given bank subsidiary to increase its supply of credit. The parent company can always increase capital in the subsidiary if lending opportunities are attractive enough and if the company has access to liquidity that can be quickly transformed into capital for the subsidiary. Our working hypothesis is that if a bank subsidiary is not well-capitalized then the parent company is unlikely to have ready access to liquidity that could be used to increase capital at

the subsidiary when lending opportunities arrive. For this reason, then, we have decided to only consider as loanable reserves those reserves in well-capitalized bank subsidiaries.

5.2 Balance sheet capacity

So far we have considered the extent to which excess reserve holdings by banks truly constitute readily available lending capacity. An alternative perspective on the remarkable increase in the stock of reserves is that those reserves could put pressure on the balance sheet capacity of banks. Reserves must be held by banks. 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 the banks' leverage ratio. 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.

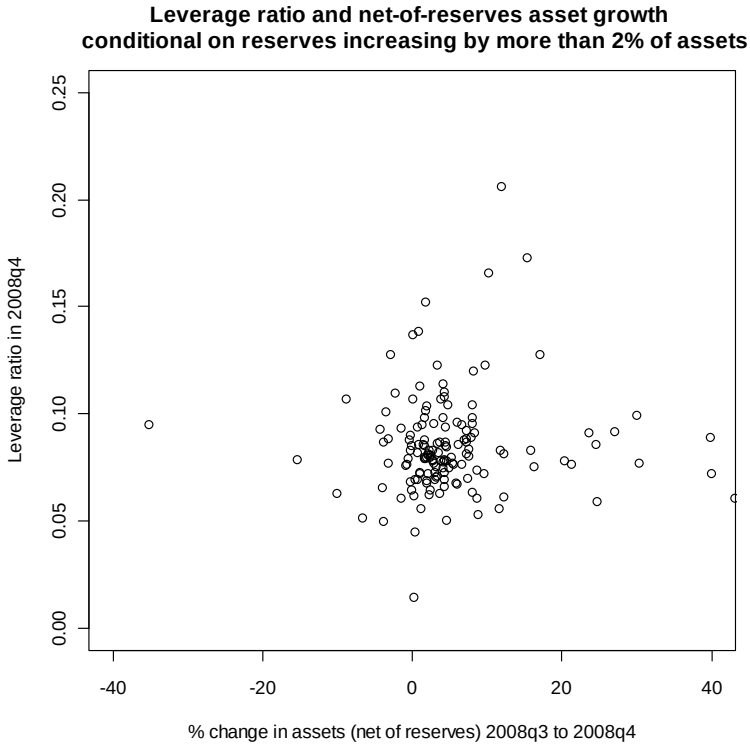

Figure 25

To get a sense of how operative this channel was at the end of 2008, when reserves were increasing rapidly, in Figure 25 we plot the leverage ratio (on the

vertical axis) against the changes in assets net of reserves for a subsample of banks. The banks we include in the subsample are those large banks (with more than $500 million in total assets in 2008q3) that experience a change in reserves between 2008q3 and q4 greater than 2% of assets (that is, banks with significant increases in reserve holdings).[35] The idea behind the picture is that if adding reserves was contractionary, then banks that increased their reserve holdings significantly and had a low leverage ratio would have decreased their assets net of reserves. In other words, the cross section presented in the figure would show a positive relationship. There is in fact little evidence of such a relationship. We conclude that reserves did not systematically absorb scarce balance sheet capacity and, hence, crowd out other kinds of banking assets, such us loans.

6 Reserves and interest income across banks

Over the more than two years that the Fed has been paying interest of 25 basis points (bps) on reserves, the economy has only slowly begun to recover from the great recession, and judging by the quantity of lending, banks on average are not seeing good lending opportunities. In the longer run however, the recovery will likely persist, and banks will expand their lending as opportunities arise. If the Fed wishes to maintain a large quantity of reserves, then an appropriate interest rate policy will require the Fed to raise the interest rate it pays on reserves. A constant IOR and large reserves in the face of a booming economy would give banks an incentive to replace reserves with higher yielding assets. In this section we investigate the cross-sectional evidence on how banks' reserve holdings relate to their interest income. The cross-sectional relationship may be useful for understanding the aggregate consequences of holding IOR fixed as lending opportunities proliferate.

Prior to autumn of 2008, reserves yielded minimal interest. Thus, banks held reserves only to meet reserve requirements and to be able to satisfy their customers' demands for funds. As has been discussed, reserves also are liquid assets that enable a bank to rapidly change the composition of its balance sheet, minimizing transaction costs that are presumably low but nonzero. Furthermore, reserves are a truly risk-free nominal asset when held overnight, whereas liquid short-term securities, such as Treasury bills (Tbills), contain some price risk unless they mature the next day. The fact that excess reserve holdings were so low prior to autumn 2008 suggests that these benefits of holding reserves were not sufficient to compensate for the unfavorable rate of return differential. In other words, the interest rate spread between liquid assets (such as Tbills) and reserves was evidently high enough that banks preferred to meet their liquidity needs primarily with short-term interest-bearing securities.

By the end of 2008, when the Fed was paying interest on reserves at 25 bps and had stopped narrowly targeting the Fed Funds Rate, a bank's decision about reserve holdings changed quite dramatically. Since the end of 2008 the

[35] To account for outliers, we also eliminate all banks that had an increase in total assets greater than 50% between the third and fourth quarter of 2008.

3-month Tbill rate has been below 25 basis points the majority of the time. For a bank choosing how to allocate its liquid assets, there is now good reason to prefer reserves yielding 25bps to a T-bill.

Tbill rates represent one element of the opportunity cost of holding reserves for any bank. However, the rate of return on loans is also an element of that opportunity cost, and banks face heterogeneous rates of return on loans. For a bank attempting to maximize profits, it would not make sense to hold large excess reserves if higher rate-of-return assets were available. In the cross section of banks, this behavior should manifest itself in a negative relationship between excess reserves as a fraction of assets and the marginal rate of return on assets.

To approximate the marginal rate of return on a bank's assets we calculate each institution's ratio of total interest income to assets. This is an imperfect measure, but we will proceed under the assumption that it is informative about marginal returns. Because interest income has a strong seasonal component, when reporting interest income over assets we use a four-quarter moving average.

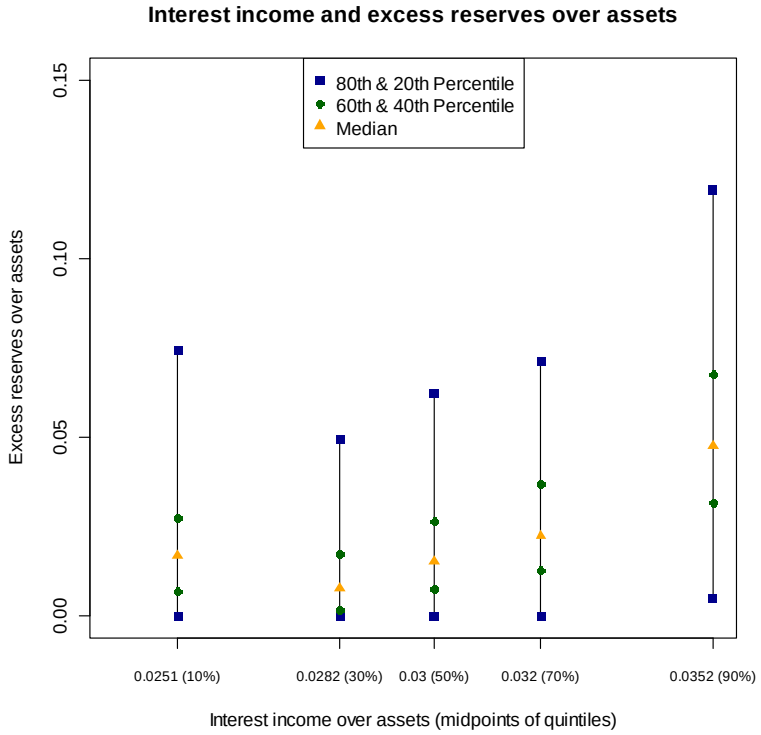

Figure 26

Figure 26 summarizes the conditional distribution of reserves over assets for the quintiles of interest income over assets for 2010q4.[36] Measured by median

[36] Unlike the earlier figures with change in reserves on the horizontal axis, Figure 26 splits

reserves over assets, or by the 40th to 60th percentile range, the relationship between reserves and interest income is u-shaped: the lowest interest income quantile has relatively high reserves, but reserves are increasing from the second through the fifth quintiles. While the positive relationship for the top quintiles is, perhaps, surprising, it is important to note that the interest income quintiles do not represent equal shares of assets or reserves. Approximately 75 percent of assets and 70 percent of reserves are held by institutions in the first two quintiles of interest income, and over this range there is evidence of a negative relationship between reserve holdings and interest on assets. Figure 27 presents a scatter plot of the reserves over assets and interest income over assets for the top 75 banks by asset size. There is a fairly strong negative correlation between these two variables, equal to -0.3 (among all institutions the correlation is only -0.09).

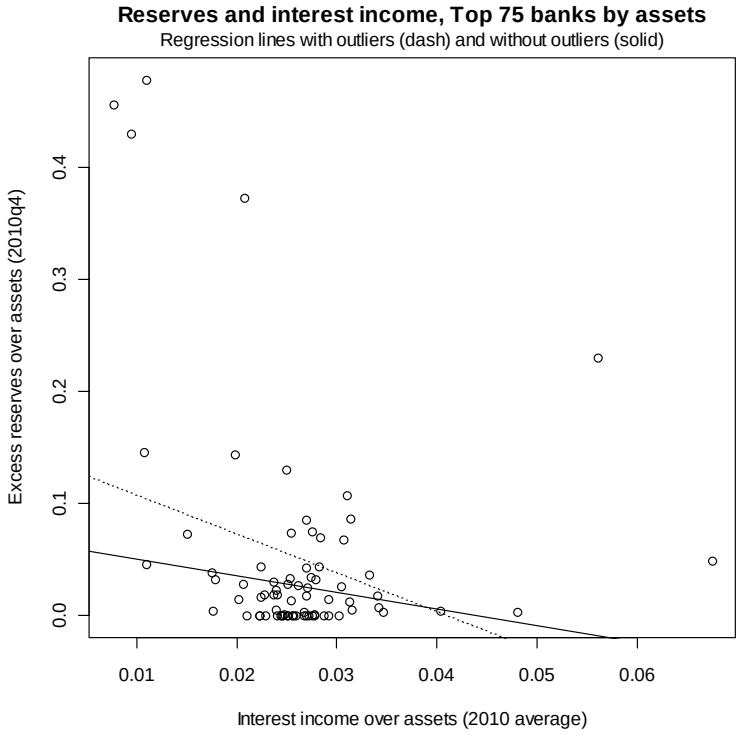

Figure 27

If there is some evidence that reserve holdings are currently concentrated in banks with low returns, have reserves been moving to such banks over time? Figure 28 plots two measures of the aggregate ratio of interest income to assets

the data into standard quintiles (e.g. - 0-20 instead of the earlier figures' 10-30, etc.).

in our sample of insured institutions. The dashed line is the aggregate ratio of interest income to assets (adjusting for reserves and interest on reserves), or equivalently a weighted average of interest income over assets, where the weights are the institutions' asset shares. The solid line is an alternative weighted average, where the weights are excess reserve shares. If the solid line is below the dashed line – as it is from 2008 onward, then reserves are held disproportionately by institutions with a low ratio of interest income to assets. Additionally, a widening spread over time between the two lines indicates that reserves are being reallocated to institutions with low interest income. From mid-2008 until mid-2009 the spread indeed widened. Late in 2009 the reserve-weighted series was extremely volatile. This seems to be associated with one large institution, Ally Bank, which increased its reserve ratio dramatically in the third quarter of 2009. In the last two quarters reserves have again shifted toward institutions with lower interest income.

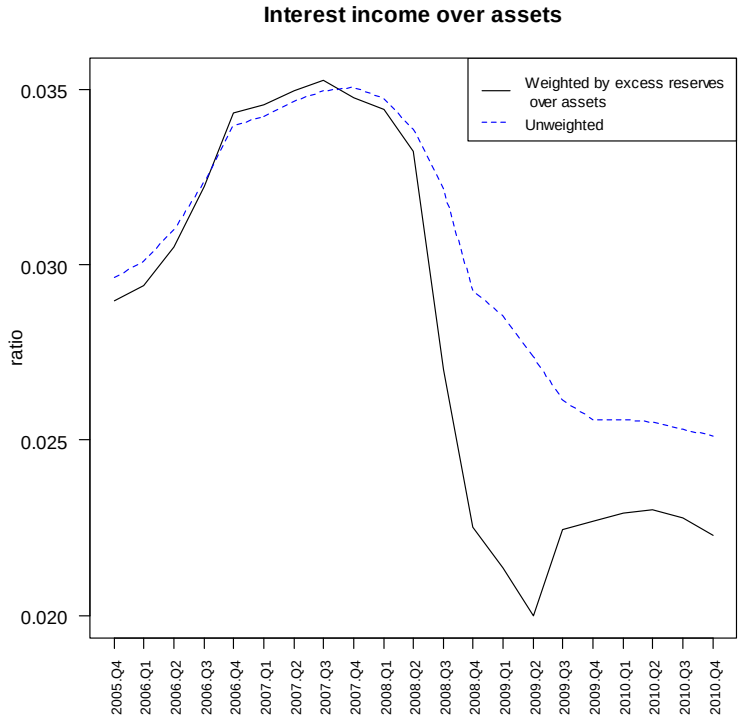

Figure 28

IOR has been fixed for more than two years, and as can be seen from Figure 28, banks' interest income has stabilized following the steep decline in the great recession. At some point in the future it is likely that rates of return in the economy will rise, and banks' ratio of interest income to assets will also rise

toward more "normal" levels. As Figures 26-28 show, reserves display some sensitivity to interest income, which suggests that banks facing higher rates of return will attempt to lower their holding of reserves, all else equal. If reserves were to remain relatively stable and IOR were to remain at 25bps, then banks would make loans or increase security holdings so as to align marginal rates of return with the level of IOR.

7 Reserves and other bank characteristics

It is clear that there is significant heterogeneity among banks with regard to their reserve holdings. There is also heterogeneity among banks' observable characteristics though, so it is natural to ask whether those observable characteristics can explain reserve holdings. The bivariate relationships discussed in the previous sections go some way towards addressing that question, but they are limited by their bivariate nature. To the extent that we can explain reserve holdings with a multivariate regression, the nature of that explanation may be a useful element in understanding how a monetary policy scenario of falling behind the curve might play out. And in turn, by better understanding what it would mean to fall behind the curve, we will be better equipped to avoid it. To that end, we report two regressions of the ratio of reserves to assets in 2010q4 on a number of other Call Report variables. One regression is unweighted, so that the many small banks play a dominant role in the parameter estimates. The other regression uses weighted least squares, with the weights given by bank assets, so that the largest banks play the dominant role. Judgement calls had to be made in choosing explanatory variables, because there are hundreds of variables in the Call Report, and we are not being guided here by a formal theoretical model.

For the most part, the variables included in the regression are variables that have appeared earlier in the paper. Interest income over assets appears because of our conjecture –weakly supported in the bivariate analysis– that banks earning high interest income will choose to hold low reserves.[37] We include loans relative to assets in the regression because this as an important dimension of heterogeneity among banks; our prior is that banks which specialize in making loans will tend to hold a higher level of reserves.[38] We also expect a positive association between deposits and reserves because servicing deposits requires holding liquidity (Kashyap et. al., 2002). Trading assets are held by a relatively small fraction of institutions; we include them as a way of controlling for different types of institutions. The change in deposits relative to assets over the most recent quarter (variable 7) appears so that we can check the conjecture that if a bank receives a large deposit inflow it simply increases reserve holdings because of the lack of attractive alternatives. Leverage and capital ratios have been

[37] As above, interest income over assets is averaged over the four quarters of 2010.

[38] Note that there is a negative mechanical balance sheet relationship between current loans over assets and current reserves over assets. To mitigate this effect, we measure loans to assets as the four quarter average over the four quarters of 2008.

discussed above: a low leverage ratio may mean that a bank has little balance sheet capacity to take on reserves, although we did not find evidence that this factor led to banks shedding assets in order to increase reserve holdings. Banks with low tier 1 capital ratios may wish to increase their reserve holdings in order to raise their tier 1 capital ratios. Holding fixed the leverage ratio however, the fact that reserves have zero risk weight induces a positive relationship between reserves and tier 1 capital. Variables 10 and 11 allow for the possibility that the size of an institution has an independent effect on its reserve holdings. Log(assets) is a pure size effect. The next variable is the tier 1 capital ratio only for those banks with assets greater than $50 billion.[39] This asset-size cutoff is meant to single out institutions that are "systemically important" and may be required to hold higher capital levels once the new regulatory environment has been clarified. Finally, the 2008q2 level of reserves to assets can be thought of as a fixed effect: in 2008q2 the level of reserves was very low, but it may be that banks increased their reserves in proportion to the aggregate increase in reserves.

Table 7. Regression of Level of Reserves/Assets in 2010q4

		unweighted			weighted by assets		
	Coefficient on	Estimate	t	sig.	Est.	t	sig.
1	Intercept	0.045	1.462		−0.125	−7.987	***
2	Int. Income/Assets	−8.874	−6.095	***	1.713	2.588	**
3	(Int.Income/Assets)^2	168.541	7.208	***	−22.07	−2.107	*
4	Loans/Assets	0.021	2.107	*	−0.059	−5.943	***
5	Deposits/Assets	0.074	4.672	***	0.146	11.700	***
6	Trading Assets/Assets	0.229	2.135	*	−0.179	−11.987	***
7	(ΔDeposits)/Assets	0.031	1.206		0.030	1.115	
8	Leverage Ratio	−0.420	−5.897	***	−0.245	−3.742	***
9	Tier 1 Capital Ratio	0.186	4.815	***	0.129	3.593	***
10	Log(assets)	0.003	2.825	**	0.004	9.659	***
11	(T.1.C.R.)×I$_{(Assets>\$50bn)}$	−0.185	−2.352	*	–	–	-
12	(Reserves/Assets)$_{2008Q2}$	0.852	4.795	***	3.243	16.001	***
	Adjusted R^2	0.091			0.344		

In discussing the results, we begin with the explanatory variables that appear with the same sign coefficients in both the unweighted and weighted regressions. As we expected, the ratio of deposits to assets has a positive coefficient, and the coefficient is large and highly significant. The coefficient on deposit growth is positive, but small and barely significant. The leverage ratio and the tier 1 capital show up with opposite signs, the former being negative. That the coefficient on tier 1 capital is positive may simply reflect the mechanical effect described above – reserves have zero risk weight and thus correspond to a higher

[39] We omit this variable from the weighted regression because the regression already overweights those institutions.

tier 1 ratio for given leverage. The negative coefficient on the leverage ratio suggests that in a static sense, banks holding high reserves may be balance-sheet constrained from making loans. On the other hand, given our earlier finding that increases in reserves did not correspond to reductions in other assets, a more reasonable interpretation of the negative coefficient may be that poorly capitalized banks choose to hold high reserves in order to reduce their riskiness as much as possible. Asset size has a small but positive coefficient, implying that a doubling of assets corresponds to a 0.3% or 0.4% increase in reserves over assets. Finally, the pre-crisis ratio of reserves to assets – from 2008q2 which predates the increase in reserves – has a positive coefficient that is large and highly significant in both regressions, but roughly four times as large in the weighted regression as in the unweighted regression. One might think that pre-crisis reserves are simply reflecting pre-crisis demand deposits which are highly correlated with current deposits. The first part of this conjecture is certainly true, as banks generally did not hold excess reserves when i.o.r. was zero. However, the partial correlation between pre-crisis reserves and current demand deposits is low (0.17).

As for the variables whose coefficients change signs in the weighted and unweighted regressions, the most notable is perhaps interest income over assets. We allowed for a quadratic in this variable because the bivariate relationship in Figure 26 appeared quadratic. In the unweighted regression the estimated relationship is convex, as suggested by Figure 26. In the weighted regression the relationship is concave. When we evaluate the marginal effect of interest income on reserves (combining the linear and the squared terms), that effect is positive at the mean interest income for both regressions. Loans and trading assets come in negative and significant in the weighted regression and positive and marginally significant in the unweighted regression. The significance of loans may simply reflect the mechanical balance sheet relationship (as one asset's share rises another must fall). The negative coefficient on trading assets suggests that banks that specialize in trading are willing to hold riskier securities rather than reserves.

8 Conclusion

We started this paper by providing a rationale for policy concerns about the large quantities of excess reserves with which the U.S. banking system is currently operating. The logic requires that banks holding reserves are able to increase lending or securities purchases relatively fast if economic conditions improve. In particular, banks need to have enough extra capital to continue to comply with requirements after undertaking these actions. Furthermore, the new opportunities should be available to banks with excess lending capacity, which is more likely to happen if that capacity is not all concentrated on the balance sheet of a few institutions. Whether these conditions are present in the current system is an empirical question.

To try to answer this question, we analyze balance sheet data from the

Call Report filings that banks submit to regulatory agencies on a quarterly basis. There are thousands of banking institutions in the U.S. and they tend to be very heterogeneous. Not surprisingly, then, broad generalizations are hard to come by. However, we do find that a large proportion of reserves is on the balance sheets of banks with sufficient slack in their capital position to (quickly) generate massive increases in lending. This has been the case, in fact, for most of the period when aggregate reserves have been high. We also find some evidence that large banks with high interest income tend to hold relatively less reserves, which may suggest that if interest income were to improve (as would be expected if economic conditions improve) then banks would try to reduce their reserves holdings.

Aside from these basic findings, we provide an overview of the evolution of banks' balance sheets from a cross sectional perspective, for the period since total reserves increased significantly (i.e., since the peak of the recent financial crisis). It is hard to provide a single explanation for how banks accommodated the increase in reserves, but we identify and explore a few possible alternatives. We also address some views that are often put forth in discussions of how banks behaved in response to the increase in reserves. We show that providing unequivocal evidence for these views is no easy task. In other words, the evidence is at best mixed and sometimes completely absent.

We see the research provided in this paper as an initial empirical inquiry into a situation that is radically new for the U.S. banking system. As we have discussed, the fact that banks are holding large quantities of excess reserves raises new and potentially important questions for policymakers. While we provide a first step in the search for answers to those questions, more research is clearly needed.

References

[1] Ashcraft, Adam, Morten L. Bech, and W. Scott Frame. 2010. "The Federal Home Loan Bank System: The Lender of Next-to-Last Resort?". *Journal of Money, Credit and Banking* 42 (4), pp. 551-583.

[2] Bech, Morten L. and Elizabeth Klee. 2009. "The Mechanics of a Graceful Exit: Interest on reserves and segmentation in the federal funds market." Federal Reserve Bank of New York Staff Report no. 416 (December).

[3] Bernanke, Ben. 2010. "What the Fed did and why: supporting the recovery and sustaining price stability." *Washington Post* Op-ed. November 4, 2010.

[4] D'Amico Stefania and Thomas B. King. 2010. "Flow and Stock Effects of Large-Scale Treasury Purchases." Finance and Economics Discussion Series. Federal Reserve Board.

[5] Dudley, William. 2009. "The Economic Outlook and the Fed's Balance Sheet: The Issue of 'How' versus 'When'" Speech, July 29. http://www.newyorkfed.org/newsevents/speeches/2009/dud090729.html

[6] Dudley, William. 2011. Speech, February 2011. "Prospects for the Economy and Monetary Policy." Speech, February 28. http://www.newyorkfed.org/newsevents/speeches/2011/dud110228.html.

[7] Ennis, Huberto M. and Alexander L. Wolman. 2010. "Excess Reserves and the New Challenges for Monetary Policy." Federal Reserve Bank of Richmond *Economic Brief*, March.

[8] Fleming, Michael J. and Nicholas J. Klagge. 2010. "The Federal Reserve's Foreign Exchange Swap Lines." Federal Reserve Bank of New York *Current Issues in Economics and Finance* 16 (4). April.

[9] Gagnon, Joseph, Matthew Raskin, Julie Remache and Brian Sack. 2011. "The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases." *International Journal of Central Banking*. 7 (1), pp. 3-43.

[10] Gertler, Mark and Nobuhiro Kiyotaki. 2011. "Financial Intermediation and Credit Policy in Business Cycle Analysis." in Friedman, Benjamin M. and Michael Woodford eds., *Handbook of Monetary Economics*, Volume 3A. Elsevier. 547-599.

[11] Goldberg, Linda S., Craig Kennedy, and Jason Miu. 2010. "Central Bank Dollar Swap Lines and Overseas Dollar Funding Costs." Federal Reserve Bank of New York Staff Reports, no. 429, January.

[12] Hall, Robert and Susan Woodward. 2009. "The Fed Needs to Make a Policy Statement." http://woodwardhall.wordpress.com/2009/04/13/the-fed-needs-to-make-a-policy-statement/

[13] Hamilton, James D. and Jing Cynthia Wu. 2010. "The Effects of Alternative Monetary Policy Tools in a Zero-bound Environment." http://dss.ucsd.edu/~jhamilto/zlb.pdf.

[14] Kashyap, Anil K., Raghuram Rajan, and Jeremy C. Stein. 2002. "Banks as Liquidity Providers: An Explanation for the Coexistence of Lending and Deposit-Taking." *Journal of Finance* 57 (1), February.

[15] Keister, Todd and Jamie McAndrews. 2009. "Why Are Banks Holding So Many Excess Reserves?" New York Fed *Current Issues in Economics and Finance* 15 (8). December.

[16] Krishnamurthy, Arvind and Annette Vissing-Jorgensen. 2010. "The Effects of Quantitative Easing on Interest Rates." http://www.kellogg.northwestern.edu/faculty/vissing/htm/qe_paper.pdf.

[17] Levin, Andrew and John Taylor. 2009. "Falling Behind the Curve: A Positive Analysis of Stop-Start Monetary Policies and the Great Inflation." Manuscript.

[18] Plosser, Charles. 2009. "Monetary Policy and the Wisdom of Wayne Gretzky." Speech, December 1. http://www.philadelphiafed.org/publications/speeches/plosser/2009/12-01-09_rochester-economic-seminar.cfm

[19] Plosser, Charles. 2011. "Exit." Speech, March 25. http://www.philadelphiafed.org/publications/speeches/plosser/2011/03-25-11_shadow-open-market-committee.cfm

[20] Van den Heuvel, Skander J. 2002. "Does Bank Capital Matter for Monetary Transmission?" Federal Reserve Bank of New York *Economic Policy Review*, vol. 8 (1), pp. 259-265. May.

9 Appendix: Other tables and figures

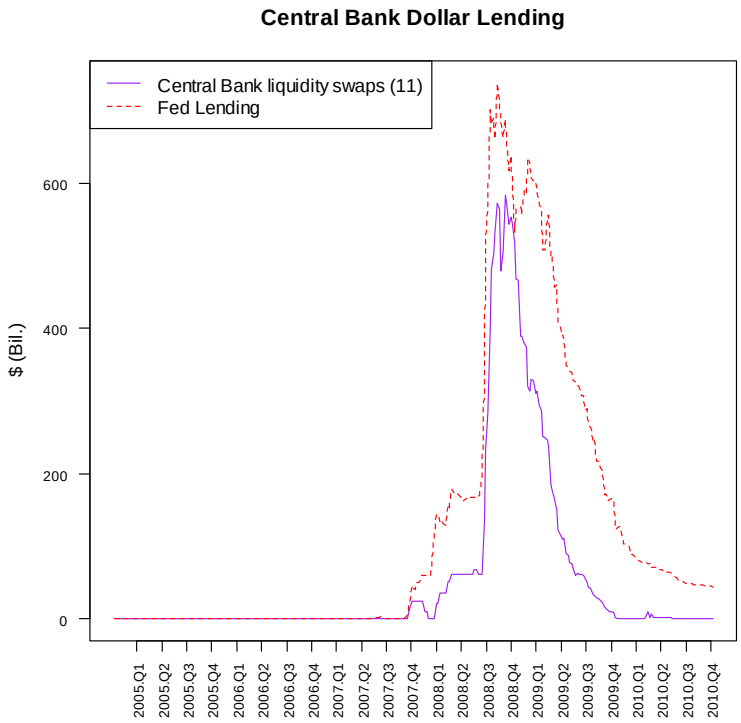

Figure A1

Table A.1. 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