

Monetary Policy and the Financial Crisis of 2007-2008

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*This essay was written while the author was the Barbara and Richard M. Rosenberg Professor of Global Finance, Brandeis International Business School; and a Research Associate, National Bureau of Economic Research. Note that as this draft was written, events were continuing to unfold. Hopefully, what I have written in February and March 2008 remains accurate. Among the vast number of people I spoke with in preparing this essay, I would especially like to thank Peter Fisher, Jens Hilscher, Spence Hilton, Anil Kashyap, Kim Schoenholtz, Jeremy Stein and Paul Tucker for their insights and comments. All errors are my own. All links in this document worked on 3 April 2008.

I. Introduction

Central bankers are conservative people. They take great care in implementing policy; they speak precisely; they explain changes completely; and they study the environment trying to pinpoint where the next disaster looms. Good monetary policy is marked by its predictability. But when the world changes around them, policymakers change with it. If a crisis hits and the tools at hand are not up to the job, then central bank officials can and will improvise. In August 2007, the world changed and the traditional instruments of monetary policy were not up to the task.

For some time now, there has been a consensus among monetary economists on the fundamentals of policy design. These agreed upon principles of best practice extend from central bank design to operational policy. They include the belief that central banks should be independent, but have clearly defined policy objectives for which they are held accountable; policymakers' operational instrument should be an interest rate; and officials need to be transparent and clear in communicating what they are doing and why they are doing it. Furthermore, there is agreement that the central bank is the right institution to monitor and protect the stability of the financial system as a whole.¹

An important part of the consensus has been that central banks should provide short-term liquidity to solvent financial institutions that are in need. But, as events in 2007 and 2008 show, not all liquidity is created equal. And critically, the consensus model used by monetary economists to understand central bank policy offers no immediate way to organize thinking about this sort of problem.²

This paper provides an account of the financial crisis that began on 9 August 2007 and continued into 2008. It is the story of how the crisis came about and how the Federal Reserve worked to contain the damage. To understand what has happened, I will start with financial developments that led up to the crisis. Section II describes some of the most relevant recent innovations in the financial system and their impact on residential mortgage lending, the focus of the early stages of the crisis. A full appreciation of the Fed's response requires an understanding of how the traditional tools of monetary policy work. This is the task of section III. Section IV describes the nature of the crisis, describing the symptoms and speculating about the causes.

Finally in Section V we get to the monetary policy responses. Because of the specific nature of the financial distress, it became clear during the fall of 2007 that the traditional central bank tools were of limited use. While officials were able to inject liquidity into the financial system, they had no way to insure that the funds got to the institutions that needed it most. Realizing the failings of their traditional tools, Fed officials innovated creating a new lending procedures in the form of the Term Auction Facility and the Primary Dealer Credit Facility, as well as changed their securities lending program creating the Term Securities Lending Facility. I describe how these new systems work and what they are intended to do.

Conceptually, these new policy tools change the composition of the central bank's balance sheet without affecting its size. Some of them are equivalent to changes securities the Fed holds, while others involve shifts between bonds and loans. In all cases, the objective is to

¹ Woodford (2003) provides the theoretical foundations for modern monetary policy.

² See Gaspar and Kashyap (2006) for discussion of the deficiencies of consensus view and a suggested extension.

shrink certain risk spreads – the difference between the yield risky and risk-free assets – without changing the risk-free rate itself.

As we will see, while these changes may have helped a bit, they have not been able to keep the problems in the financial system from having an impact on real economic activity. In the end, the losses financial intermediaries incurred have damaged their capital. With lower levels of capital, there has been a forced reduction in credit extended. Fixing this requires recapitalization of the financial system, not just changes in central bank lending practices.

II. Prelude to the crisis

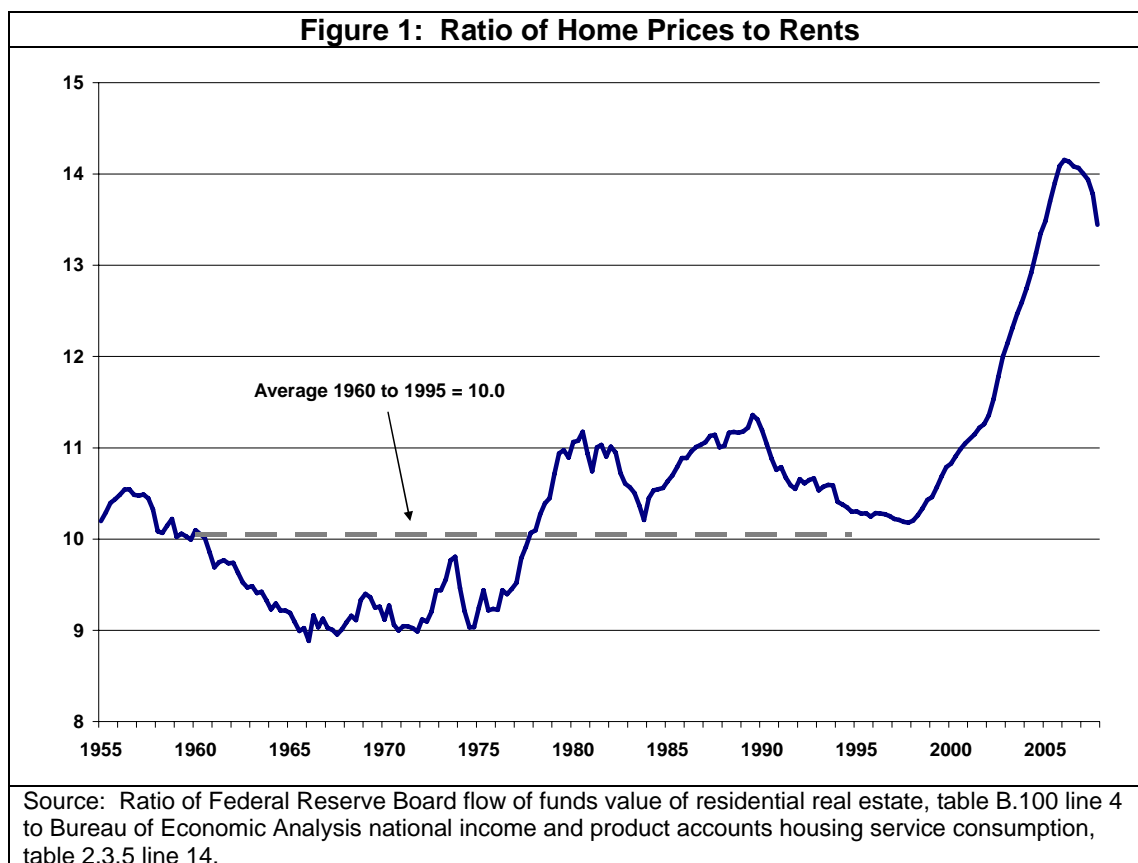
Over the last several decades, the financial system has evolved in a way that improves the efficient operation of the economy. In the past, payment streams and risks tended to come bundled together. Bonds were sequences of coupons with a principal payment at maturity. Today bonds can be stripped so that coupons and principal can be purchased separately. More generally, it is possible to purchase or sell virtually any payment stream with any risk characteristics.

This ability to separate financial instruments into their most fundamental pieces – the financial analog to particle physicists separating atomic nuclei into protons and neutrons – has had profound implications for the way in which risk is bought and sold. Today, risk is much more likely to go to those people who are most able to bear it. The result is that we can insure virtually anything and engage in many activities we wouldn't have undertaken in the past.

In a critical development, the slicing and dicing of risk extended to consumer lending. Home mortgages, credit card debt, automobile loans, student loans and the like were all pooled, or grouped together, and assets were issued that were backed by the groups. These asset pools were structured in a way that both reduced the risk faced by the buyer of the “asset-backed” securities, and allowed borrowers access to credit they otherwise would not have had. It sounds like everyone wins; a pure efficiency gain.

This all looked great, until 2007 when it became apparent that the quality of some of the loans in the residential mortgage pools might not be what they should have been. To understand what happened, we can look at a few selected pieces of information, starting with home prices. Figure 1 plots data on the ratio of the total value of residential real estate to a measure of the rental value at an annual rate. Equivalent to a price-earnings ratio for equity, data beginning in 1955 make clear how extraordinary the first five years of the 21st century were. Normally, home prices are between 9 and 11 times the annual level of rent paid. That makes sense, as it implies an average user cost of housing of around 10 percent. But since 2000, prices have skyrocketed, leaving rents in the dust. The price-to-rent ratio peaked at the end of 2006, reaching the rather extraordinary level of 14.5, clearly suggesting the existence of a “bubble” in residential housing. Home prices were at levels far higher than justified by fundamental values (or replacement costs).

The preliminary conclusion from information like that in Figure 1 is that either the price of home price would have to fall, rents would have to rise, or some combination of the two. And the size of the adjustment needed to be large – at least 20 percent.³



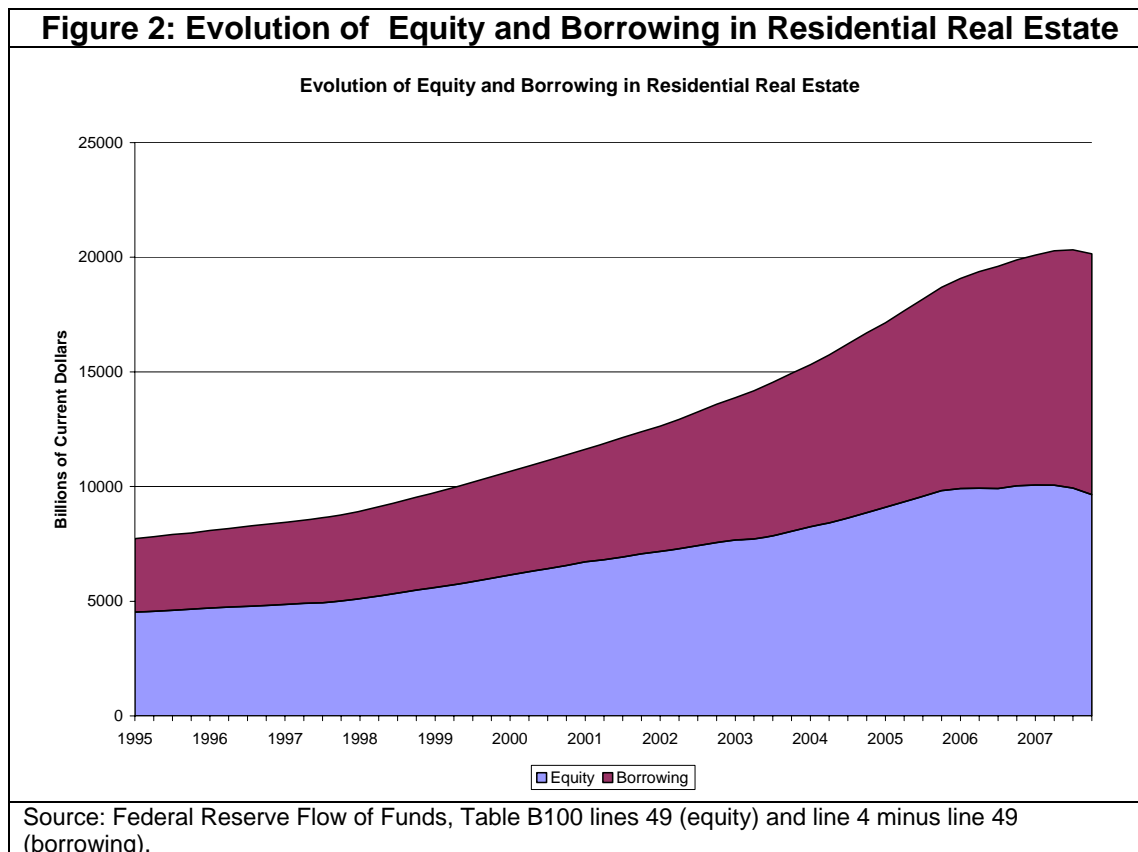
The residential real estate price rise that began in 2000 had a number of important side effects. First, when the value of housing rises, it creates wealth and wealthier people consume more. This consumption-wealth effect is substantial. Using data from 14 developed countries Case, Quigley, and Shiller (2005) estimate that a one percent increases in housing wealth raises consumption by between 0.11 and 0.17 percent.

The simplest way to convert housing wealth into consumption is to borrow. And this is where, in hindsight, we can find the second sign of trouble. Figure 2 separates the value of residential housing into owners' equity and borrowing (combining mortgages and home equity loans). What we see is that as the value of residential real estate rose, mortgage borrowing increased even faster. Since 1995 home equity has fallen from 58, already far below the 69 percent level a decade earlier, to 52 percent of home value.

Securitization facilitated this increase in household leverage. Briefly, here's how the process works. Instead of a lending to a home buyer and holding the mortgage on its own balance sheet, the lender makes the initial loan and puts it into a "pool" containing a large number of

³ It possible that the reduced real volatility of real growth starting in the mid-1980s, the "Great Moderation," lowered risk premia, which in turn raised the equilibrium level of the price-to-rent ratio. If this is the case, then the appropriate benchmark in Figure 1 would be on the order of 11.

other similar mortgages. This pool then serves as collateral for what are called mortgage-backed securities (MBS). The owners of these mortgage-backed securities (known also as “pass-through” securities) received the payments from the borrowers whose mortgages are in the pool.

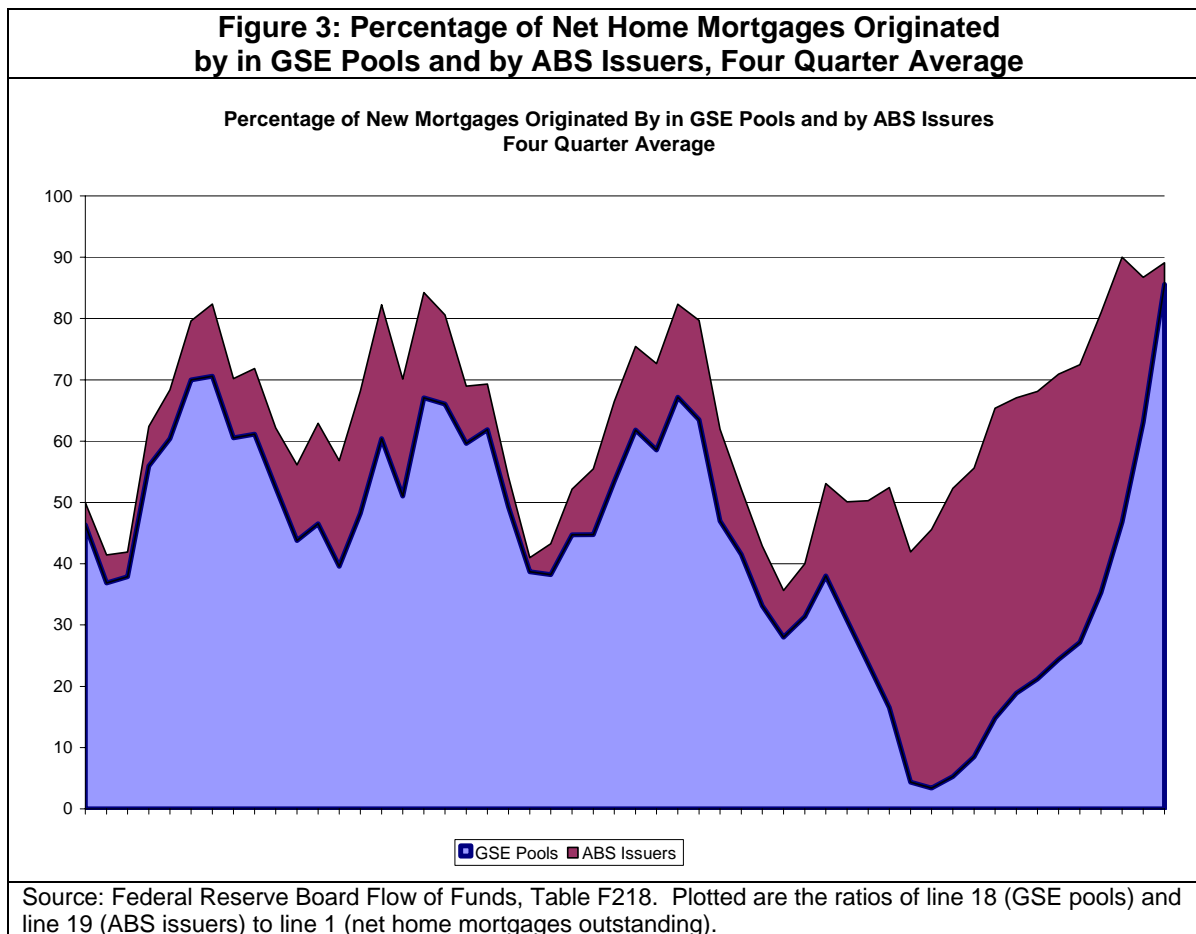


Looking at the data slightly differently, Figure 3 shows the fraction of newly issued mortgages that went into mortgage pools. The mortgage-backed data are separated into two categories. The first are Government-Sponsored Enterprises, or GSEs, primarily the Federal National Mortgage Association (Fannie Mae) and the Federal National Mortgage Corporation (Freddie Mac). The mortgage pools sponsored by the GSEs include loans with a maximum value, increased from \$417,000 to \$727,750 in March 2008, and a variety of requirements for borrowers. Importantly, the GSEs' basic business is to insure mortgages, so buyers of the securities issued by GSEs can do so without fear of default on the underlying mortgages. Mortgage-backed securities issued by other financial intermediaries, the ones labeled simply “ABS issuers” in the figure, do not have this same insurance.

Over the past decade, the sources of mortgage funding changed dramatically. In the mid-1990s, the majority were being purchased and pooled by GSEs, peaking at 70 percent in 1996. By 2004 the GSEs accounted for less than 10 percent of new mortgages, while the alternative issuers of asset-backed securities had raised their share to more than 40 percent.

There are two reasons that mortgages would not find their way into GSE pools. Either the mortgage was too large, exceeding the maximum allowable size, or the borrower failed to meet the credit quality standards set for inclusion. And by 2005 the financial system had created a

myriad of products that facilitated the origination of these alternative mortgages. Greenlaw, Hatzius, Kashyap, and Shin (2008) report that from 2001 to 2006 the percent of mortgage originations (measured by value) in the first group, so-called “jumbo” mortgages, actually fell slightly, while the fraction in the second exploded. Over this six year period, mortgages in this low quality group rose from 9.7% to 33.5% of mortgages issued.⁴



While our new-found ability to cheaply and easily cut up and repackage risk has created opportunities, it has also created new risks. In May 2007 Federal Reserve Board Chairman Ben S. Bernanke (2007) noted that in the case of the sub-prime mortgage market it has created what is known as a “principal-agent” problem. Sub-prime mortgage originators act as the agents for the investors, who are the principals. And the principals failed to impose sufficient discipline on their agents.⁵ The result has been a myriad of increasingly complex and insufficiently transparent securities that virtually no one understands how to value. Unsophisticated investors purchased these assets without even realizing what questions they should be asking of the sellers. The result of this lack of discipline and transparency is that the securities were overpriced.

⁴ Low credit quality mortgages sums together “Alt-A” and “subprime” categories. Reasons that borrowers might fall into these categories include the existence of a second lien, low or poorly documented incomes, low credit scores, or a high overall debt-to-income ratio.

⁵ Keys, Mukherjee, Seru, and Vg (2008) show that this is empirically important. They document that portfolios of securitized mortgages are more likely to default, all other things equal.

Mortgage-backed securities are just one of a class of so-called “structured products.” As I said at the outset, financial innovators have developed ways to slice and dice risk creating virtually any payment stream with any risk characteristics that a person wants. These financial engineers did not just stop at pooling mortgages. Among other things, they took a variety of mortgage-backed securities and recombined them into new pools. These products come under the general classification of “collateralized debt obligations” or CDOs. CDOs are commonly constructed from not only home mortgages, but also things like credit card debt and student loans. They are then cut up into tranches with different credit ratings – the AAA-rated, or senior, tranches are paid first; then there might be a BBB-rated tranche paid, and eventually what is called the “equity” tranche that is paid last (and suffers the first default).

Ratings play an important role in all of this. The creation of structured financial products relies on the ratings agencies – Moody’s, Standard and Poors, and Fitch – to give their blessing to what is being sold. Without a AAA rating, the senior tranches of CDOs would command lower prices and might not be worth selling.⁶

To recap, by the beginning of 2007:

- Home prices were at unprecedented levels.
- Home owners had more leverage than ever before.
- Mortgage quality had declined substantially.
- Asset-backed securitizations had spread well beyond the GSEs.

This sets the stage for the crisis. But since our ultimate objective is to understand how Federal Reserve policymakers reacted to financial developments in the summer and fall of 2007, we need to take a detour and discuss the inner workings of the Federal Reserve System. What tools do monetary policymakers have at their disposal, and how do they use them?

III. Tools the Fed has at its disposal

Section 2A of the Federal Reserve Act succinctly states the objectives of U.S. monetary policy:

“The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and credit aggregates commensurate with the economy’s long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates.”⁷

Most observers, as well as Federal Reserve officials themselves, have interpreted this mandate as implying that policy should strive to keep inflation low and stable while real growth remains high and stable.

This is a complex task. To understand how central bankers approach it, the best place to start is their balance sheet. This is the Federal Reserve’s point of contact with the financial system. It is through by manipulating the assets and liabilities they hold that the monetary policymakers affect the quantity of funds available in the financial system, the price of those funds (the interest rate), and the behavior of commercial banks and other financial

⁶ Kohn (2007) notes that these complex securities were extremely difficult to understand, and consequently hard to price. For a detailed discussion of the pricing of CDOs see Coval, Jurek, and Stafford (2007)

⁷ The Federal Reserve Act, as amended, can be found at www.federalreserve.gov/GeneralInfo/fract/.

intermediaries. (Note: throughout the text that follows I use the unqualified term “bank” to mean commercial bank.)

III.1 The Central Bank’s Balance Sheet

Table 1 reports a stripped-down version of the Federal Reserve System’s balance sheet as reported weekly on the Federal Reserve Board’s website.⁸ In order to highlight recent changes, we start with a whirl-wind tour of the liabilities and the assets as they existed before the crisis began.

Assets		Liabilities	
Securities		Federal Reserve Notes	\$781.4
Held Outright	\$790.6	Commercial Bank Reserve Balances	\$ 16.8
Repurchase Agreements	\$ 30.3	Liabilities related to Foreign Official and US Treasury Deposits	\$ 42.4
Loans		Other Liabilities	\$ 5.7
Primary Lending	\$ 0.19	Total Liabilities	\$846.3
Foreign Exchange Reserves	\$ 20.8	Capital	\$ 34.1
Gold	\$ 11.0		
Other assets	\$27.5		
Total Assets	\$880.4		

With the exception the value of foreign exchange reserves, which is for 30 June 2007, all numbers as of 4 July 2007.
 Source: Federal Reserve Statistical Release H.4.1, Table 2, www.federalreserve.gov/releases/h41/; and quarterly *Treasury and Foreign Exchange Report*, April-June 2007, Federal Reserve Bank of New York www.ny.frb.org/markets/quar_reports.html

Liabilities: Currency and Reserves

Starting with the liability side of the balance sheet (what the Fed owes); note that there is a tremendous amount of currency outstanding. The number is extremely large, representing roughly \$2600 per U.S. resident. But one-half to two-thirds is held outside the country.⁹

Since currency plays no role in our story, we move immediately to the entry for commercial bank reserve balances. Banks hold reserves at the Fed for three primary reasons: (1) they are required to hold them; (2) they need them to do business, so that they can meet customer demands for withdrawals and they can make payments to other banks; and (3), it is prudent to do so; reserves act as the bank’s emergency fund – they are always ready just in case disaster strikes.

⁸ As a legal matter, the Federal Reserve Board is not a bank; it is a part of the U.S. government. By contrast, the 12 regional Federal Reserve Banks spread around the country are chartered banks and private nonprofit corporations. The balance sheet in Table 1 is the consolidated position of these 12 banks.

⁹See U.S. Treasury (2006).

Looking at Table 1, we see that the level of these reserve balances is \$18 billion. This is a relatively small number – approximately one-tenth the level held by European banks in the national central banks of the Eurosystem. The reason is that U.S. banks receive no interest on their reserve balances, while European banks are paid something close to the overnight interbank lending rate. The result is that American banks have a big financial incentive to economize on their reserve account balances.¹⁰

You will also note that two additional liabilities appear on the simplified balance sheet in Table 1. The first concerns deposit accounts that belong to either the U.S. Treasury or to foreign governments and central banks. These institutions need bank accounts just like any person or business, and the Federal Reserve offers them this service. Finally, there is a very modest level of “other liabilities.”

Assets: Securities Holdings, Loans, and Foreign Exchange Reserves

Moving to the asset side of the balance sheet (what the Fed owns), we see that the Fed holds securities both outright and as part of repurchase agreements. It is worth making a few points about each of these. First, the securities holdings are entirely U.S. Treasury bills, notes, and bonds. Second, the Federal Reserve Act stipulates that additions to the outright holdings can only occur through secondary market purchases. That is, the Fed cannot add to its holdings by buying securities directly from the U.S. Treasury; nor, with the exception of rolling over maturing issues it already holds, can the Fed participate in the auction in which new Treasury bills, notes and bonds are issued.

The Fed also holds securities in repurchase agreements, or “repo” for short. In Table 1, these account for \$28 billion. Repurchase agreements are extremely important, as they are the method the Fed uses to adjust the level of reserves in the banking system from day to day. And when we hear on that the Federal Reserve Bank of New York’s Open Market Desk put \$38 billion into the banking system on 10 August 2007, they did it with repurchase agreements.

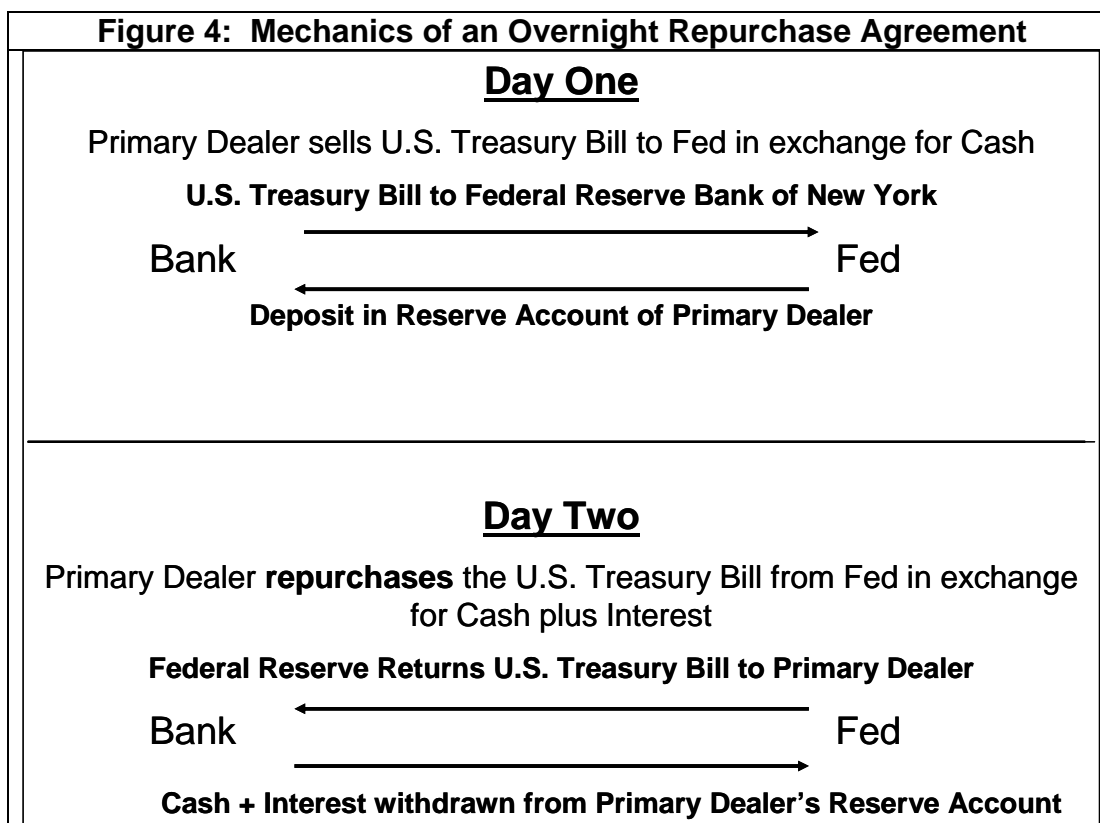
It is worth taking a minute to understand what repos are. Here is a dictionary-style description: A repurchase agreement is a short-term collateralized loan in which a security is exchanged for cash, with the agreement that the parties will reverse the transaction on a specific future date at an agreed upon price, as soon as the next day. The easiest way to think about a repo is as an overnight mortgage (because it is fully collateralized). In the same way that you pledge your house to the bank in exchange for a loan, a financial institution pledges a bond to the Fed in exchange for funds. Figure 4 displays the details schematically.

The Fed carries out these transactions through the Federal Reserve Bank of New York’s Open Market Desk (the “Desk”). The Desk engages in repurchase agreements every morning (usually at 8:30am or 9:40am). The quantities normally range from \$2 billion to \$20 billion dollars.¹¹ The Desk puts out a call for bids to a set of “primary dealers,” stating the term of the repo and the type of collateral that they will accept. Banks and securities dealers submit their offers – quantities, prices, and collateral – and then the Manager at the New York Fed decides how much to accept. There are three types of collateral: U.S. Treasury Securities, U.S. agency

¹⁰ On 13 October 2006, the U.S. Congress passed the Financial Services Regulatory Relief Act of 2006 (Public Law 109-351) authorizing the Federal Reserve to pay interest on reserves beginning on October 1, 2011. At this writing, the Federal Reserve Board has not yet announced whether it will do so, but there is a strong suspicion they will.

¹¹ The biggest ever recorded as is \$81.25 billion on 14 September 2001, in the aftermath of the 9/11 terrorist attacks.

securities (issued by entities like Fannie Mae and the Small Business Administration), and AAA-rated and insured mortgage-backed securities.¹² And there are only 19 primary dealers, most of whom are investment banks, and they are the only ones who are qualified to participate in open market operations.¹³ The total quantity of securities offered (at all interest rates) averages roughly 5 times what is accepted for Treasury securities, 10 times for agency securities, and 15 times for mortgage-backed. While most are overnight, it is standard to engage in repos with maturities as long as 14 days.



Continuing with the asset side of the balance sheet, we see loans. Historically, banks have been extremely reluctant to use the primary lending facility. Prior to the start of the crisis, borrowings averaged less than \$200 million per day.¹⁴ Even since the start of the crisis in August 2007, the quantity of discount borrowing has generally been below \$1 billion.

The stigma attached to borrowing from the Fed probably arises from two sources. First, prior to 2003 the system worked differently. Then, discount loans were made at an interest rate below the federal funds rate target, but banks were admonished for over use. The threat of punishment by the Fed created a distinct disincentive. But recently, the Fed has tried to allay the fears this created, emphasizing that borrowing should be a normal part of business. Even so, banks have been hesitant to borrow. This is likely a result of fear that a borrowing bank will

¹² Section 14(b) explicitly lists the securities that the Federal Reserve can hold in its portfolio.

¹³ For the current list see www.ny.frb.org/markets/pridealers_current.html.

¹⁴ The aftermath of the 9/11 terrorist attacks is a glaring exception to this. Then bank borrowing peaked at roughly \$40 billion.

be discovered by other banks that would then draw a negative conclusion. It is one thing to have to borrow from your parents. It is something else for your friends to find out.¹⁵

Next on the asset side are foreign exchange reserves. As of 30 June 2007, the Fed held \$13.1 billion in Euro-denominated assets and \$7.7 billion in Japanese Yen in a combination of marketable securities and deposit accounts at foreign institutions.¹⁶

General Principles of Balance Sheet Management

There are two general principles associated with the management of the central bank's balance sheet. First, policymakers control the size of their balance sheet. Unlike you and me, if Fed wishes it can simply issue liabilities in order to purchase additional assets. This is exactly what happens in an open market operation: In order to purchase of a security, the Fed creates a reserve liability, crediting the deposit account of a commercial bank. Importantly, the central bank can do this without limit. (The price of the Fed's liabilities – the interest rate – is affected by this, so if policymakers really do create reserves without, limit the overnight interest rate will go to zero.)

Second, the central bank controls the composition of the assets it holds. Given the quantity of assets it owns, the Fed can decide whether it wants to hold Treasury securities, foreign exchange reserves, or a variety of other things. While changes in the quantity of assets affects the level of the risk-free interest rate, changes in composition will influence relative prices – one currency relative to another, one bond relative to another, etc. There are legal limits, but like any investor, the Fed can adjust things like the maturity structure of its portfolio. Sterilized foreign exchange intervention, where a central bank sells a bond denominated in one currency and uses the proceeds to buy a bond denominated in another currency, is a classic example of a decision related to the composition but not the quantity of assets the central bank holds.

III.2 The Monetary Policy Toolbox

A textbook treatment of monetary policy focuses on three traditional tools, each of which is based directly on actions related to the central bank's balance sheet. These are:

1. Federal Funds Rate Target
2. Discount Lending
3. Reserve Requirement

Let's have a look at each one. You should think of the brief descriptions that follow as the state of the world before the crisis began on 9 August 2007.

Federal Funds Rate Target

The first of these is the most familiar as it is the subject of the periodic decisions made by the Federal Reserve's policymaking body, the Federal Open Market Committee (FOMC).¹⁷ The federal funds rate is the market-determined interest rate on overnight interbank loans.¹⁸

¹⁵ There is a modest literature on discount window borrowing. See, for example, Artuç and Demirlap (2007) and the references therein.

¹⁶ The Federal Reserve holds half of the foreign exchange reserves of the United States. The other half is on the balance sheet of the U.S. Treasury's Exchange Stabilization Fund. In the rare event of an intervention, the quantity is split evenly between the two.

¹⁷ The FOMC is composed of the seven Governors of the Federal Reserve Board, and five of the twelve Presidents of the Federal Reserve Banks. While all twelve Presidents participate in meetings, only five vote in rotation.

It is by adjusting the federal funds rate target that the FOMC hopes to achieve its goals of “maximum employment, stable prices, and moderate long-term interest rates.” Changes in the level of this overnight interbank lending rate ripple through the economy, influencing growth and inflation. The “transmission mechanism” has a variety of channels. There is the traditional interest-rate channel whereby higher interest rates lead to fewer investment projects being funded. There is the exchange rate channel in which higher interest rates result in currency appreciation which makes imports more attractive to domestic residents and exports more expensive to foreigners, so net exports go down. There are lending channels, where interest rate changes influence both the ability of lenders to make loans and the creditworthiness of borrowers. And finally, there are asset price channels where interest rate changes influence stock and property prices, which influence consumption through wealth effects of the type described earlier.¹⁹

Once the FOMC sets the target, the Open Market Operations Desk at the Federal Reserve Bank of New York engages in daily operations, adjusting the supply of reserves in an effort to keep the market rate close to the target using the methods described earlier.²⁰

Traditional Discount Lending

Banks can borrow from the Fed at what is technically called the “primary lending rate” and is more commonly known as the “discount rate.”

Each of the 12 Federal Reserve Banks has a standing offer to lend to the banks in their district that they deem to be sound (as measured by standardized supervisory ratings).²¹ Since the January 2003 change in procedures, the primary lending rate has been set at a premium above the target federal funds rates. Prior to the start of the crisis in 2007, the premium was one percentage point, or 100 basis points. As long as a bank qualifies and is willing to pay the penalty interest rate, it can get the loan. The rules allow a borrowing bank to re-lend the borrowed funds to another bank, if it wishes to do so.

Primary credit is designed both to provide funds at the end of the day to allow banks to meet their obligations without overdrawing their reserve account, and to enable institutions to borrow against collateral that the market will not otherwise finance. The second of these is associated with the classic lender of last resort function.

As I just mentioned, discount borrowing is collateralized. This means that the borrowing bank must have assets of sufficient value that in the event of default, the Federal Reserve will not suffer a loss. As evidenced by a case in 1985 when the Fed lent the Bank of New York \$23 billion and took the entire bank – buildings, furniture and all – as collateral, they will accept

¹⁸ Overnight lending and repayment is made straightforward and cheap by the fact that all banks utilize the interbank payments system called the Fedwire. Run by the Federal Reserve, the Fedwire enables banks to easily transfer funds into and out of their reserve accounts.

¹⁹ For more detail see Chapter 23 of Cecchetti (2008).

²⁰ The Fed is the monopoly supplier of reserves to the banking system. As a monopolist, they can choose to control either the quantity of the price of reserves. Since 1982, the Fed has chosen the latter. For details on the daily operations see www.newyorkfed.org/markets/omo/dmm/temp.cfm.

²¹ Banks that do not meet the supervisory criteria set for primary lending can borrow at a higher interest rate, known as the secondary lending rate.

virtually anything.²² In general, banks pledge collateral of various types, and simply leave it at that.²³

So, at least in principle, the Fed's discount lending operation allows a bank to borrow whenever it wants, so long as it has sufficient collateral and is willing to pay the interest rate that is charged. There are two important differences between discount lending and open market operations: (1) Any bank can borrow, while only 19 primary dealers can participate in open market operations; and (2) the Fed allows a discount loan to be collateralized by a very broad range of assets, while only a narrow set of very high quality assets qualify for repurchase in regular open market operations.

Reserve Requirement

Banks are required to hold reserves equal to a fraction of qualifying deposits. The reserve requirement is a potentially powerful policy tool, but there are two reasons that this potential is not realized. The first is that the tool is too powerful. Small changes in the reserve requirement can, at least in principle, have very large and difficult to predict effects on bank behavior.²⁴ Second, and more to the point, in the current environment the reserve requirement does not bind on commercial bank behavior.

Briefly, the Federal Reserve Board has the authority to set the minimum level of reserves banks must hold either as cash in their vaults or on deposit at the Fed. The requirement is computed as a percentage of the two-week average of balances on deposits with unlimited withdrawal privileges.²⁵ The reserves a bank must hold are also averaged over a two-week *maintenance period*, which does not overlap with the reserve computation period used to measure the level of deposits against which reserves must be held. Because reserve balances are not remunerated – the interest rate is zero – they are expensive to hold, so banks economize on the need to hold them. As described in Cecchetti (pg. 420, 2008), banks use complex algorithms to shift funds in and out of accounts with limited withdrawal privileges that do not attract a reserve requirement.²⁶ They do this in such a way as to make the reserve requirement irrelevant.

IV. The Crisis Hits

A complete chronology of the crisis might start in February 2007 when several large subprime mortgage lenders started to report losses and include a description of how spreads between risky and risk-free bonds (“credit spreads”) began widening in July. But the real trigger came on Thursday August 9, the day that the large French bank BNP Paribas temporarily halted

²² For somewhat more details about this story, see Cecchetti (2008), page 336.

²³ The technicalities of the pledging and valuation of collateral is complex. Briefly, a bank can pledge collateral by either giving it to a custodian or holding it on its own premises. Valuation depends on both what the collateral is and whether there is an active market price available. The published schedule includes everything from U.S. Treasury securities, which are normally held by a custodian and for which there is an active secondary market, to subprime credit card receivables, which the banks almost surely holds itself and are likely to be very difficult to sell in all but the best of circumstances. For more details see www.frbdiscountwindow.org/index.cfm.

²⁴ For details on the operation of the reserve requirement see Chapter 18 of Cecchetti (2008).

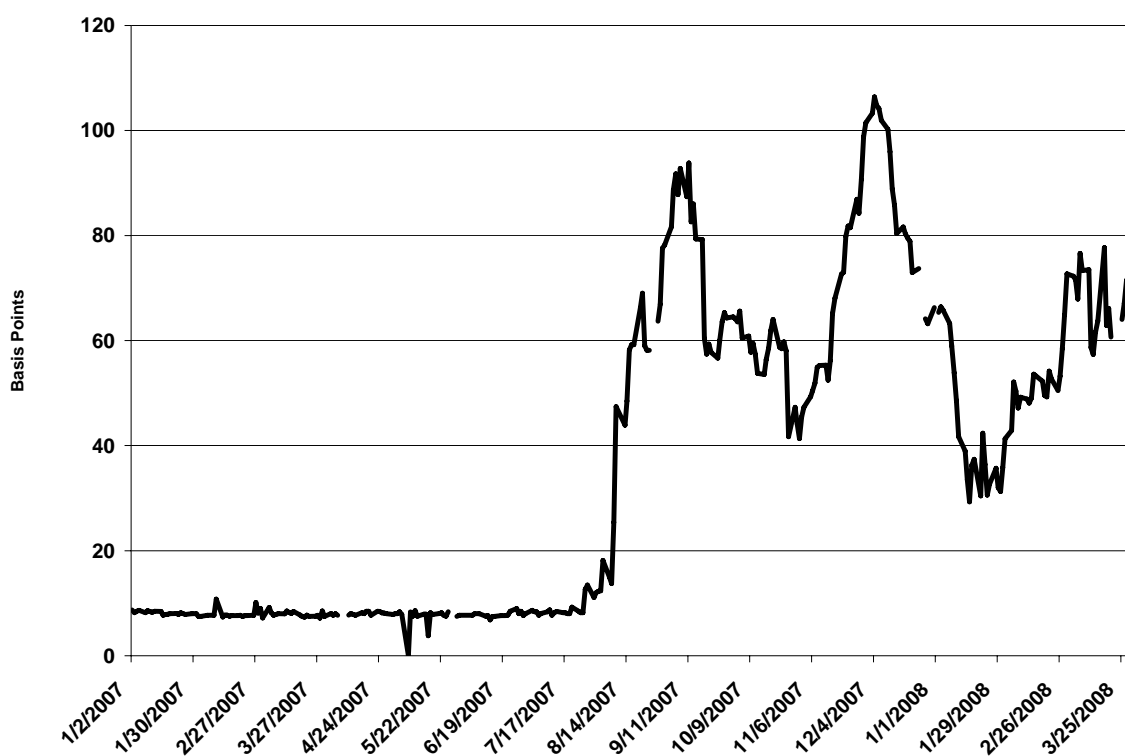
²⁵ The requirement is graduated, with the first few million dollars in deposits exempt, then 3 percent on the next \$45 million or so, and 10 percent on amounts above that.

²⁶ To see how this works, consider a simple example where each Friday afternoon just before closing a bank moves the balances from a transactions account into a shadow account that allows six withdrawals per month. Then, each Monday morning, immediately after opening, the bank shifts the funds back. Since the weekend counts for three days, this action alone will reduce the bank's required reserve level by 3/7ths.

redemptions from three of its funds that held assets backed by U.S. subprime mortgage debt. As a direct consequence, overnight interest rates in Europe shot up, and the European Central Bank immediately responded with the largest short-term liquidity injection in its 9 year history, €94.8 billion (\$130 billion at the time) worth of overnight repos. The following day, as these overnight repurchase agreements expired, the operation to renew them was two-thirds the size – a still very large €61.1 billion. Meanwhile, the Open Market Trading Desk of the Federal Reserve Bank of New York used one-day repurchase agreements to inject \$24 billion in reserves into the U.S. banking system on Thursday; and when those expired on Friday the Desk upped the amount by \$38 billion for the weekend.

The central banks supplied these large quantities of reserves in response to increases in bank demand. Stresses in the interbank lending market are evident from the behavior of the London Inter-Bank Borrow Rate, or LIBOR, the benchmark rate on interbank lending set by a group of eight large banks each morning (like the federal funds market, LIBOR lending is uncollateralized).²⁷

**Figure 5: Spread between 3-month LIBOR and 3-month Expected Federal Funds Rate
January 2007 to March 2008, Daily**



Source: LIBOR data are from the British Bankers' Association www.bba.org. The expected federal funds rate data are from Exhibit 2.10 of Greenlaw, Hatzius, Kashyap and Shin (2008). Note that because the LIBOR rate is determined at 11am UK time, which is 5am Eastern US time, I plot the expected federal funds rate on date t minus LIBOR at $t-1$. This avoids spurious spikes that would occur on dates with the FOMC made unexpected, inter-meeting, changes in the target federal funds rate.

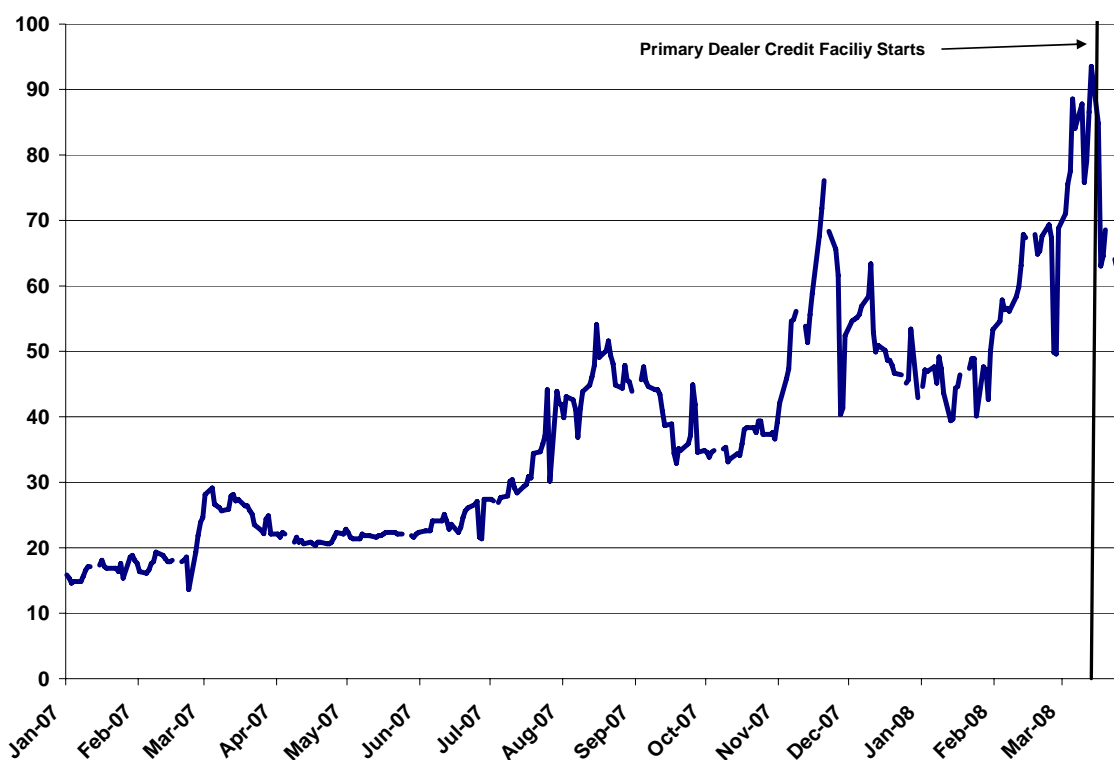
²⁷ LIBOR is also a key benchmark for types of consumer and business loans, including various kinds of mortgages.

Figure 5 plots the spread between LIBOR and what is known as an Overnight Indexed Swap (OIS). This compares a 3-month fixed-rate loan with the expected interest rate that would accrue from repeatedly rolling over an investment at the overnight rate for three months.

Normally less than 10 basis points, on Thursday 9 August 2007 the 3-month LIBOR-OIS spread jumped to 40 basis points. And normally stable, with a standard deviation of several basis points, the spread fluctuates between 25 and 106 basis points through the fall. Something is clearly wrong. There should be an arbitrage that allows a bank to borrow overnight, lend for three months, and hedge the risk that the overnight rate will move in the federal funds futures market leaving only a small residual level of credit and liquidity risk that accounts for the small spread we see before the onset of the crisis. Obviously, banks could not do it. The question is why.

Another symptom of the crisis comes from looking at the average spread between U.S. government agency securities – those issued by Fannie Mae, Freddie Mac and the like – and U.S. Treasury's of equivalent maturity plotted in Figure 6. Normally these securities are normally viewed as only very slightly more risky and less liquid than Treasury issues themselves. But starting in August 2007, the spread doubled from 15 to 25 basis points to more than 40. Then, as the crisis intensified through the fall and winter, the agency spread remained high until it exploded to more than 90 basis points March 2008. There was a flight to quality in which people shunned anything but U.S. Treasury securities themselves.

**Figure 6: Spread between U.S. Agency and Treasury Securities
January 2007 to March 2008, Daily**



Data are averages across a broad spectrum of available maturities of large, liquid, issues of GSE and agency debt.

Source: Citigroup, Inc.

Prices, are one thing, quantities are another. The banks that participate in what is called “fixing” the LIBOR rate have no obligation to lend at those rates. Since there is no quantity data on interbank lending, there is no way to know if any loans were actually going through at these rates.

There is one place where we have data on both prices and quantities: the commercial paper market. Figure 7 plots the behavior of 30-day commercial paper rates and quantities outstanding beginning in June 2007. Panel A compares the evolution of the rate on high-grade, AA-rated, nonfinancial commercial paper, issued by large corporations like General Electric and Coca Cola, with asset-backed commercial paper (or “ABCP”). ABCP is issued by firms that hold things like the securities backed by mortgage pools as assets. The spread on ABCP closely follows a pattern similar to that in the market. Before mid-August the premium on ABCP was between 5 and 10 basis points. By August 23, it rose to 86 basis points, and then in early December peaked at more than 100 basis points.

Commercial paper quantities outstanding tell an interesting story as well. From 2002 to 2007, the Federal Reserve reports that the total quantity of commercial paper grew at a nearly 10 percent average annual rate, reaching \$2.2 trillion in August 2007. ABCP accounted for more than half of this total, peaking at nearly \$1.2 trillion. (It is worth keeping in mind that the vast majority of these securities are very short term. On any given day more than two thirds of all outstanding commercial paper has a maturity of 5 business days or less.)

Starting in mid-August, as borrowers had trouble rolling over maturing issues, the quantity of commercial paper outstanding dropped precipitously falling by nearly \$300 billion in the first two months of the crisis and \$400 billion by year end. And, as Panel B of Figure 7 shows, the fall is entirely accounted for by the fall in ABCP outstanding. It is standard practice for issuers of commercial paper to have backup lines of credit with banks available to them in the event that they have problems at maturity. And that is what they did. During the last five months of 2007, total commercial bank credit extended rose by \$575 billion, more than offsetting the fall in commercial paper.²⁸

As various market interest rates were rising steeply, yields on short-term U.S. Treasury issues were plummeting. Prior to the crisis, the 3-month Treasury-Bill rate stood near 4.8 percent, implying a risk (or liquidity) premium on 3-month LIBOR of 50 to 60 basis points.²⁹ On 20 August 2007, as the T-Bill rate plunged to 3.08 percent, the LIBOR spread briefly went over 240 basis points. Then, after falling to around 100 basis point in late October, the spread increased and remained around 200 basis points from 26 November to 21 December 2007.

Figures 5, 6 and 7 suggest a chronology that goes something like this: Starting in early August risk spreads abruptly widened. Then, through late September and early November, things looked as if they were calming down. At the end of November, as both the year end approached and it became clear that financial institutions were experiencing large losses, conditions worsened, and continued to deteriorate into the winter of 2008.³⁰

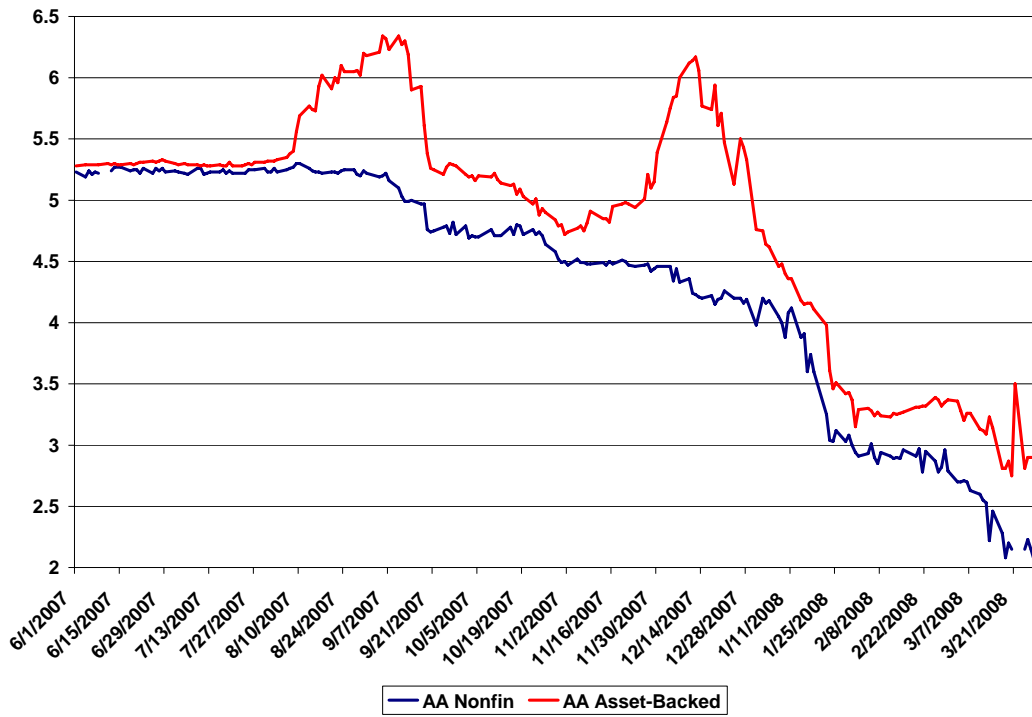
²⁸ Commercial bank credit data are not seasonally adjusted levels taken from line 5, page 2, of the Federal Reserve Board's H8 statistical release.

²⁹ The difference between 3-month LIBOR the 3-month Treasury bill rate is a widely-used measure of credit risk, since both obligations are unsecured. It is essentially the same as the Treasury-Eurodollar (TED) spread.

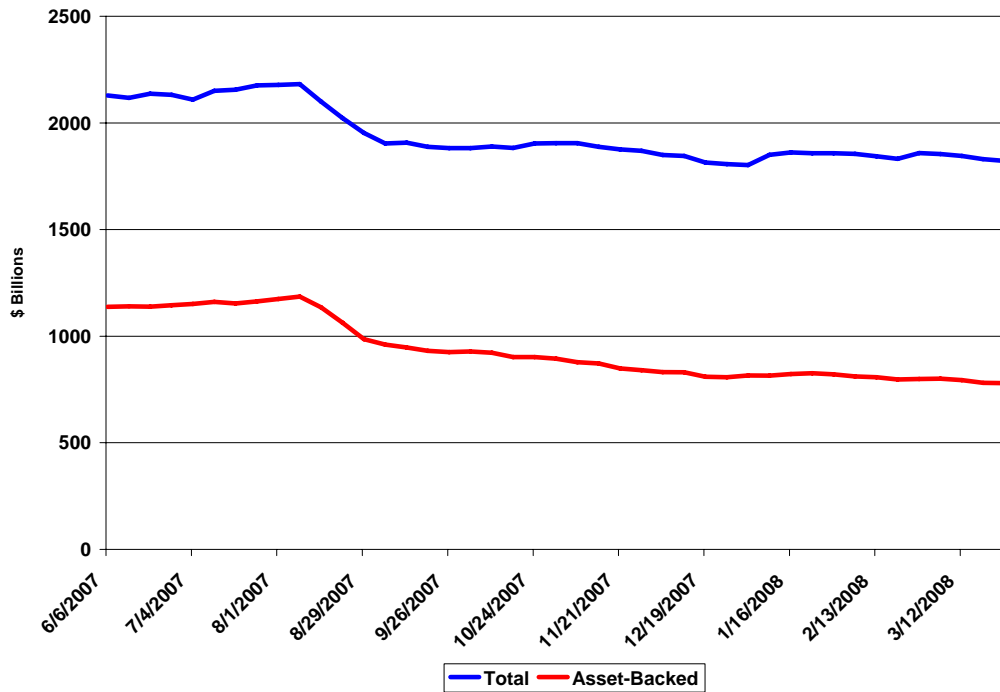
³⁰ A compilation of these losses from news reports in late 2007 suggested that commercial and investment bank losses had surpassed a combined total of \$150 billion. Estimates several months later exceeded \$400 billion. See Greenlaw et al. (2008).

Figure 7: Commercial Paper, June 2007 to March 2008

A. 30-Day Interest Rates



B. Quantities Outstanding



Interest rate data are daily, and quantity data are weekly. All data are not seasonally adjusted.
 Source: Board of Governors of the Federal Reserve System, www.federalreserve.gov/releases/cp/.

What was happening? Why did supply in the interbank lending market dry up? There are two possible explanations for this unwillingness to lend: (1) Lenders perceived a substantial increase in credit risk, so they increased the interest rate they were charging, or (2) banks that normally lent faced a combination of uncertainties and constraints related to the size of their own balance sheets.³¹

A variety of factors suggest that the second explanation is more likely: First, LIBOR is a benchmark rate charged to the best borrowers. Lenders regularly assess less creditworthy borrowers a premium. Second, banks were in fact expanding their balance sheets, increasing lending especially to nonbank borrowers.³² There is strong suspicion that this added lending was associated with lines of credit that banks had extended as insurance to the entities that had been issuing asset-backed commercial paper but were not able to after August 9.³³

Finally, soon after the crisis started, it became clear that everyone, banks included, were having trouble valuing a broad range of assets. This is exactly what one expects to see in a crisis, and it has important consequences. Not knowing the value of what was on their own balance sheets, bankers were unsure of their own lending capacity.³⁴ Adding to the problem is that increased volatility in markets drove up conventional measures of risk, forcing banks to reduce the overall size of their balance sheets, all else equal. Together, these led to a vastly reduced level of term lending.

Looking at all of this, a picture of the crisis emerges in which opaque, difficult to value assets cannot be used as collateral to back either commercial paper issuance or lending. As a result, it became impossible for some financial intermediaries to finance themselves through what had been accepted channels. Those that had issued commercial paper into financial markets could not; and those that had borrowed from their fellow financial intermediaries, could not either. No one knew what securities were worth, so there was no way to establish the value of collateral or the creditworthiness of borrower. Add to that the fact that banks did not want to lend because of the risk of hitting the constraint imposed by the regulatory capital requirement, and we have a severe financial crisis.

³¹ Taylor and Williams (2008) describe these as “counterparty risk” and “liquidity risk”, respectively.

³² This expansion may have been involuntary, as it could have been a result of commitments that were made before the crisis started.

³³ Unfortunately, we only have anecdotal evidence that loans under commitment were increasing. But the fact that, after rising by \$544 billion from 8 August to 26 December 2007, bank credit outstanding rose only \$60 over the first 8 weeks of 2008 is surely very suggestive that the lending was made only to people to whom banks had commitments incurred prior to the beginning of the crisis.

³⁴ The issuance of complex securities such as CDOs and the like had relied heavily on the work of the rating agencies to certify that parts of asset pools were highly rated, while other parts had lower risk ratings, and so on. Starting in the fall, there was a nearly continuous stream of downgrades where rating agencies changed their views on the credit quality of these instruments. For example, on 30 January 2008 Standard and Poor's issued a single report in which it downgraded over 8000 securities backed by assets of various kinds. See www2.standardandpoors.com/spf/pdf/media/subprime_action_rmbs_cdo.pdf.

V. Federal Reserve Interventions

In the middle of this mess sits a group of central bank officials who have been assigned to be the risk managers for the financial system. But what tools did Federal Reserve policymakers have to address the problems that it faced beginning in the summer of 2007? Is there anything that the Fed can do to bring the LIBOR spread down, or help provide banks with term financing?

Table 2: Major Federal Reserve Policy Actions 9 August 2007 to 18 March 2008	
August 9	Increase in the level of temporary open market operations
August 10	FOMC statement
August 17	Cut in primary lending rate from 100 to 50 basis points above the federal funds rate target; an increase in the term of discount lending from overnight to a maximum of 30 days; and release of FOMC policy announcement
September 18	50 basis point cut in target federal funds rate at regular FOMC meeting
October 31	25 basis point cut in target federal funds rate at regular FOMC meeting
December 11	25 basis point cut in target federal funds rate at regular FOMC meeting
December 12	Announced creation of the Term Auction Facility (TAF) and the swap lines with the European Central Bank and the Swiss National Bank of \$20 billion and \$4 billion, respectively.
December 17	First TAF auction: \$20 billion, 98 bidders
January 21	75 basis point cut in target federal funds rate at an unscheduled meeting, and cut in the discount rate
January 30	50 basis point cut in target federal funds rate at regular FOMC meeting, and cut in the discount rate
March 2	Announced intention to conduct 28-day repos cumulating to \$100 billion
March 7	Announced an increase in the size of the TAF from \$60 billion to \$100 billion outstanding at any given time.
March 11	Announced creation of Term Securities Lending Facility and the intention to lend \$200 billion worth of Treasury Securities to Primary Dealers. Increase in the swap lines with the European Central Bank and the Swiss National Bank to \$30 billion and \$6 billion, respectively.
March 14	Announced approval of loan to Bear Stearns through JPMorgan Chase
March 16	Announced creation of Primary Dealer Credit Facility (PDCF) 25 basis point cut in the discount rate to 3¼ percent; an increase in the maximum term of discount lending from 30 to 90 days; announced approval of \$30 billion loan to JPMorgan Chase for the purposes of purchasing Bear Stearns.
March 18	75 basis point cut in target federal funds rate at regular FOMC meeting, and cut in the discount rate
Source: Board of Governors of the Federal Reserve System and Federal Reserve Bank of New York, various press releases.	

To see, we can start by looking at what actually happened. Table 2 lists the policy actions taken by the Fed between 9 August 2007 and 18 March 2008. The list includes

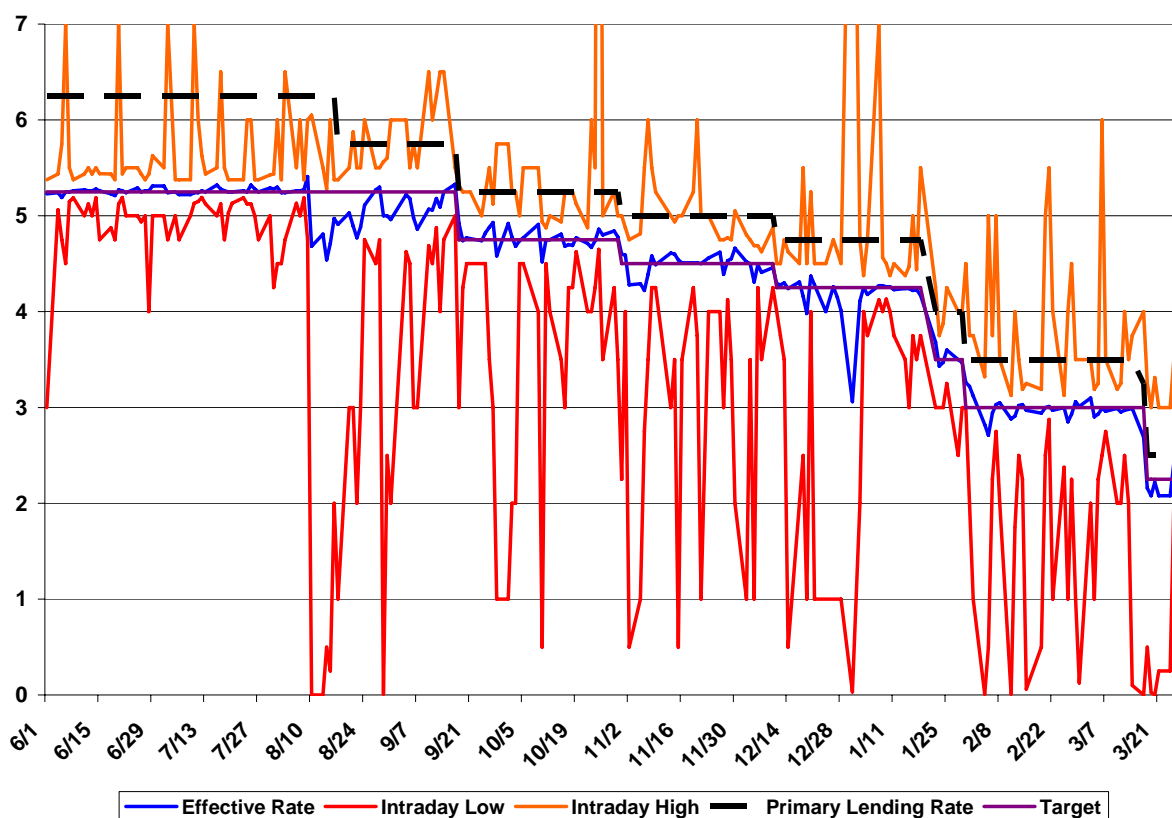
- five cuts in the target federal funds rate totaling 225 basis points, or 2¼ percentage points;
- a drop in the premium on primary (discount) lending from 100 to 50 and then to 25 basis points, above the federal funds rate target;
- the creation and then enlargement of the “Term Auction Facility” (TAF);
- the extension of \$24 billion in credit to the European Central Bank and the Swiss National Bank, later raised to \$36 billion;
- the change in the preexisting securities lending program to initiate the “Term Securities Lending Facility” (TSLF);

- extension of credit to primary dealers through the newly created “Primary Dealer Credit Facility” (PDCF)
- and the authorization of lending to support the JP Morgan Chase purchase of Bear Stearns.

To understand how each of these works, we need to return to the Fed’s balance sheet and toolbox described in Section III. It would seem that the cut in the cost of discount borrowing and the increase in the term of the loans announced on August 17, followed by cuts in the federal funds rate target starting in mid-September should have addressed the problem. This should have given banks access to short-term funding at lower interest rates than they had been facing, reduced the demand for interbank loans, and helped these funding markets return to normal.

Offering discount loans of up to 30 days at an interest rate only 50 basis points above the federal funds target should have given banks access to the liquidity they needed to carry on their day-to-day operations. And a low federal funds rate will increase the slope of the yield curve should help banks profit from its “maturity transformation” business of issuing short-term liabilities and making longer term loans.

**Figure 8: Federal Funds Rate
Target, Effective Rate, Range, and Primary Lending Rate
June 2007 to March 2008**



Source: Federal Reserve Bank of New York, www.ny.frb.org/markets/omo/dmm/fedfundsdata.cfm.

While all of this may have helped, the mere fact that there was no return to normalcy, and that problems worsened through the late fall and early winter, means that these policies did not achieve their desired objective. To understand why, we can look at the behavior of the federal funds rate. Figure 8 plots daily data on the federal funds rate target, the primary lending rate, the effective federal funds rate and the trading range in the federal funds market as reported by dealers to the Federal Reserve Bank of New York.

These data regularly are remarkable. Historically, the open market trading desk in New York has been very good at keeping the market-determined federal funds rate close to the target, and the range of trading has been a narrow band around that same target. “Normal” behavior is what we see in the left-hand portion of the figure. Suddenly, beginning on 9 August 2007, the effective rate is much more variable around the target and there is a clear tendency to come in below the target.³⁵ Not only is the market “soft” in mid- to late-August, but the trading range explodes. The daily low is often well below the target, while the daily high is frequently above the primary lending rate. Prior to the crisis, the high end of the federal funds trading range exceeded the discount rate roughly one in ten business days.³⁶ Since the start of the crisis, the rate has gone up to one in three days. If anything, it looks as if the stigma associated with borrowing increased during the crisis.

Term Auction Facility

As the fall of 2007 proceeded and it became increasingly clear that the innovative discount lending policy put in place in mid-August was not working, Fed officials looked for alternatives. This brought them back to some procedures that were discussed in 2001. During 1999 and 2000 the Federal Government was operating in surplus, reducing the quantity of Treasury securities outstanding. Forecasts at the time suggested the possibility that the level of government debt would continue to decline in a way that would require a change in the Federal Reserve’s balance sheet management. Federal Reserve System staff undertook a study of possible alternative operating procedures. The results were published in December 2002 and one of the suggestions was to supply reserves through an auction mechanism.³⁷ In December this procedure was implemented in the form of the Term Auction Facility (TAF).

Using the TAF, the Fed started to supply reserves in substantial quantities, for relatively long periods – initially \$20 or \$30 billion, then \$50 billion, for terms of 28 or 35 days. Here’s how it works: Any of the more than 7000 commercial banks in the country can bid in the auction. The minimum bid rate is determined by the expected federal funds rate over the term of the auction as determined by the market. An individual bank’s bid cannot exceed 50 percent of the value of its pledged discount window collateral.³⁸ And, importantly, the TAF offers anonymity to the bidders.

³⁵ The data in Figure 7 suggest that the Open Market Desk had an asymmetric objective, attaching a higher cost to ending up above the target than coming in below it. This makes some sense, since in the middle of the crisis policymakers do not want to be responsible for a sudden rise in the risk-free interest rate.

³⁶ This is related to the fact the reserve requirement is averaged over a two week period ending every other Wednesday, there tends to be one day every two weeks when the market is more difficult to control. See Cecchetti (2008) Chapter 18 for a discussion of the mechanics of reserve management.

³⁷ See the discussion of the Auction Credit Facility in Chapter 3 of Federal Reserve System Study Group on Alternative Instruments for System Operations (2002).

³⁸ There have been claims that the TAF provides a way for banks to supply their worst collateral to the Federal Reserve, keeping the good stuff for use elsewhere. While this may be true in part, the fact that TAF bids must be over-collateralized by a factor of two, and that the awards have been systematically less than the bids, implies that this is not an important concern. See, for example, Tett (2008).

Starting in December, there have been two auctions per month, with total reserves supplied at \$60 billion through February, and \$100 billion starting in March. Importantly, banks bid in the auction in a way that they refuse to use the more traditional primary credit facility. Between 52 and 93 banks bid in the first six, and the total quantity of the bids has been roughly twice the total quantity supplied. And the interest rate on loans obtained through the auction has been below the primary lending rate available at the time. But more important than the low price banks have paid for the loans is the fact that they are willing to participate.³⁹ Table 3 summarizes the outcome of the first eight TAF auctions.

Auction Date	Amount Auctioned	Number of Bidders	Minimum Bid Rate	Bid-to-Cover Ratio	Stop-Out Rate
Dec 17	\$20 billion	93	4.17	3.08	4.650
Dec 20	\$20 billion	73	4.15	2.88	4.670
Jan 14	\$30 billion	56	3.88	1.85	3.950
Jan 28	\$30 billion	52	3.10	1.25	3.123
Feb 11	\$30 billion	66	2.86	1.95	3.010
Feb 25	\$30 billion	71	2.81	2.27	3.080
Mar 10	\$50 billion	82	2.39	1.85	2.800
Mar 24	\$50 billion	88	2.19	1.78	2.615
April 7	\$50 billion	Not completed			
April 21	\$50 billion	Not completed			

All U.S. commercial banks are qualified to bid. The minimum bid rate is the market-determined forward rate for the term of the loan in the uncollateralized interbank lending market of auction announcement. The bid-to-cover ratio is the ratio of the total quantity bid divided by the amount awarded in the auction. The stop-out rate is the interest rate at which the quantity auctioned equals the quantity bid. Each TAF auction is a single-price auction, with all awarded borrowers charged the stop-out rate.
Source: www.federalreserve.gov/monetarypolicy/taf.htm

Figure 9 reproduces the spread data from Figure 5, together with vertical lines at the dates of the first seven TAF auctions. The spread declines with each of the auctions until the last on 11 February 2008. It may seem surprising that that TAF would succeed at all where standard policy responses failed. The surprise comes from the fact that the auctions involve a change in the composition of the Fed's assets.⁴⁰ The shift in securities held either outright or in repurchase agreements, to loans, leaves the quantity of assets unaffected. And it is quite separate from the changes in the federal funds rate target.

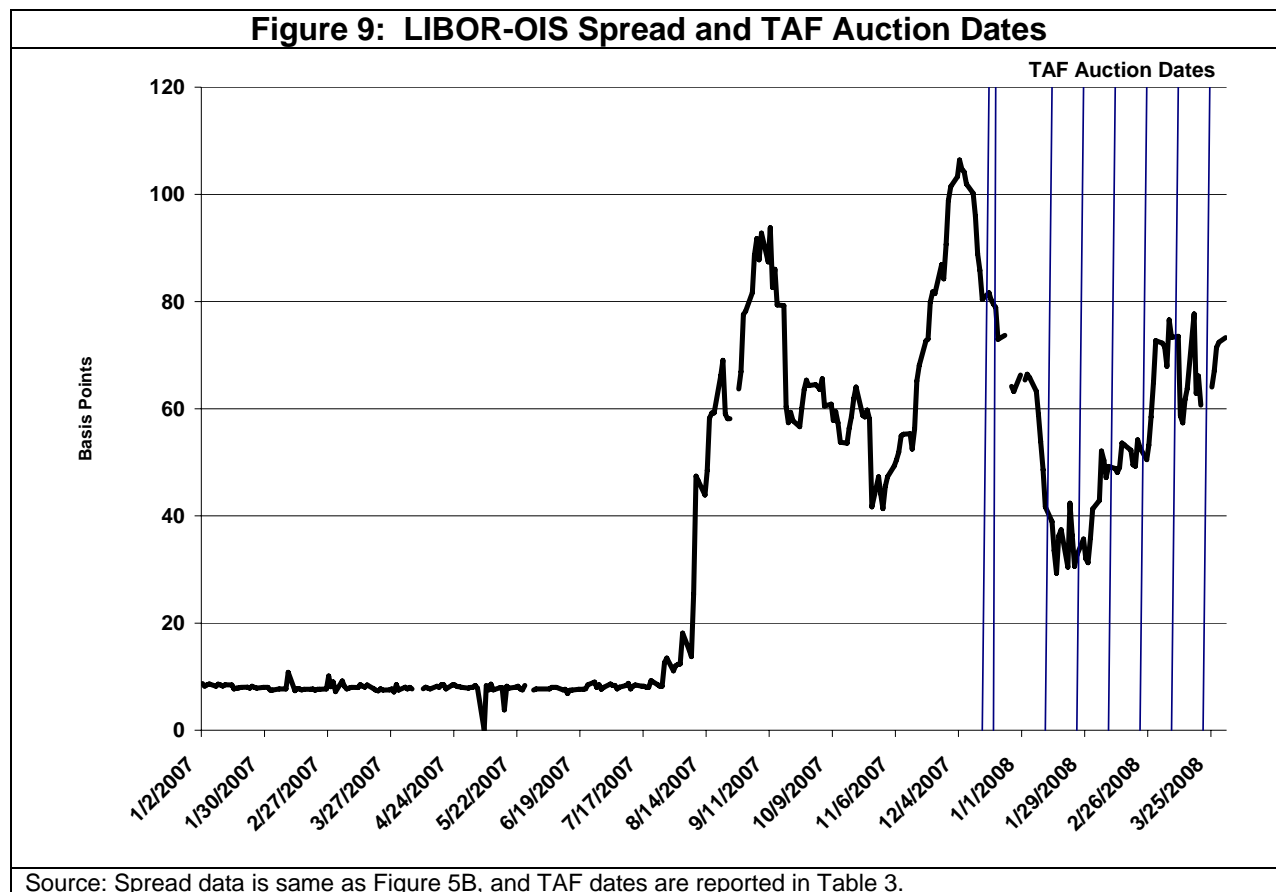
The reason for the surprise is that things like this have been tried and failed in the past. During the early 1960s, the Fed attempted to flatten the yield curve, selling short-term Treasury bills and buying long-term Treasury bonds in what came to be called "Operation Twist."⁴¹ Sterilized foreign exchange intervention, whereby the central bank exchanges securities denominated in

³⁹ The Federal Reserve's weekly balance reports TAF lending separately by Federal Reserve District. It is interesting to note that roughly two-thirds of the loans are going to banks in the New York district, the location of the U.S. subsidiaries of foreign banks. This is at least consistent with the possibility that the TAF loans are going primarily to European banks. See the line labeled "Term Auction Credit" in Table 4 of the H.4.1 weekly release.

⁴⁰ Taylor and Williams (2008) do argue that it has been ineffective.

⁴¹ See Volcker (2002) for a description.

one currency for securities in another, is another example.⁴² There is a broad consensus that these sorts of thing simply do not work.



Over the fall of 2007 central banks became aware of something that they had not expected. While there is a well established mechanism for injecting reserves into a country's financial system, there is no way to guarantee that it will get to the banks that need it. So, in the case of the U.S. the fact that standard Open Market Operations can put reserves into the hands of 19 primary dealers does not mean that the funds will then be distributed in the system. While we have not discussed this, the problem turns out to be particularly acute when the banks that are short dollar reserves are not American banks.⁴³

But the TAF does more than merely distribute funding to the banks that need it. The rules of the TAF allow banks to pledge collateral that might otherwise have very little market value. Technically TAF loans may be over-collateralized by at least a factor of two, but in reality the Fed is taking collateral at a price that is almost surely above what they could get for it elsewhere. The result of this is two-fold. First, it gets liquidity to places where it wasn't going. And second, it gives banks the time they need to value the assets they have.

Returning to Figure 9, we can see that as the winter of 2008 progressed, the LIBOR-OIS spread began to increase again. After falling from over 100 basis points in early December to

⁴² The last American foreign exchange intervention was on 22 September 2000.

⁴³ The creation of the swap lines in which the ECB and the Swiss National Bank then supplied \$10 billion and \$4 billion to their banks respectively was designed to relieve the shortage of dollars in the European banking system.

less than 30 basis points in late January, stress increased again in February. As March dawned, the spread approached 90 basis points.⁴⁴

Term Securities Lending Facility

It was at this point, with measures like the agency spread in Figure 6 far above its historical norm, that Federal Reserve officials showed their capacity for innovation yet again. First they increased the size of the TAF from \$60 billion to \$100 billion, and then, on 11 March, they announced an extension in their long-standing securities lending program creating the Term Securities Lending Facility (TSLF). Understanding the TSLF requires some explanation.

For many years the Fed has lent Treasury securities to primary dealers on an overnight basis.⁴⁵ The purpose of the lending is to reduce the number of failed securities transactions. Treasury dealers routinely sell and promise to deliver securities that they do not own, counting on their ability to procure the right Treasury bill, note or bond in time to complete the transaction. Sometimes the sellers miscalculate. This is where the lending program comes in. Unable to obtain the specific issue they have promised to deliver, a primary dealer can go to the Fed in the early afternoon and get what they need. There is a small fee for this, and the borrower is expected to return the security the next day. Since the Fed holds some of nearly every Treasury issue, they can lend whatever is needed, thereby ensuring that markets function smoothly.⁴⁶

The TSLF takes this existing lending program and transforms it in two important ways. First, while the traditional program lends overnight, the new one provides securities for 28 days. Second, the TSLF broadens the collateral accepted quite dramatically. Until March 2008, loans traded one Treasury security for another. So, if someone simply had the wrong mix of securities in their inventory, they could go to the Fed temporarily for help. By contrast, the TSLF explicitly allows broader collateral, including “AAA/Aaa-rated private-label residential [mortgage-backed securities] not on review for downgrade.”⁴⁷ And finally, the Fed announced its willingness to loan up to \$200 billion through the TSLF.

Operationally, the TSLF is an auction where primary dealers bid for Treasury securities. Potential borrowers bid the fee they are willing to pay, with a 25 basis point minimum. In the first auction on 27 March 2008, the Fed offered \$75 billion face value of securities, received \$86.1 billion in bids and the winning bid was 33 basis points. So, for 33 basis points a dealer could exchange a residential mortgage-backed security that might be selling at discount implying a risk premium of up to several hundred basis points for a Treasury security.

The securities lending program is really an extension of the TAF – another mechanism that changes the composition of the Fed’s asset holdings without affecting their size. While the Fed is not explicitly selling its Treasury holdings and buying residential mortgage-backed securities (MBS), what they are doing something is conceptually equivalent. And like previous changes in asset composition, this one is directed at reducing risk spreads. The TAF was aimed at

⁴⁴ One possible explanation for this pattern is that, while the ECB participated in the TAF by auctioning off dollars in December and January, they did not continue in February. The pattern in Figure 7 is consistent with the conclusion that the spread widened as soon as the ECB stopped participating.

⁴⁵ The lending program has been included in the annual authorization of open market operations since at least 1978, the first year for which the FOMC meeting minutes are available in electronic form.

⁴⁶ In February 2008, the Federal Reserve held 210 of the 238 distinct Treasury issues outstanding. See www.ny.frb.org/markets/soma/sysopen_accholdings.html for the exact Fed holdings.

⁴⁷ See the announcement at www.ny.frb.org/newsevents/news/markets/2008/rp080311.html.

interbank lending, the TSLF is directed toward the spreads on MBS that had become elevated as financial market participants started to shun them. The hope is that if primary dealers can exchange MBS for Treasuries through the new lending program, then traders and asset managers would be willing to hold them again.

Bear Stearns

Friday 14 March 2007, the Federal Reserve Bank of New York made a loan directly to Bear Stearns. Data released on 20 March, combined with press reports that the loan was repaid on Monday 17 March, allow us to infer that Bear borrowed approximately \$12.9 billion over the weekend.

Article 13.3 of the Federal Reserve Act gives the Board of Governors the power to authorize Federal Reserve Banks to make loans to any individual, partnership, or corporation provided that the borrower is unable to obtain credit from a banking institution. Fed officials had concluded that Bear Stearns was on the brink of failure not because it was insolvent, but because it was illiquid. But since it is not a commercial bank, Bear Stearns could not obtain a traditional discount loan.

By any measure, this was an extraordinary action. Not since the 1930s had the Fed actually made a loan based on Article 13.3. But after determining that the failure of Bear Stearns would put the entire financial system at risk, they did. And then, over the weekend, central bank officials brokered a deal in which JP Morgan Chase purchased Bear Stearns. Included in the deal is the promise of a \$29 billion loan from the Federal Reserve Bank of New York.

Primary Dealer Credit Facility

The evening of Sunday 16 March the Federal Reserve used this power in Article 13.3 a second time in three days to create the PCDF. The 19 primary dealers authorized to participate in daily open market operations and the Treasury auctions are not banks. They are investment banks and brokers. As a result, they do not have access to either traditional discount loans or the TAF. Now they can borrow.

Like discount loans made to commercial banks, the PCDF allows borrowers to pledge a relatively broad set of collateral. Importantly, since primary dealers are involved in open market operations, to do anything at all, the PCDF had to accept collateral that is broader than what can be used in standard open market repurchase agreements. Collateral for loans to primary dealers includes “investment-grade corporate securities, municipal securities, mortgage-backed securities and asset-backed securities for which a price is available.”⁴⁸

Unlike the traditional discount window, which commercial banks continue to shun, the PCDF was immediately popular. For the first 10 days of its existence, borrowing averaged slightly over \$30 billion per day. (A close look at Figure 8 reveals that the implementation of the PCDF made the federal funds rate even more difficult to control than it had been.)

We can identify two objectives of the PCDF. The first is simply to insure the liquidity of the investment banks that now have direct borrowing access. Experience with Bear Stearns, which sustained a sudden loss of liquidity but looks to have remained solvent, made Fed officials realize that lender-of-last resort operations needed to be extended beyond commercial banks.

⁴⁸ See the announcement at www.ny.frb.org/newsevents/news/markets/2008/rp080316.html.

In addition, and like the reformulated securities lending program, the PCDF is designed with the idea of helping to reduce spreads on the eligible collateral. Since primary dealers can now take a relatively broad set of bonds to the Fed and obtain immediate cash, the idea is that these securities should now be more readily acceptable as collateral in private borrowing arrangements. This is one of those things that if it works, all the Fed should have to do is announce the program; they should not have to make the loans. Looking back at Figure 7, we can see that the agency spread fell immediately on 17 March with the creation of the PCDF and continued to decline, although much more modestly, as the TSLF got going. By the end of March, the agency debt yields that are normally 15 to 25 basis points were still 60 basis points – not great, but better than they were the week before.⁴⁹

The Evolution of the Federal Reserve's Balance Sheet

To understand the comprehensive impact of all of these changes in Fed operations, we now return to the balance sheet. Figure 4 shows the evolution Fed assets over the nine months from July 2007 to March 2008; and the changes are enormous.⁵⁰ (Since they have not changed in any material way, I omit the liabilities side.)

	4 July 07	2 Jan 08	19 March 08	26 March 08
Securities				
Held Outright	\$790.6	\$740.6	\$660.5	\$612.3
Repurchase Agreements	\$ 30.3	\$ 56.3	\$ 62.0	\$106.8
Loans				
Primary Credit	\$ 0.19	\$ 4.9	\$0.12	\$0.58
Term Auction Credit		\$ 40.0	\$80.0	\$80.0
Primary Dealer Credit			\$28.8	\$37.6
Other credit extensions			\$0.0	0
Foreign Exchange Reserves	\$ 20.8	\$27.3	\$27.3	\$27.3
Gold	\$ 11.0	\$11.0	\$11.0	\$11.0
<u>Other assets</u>	<u>\$27.5</u>	<u>\$45.6</u>	<u>\$21.0</u>	<u>\$20.2</u>
Total Assets	\$880.4	\$925.7	\$890.7	\$895.8
Note: The swap agreements with the SNB and ECB appear in the "other assets" line. These were active on 2 January 2008, but not on the other dates in this table.				
Source: Board of Governors of the Federal Reserve System, Release H.4.1, various dates.				

⁴⁹ It is difficult to know exactly what is responsible for this reduction in the spread. It could have been the new Federal Reserve programs, the PCDF and TSLF, but it also could have been the reduction in Fannie Mae's and Freddie Mac's capital requirements announced on 19 March or Goldman Sachs and Lehman Brothers release of their quarterly earnings on 18 March.

⁵⁰ It is worth noting that aid to commercial banks does not end with the changes in Federal Reserve practice. The little-known Federal Home Loan Banks have been another source of funding. During second half of 2007, these government-sponsored enterprises provided commercial banks with roughly \$230 billion in loans. These loans are for longer terms than the discount window, are cheaper than discount loans even at a penalty spread of 25 basis points, and allowed for a broad range of mortgage-based collateral.

Before the crisis, the Fed held nearly \$800 billion in securities outright. That amount has been reduced to just over \$600 billion. Repurchase agreements used to be in the neighborhood of \$30 billion, now they exceed \$100 billion. Prior to December 2007, lending was inconsequential. Now, it exceeds \$100 billion. And all the while, the size of the balance sheet has hardly changed, rising at the end of the year to accommodate seasonal demand, but falling back since then.

VI. Conclusion

To recap, by early 2007 U.S. home prices had reached unprecedented levels; home owners had become more leveraged than they had ever been; mortgage quality had declined; and asset-backed securitization had spread well-beyond its traditional base. On 9 August 2007 the financial system started to crack. Banks realized that they held substantial amounts of mortgage-backed securities that were difficult to value. Experiencing large losses, banks' balance sheets could not accommodate additional lending. As a result, some financial intermediaries began to have trouble finding the short-term financing that was essential for them to carry on their daily business.

Seeing this, policymakers tried to figure out what to do. Traditional interest rate instruments proved to be ineffective, so Fed officials tried a variety of new things. Starting in mid-December, they changed the way in which they lent to commercial banks, creating the Term Auction Facility. Then, in mid-March they both offered to loan large amounts of Treasury securities in exchange for lesser-grade instruments, and began making loans directly to investment banks. Along the way, the Fed swapped dollars for euros with the ECB and Swiss francs with the Swiss National Bank; dramatically increased the size and term of the repurchase agreements they engaged in; and made an extraordinary loan to a single investment bank, Bear Stearns.

By lending both cash and securities, based on collateral of questionable value, the Fed has tried to bring some order back to the market. And the amounts are massive. By the end of March 2008, the Fed had committed more than half of their nearly \$1 trillion balance sheet to these new programs:

- \$100 billion to the Term Auction Facility,
- \$100 billion to 28-day repo of mortgage-backed securities,
- \$200 billion to the Term Securities Lending Facility,
- \$36 billion to foreign exchange swaps,
- \$29 billion to a loan to support the sale of Bear Stearns,
- and \$30 billion so far to the Primary Dealer Credit Facility.

Reflecting on all that has happened, it is natural to wonder whether the Federal Reserve should have refashioned their tools in the way that they did. It seems clear that the 19th century view of the lender of last resort does not work. But what should take its place? Should it be a more aggressive central bank that makes loans to a broader set of borrowers, taking credit risk along the way? Or, should this function belong to the Treasury? After all, it is the fiscal authority, not the monetary authority that has responsibility for the public purse.

But these are really questions for another day. In the heat of a financial crisis, the central bank is the only official body that can act quickly enough to make a difference. Politicians are not well-equipped to take actions literally from one day to the next. So, while we might want to

reassess the role of the central bank once the crisis is over, for now it is difficult to fault the Federal Reserve's creative responses to the crisis that began in August 2007. Let's just hope that they work.

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