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Abstract

This paper examines the Federal Reserve's unprecedented liquidity provision during the financial crisis of 2007-2009. It first reviews how the Fed provides liquidity in normal times. It then explains how the Fed's new and expanded liquidity facilities were intended to enable the central bank to fulfill its traditional lender-of-last-resort role during the crisis while mitigating stigma, broadening the set of institutions with access to liquidity, and increasing the flexibility with which institutions could tap such liquidity. The paper then assesses the growing empirical literature on the effectiveness of the facilities and provides insights as to where further research is warranted.

Key words: central bank, liquidity facilities, lender of last resort

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1. Introduction

The Federal Reserve (Fed) undertook numerous measures to mitigate the effects of the financial crisis that started in August 2007. Aside from easing the stance of monetary policy using its conventional tools, the central bank eased the terms with which it provided liquidity to depository institutions and launched a range of new programs to provide liquidity to other institutions. This article explains how and why the Fed engaged in such an unusual effort, whether the liquidity facilities operated as expected, and what the effects of the facilities were on financial markets.

The idea that a central bank should provide liquidity to support the financial system goes back to the 19th century work of Henry Thornton and Walter Bagehot. Bagehot suggested that in a liquidity crisis, a central bank should lend freely, at a high rate of interest relative to the pre-crisis period, to any borrower with good collateral (Freixas, Giannini, Hoggarth, and Soussa (2000)). Central banks may be best suited to provide liquidity because they have better information about the solvency of banks or because they have the ability to finance the entire banking sector's liquidity needs by virtue of their size and their unique ability to issue money (Flannery (1996)).

Since the Great Depression, the Fed has provided liquidity to individual institutions by way of its discount window, through which the Fed makes fully collateralized short-term loans to depository institutions at a penalty rate. While the window has traditionally met institutions' unusual, short-term funding needs, there is evidence that firms are reluctant to come to the window because of a perceived stigma. Furthermore, the window is not open to non-depository institutions, which have taken on an increasingly important role in financial intermediation over the past 30 years (Adrian and Shin (2010)).

During the crisis, the Fed initially adjusted the terms of discount window use to expand liquidity provision to depository institutions. It proceeded to introduce numerous additional facilities to increase the flexibility with which institutions could access liquidity, to broaden the set of institutions eligible to access liquidity, and to mitigate institutions'

traditional hesitance to draw on such facilities.[1] The Fed's unprecedented response and the active use of the new programs present a unique opportunity to assess the effectiveness of central bank liquidity facilities.

We begin this article by reviewing Federal Reserve liquidity provision before the financial crisis. We proceed to discuss how and why the Fed expanded its liquidity provision during the crisis through an extraordinary range of new and existing programs. We then assess the empirical evidence on the effectiveness of the liquidity facilities, including whether the programs operated as expected, as well as their effects on financial markets. The last section concludes.

2. Background

The Federal Reserve uses open market operations as its principal tool to manage reserves in the banking system and thereby control the federal (fed) funds rate. To add reserves on a "permanent" (or long-term) basis, for example, the Fed buys securities in the secondary market. To add reserves on a "temporary" (or short-term) basis, it engages in repurchase agreements (repos) whereby it buys securities while agreeing to resell them at a later date. In either case, the Fed transacts with the "primary dealers" (dealers with a trading relationship with the Fed), with reserve balances affected when the Fed receives or sends funds to a dealer's account at its clearing bank.

The discount window operates as a backstop, providing a source of reserves to individual depository institutions when conditions in the fed funds market tighten or when depository institutions face short-term funding pressures. "Primary credit" lending, in particular, is available on a short-term basis to institutions with strong financial positions and ample capital (the window also offers "secondary credit" to institutions that do not qualify for primary credit and "seasonal credit" to small and medium-sized institutions with a recurring pattern of seasonal funding needs). Discount window loans are offered at a rate above the fed funds rate and must be fully collateralized.

[1] The Fed also provided support for specific institutions and it engaged in direct purchases of assets. We focus on the liquidity facilities in this article.

While the Fed's traditional framework for liquidity provision has generally been adequate, there have also been signs of its limitations. In particular, the effectiveness of the discount window is thought to be limited by the reluctance of depository institutions to approach the window because of a perceived stigma (see, for example, Clouse (1994), Peristiani (1998), and Furfine (2003)). The stigma arises from a perception that market participants will draw adverse inferences about an institution's financial condition if its borrowing were to become known. To mitigate stigma, the Fed has historically not released the names of borrowers from the window, although the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 now requires that the Fed disclose details of discount window loans with a two-year lag.

Concerns about stigma also motivated a key change to the discount window in 2003. Until then, the main lending rate was typically set below the fed funds rate, creating an incentive for institutions to borrow from the window. To compensate for this incentive, the Fed required institutions to exhaust other sources of funds before coming to the window and to explain their need for credit. This requirement is thought to have contributed to stigma, while also increasing uncertainty about an institution's ability to access the window. The 2003 change created a "no-questions-asked" policy for primary credit borrowing, potentially reducing such stigma. At the same time, the lending rate was set above the target fed funds rate, removing the incentive for institutions to borrow from the window under normal circumstances.

Aside from lending to depository institutions, section 13(3) of the Federal Reserve Act traditionally allowed the Fed to lend to individuals, partnerships, and corporations that are not depository institutions.[2] To do so, the Fed had to determine that credit was not available from other sources and that failure to provide credit would adversely affect the economy. Until the financial crisis of 2007-2009, such emergency lending had last been made in the 1930s.

[2] The Dodd-Frank Act limits such emergency lending to programs with broad-based eligibility for the purposes of providing liquidity to the financial system and requires that the Treasury Secretary provide prior approval of such programs.

While the Fed did not utilize its 13(3) authority in the decades leading up to the financial crisis, the Fed did depart from its traditional operating framework on various occasions. In advance of Y2K, for example, the Fed took several steps to ease concerns about a possible liquidity shortage, including extending the maximum term of its temporary operations and broadening the pool of securities that could be pledged as collateral in such operations. Of particular note, it created options which allowed primary dealers to borrow funds from the Fed at a predetermined spread to the fed funds target rate over a period that covered the century date change. Sundaresan and Wang (2009) find that the options eased funding concerns, causing the liquidity premium of Treasury securities to decline.

After the September 2001 attacks, the Fed supplied abundant liquidity to the banking system using its usual tools of open market operations and discount window loans (McAndrews and Potter (2002)). The Fed also established temporary swap arrangements with the European Central Bank and the Bank of England, and augmented the facility in place with the Bank of Canada. The agreements allowed the foreign central banks to draw U.S. dollars in exchange for local currency, which could then be lent to local banks to facilitate settlement of dollar transactions (Kos (2001)).

3. Federal Reserve Response to the Crisis

The Federal Reserve employed both conventional and unconventional policy on an unprecedented scale during the financial crisis. To address the deteriorating economic outlook, the Fed lowered the fed funds target rate 10 times between September 2007 and December 2008, to an ultimate level close to zero. Moreover, to address the disruptions in financial markets, the Federal Reserve introduced or expanded liquidity facilities, provided support for specific institutions, and engaged in direct purchases of assets. The liquidity facilities employed and some of their characteristics are listed in Table 1.

a. Liquidity Provision to Banks

The start of the financial crisis, and the initial policy responses, are often dated to August 2007, when problems in the interbank lending market emerged. On August 9, 2007,

BNP Paribas announced that it was unable to determine net asset values for three of its credit-focused hedge funds because of illiquid markets and would suspend redemptions from those funds. The announcement caused financial institutions to reassess their counterparty credit risk, especially given concerns over the credit quality of subprime mortgages. The disruptions in the interbank lending market are illustrated in Figure 1 by the spread between the London interbank offered rate (LIBOR) and the overnight indexed swap (OIS) rate, a measure of average expected overnight rates. The rise in the spread reflects the increased perceived riskiness of lending at longer maturities.

On August 10, the Fed announced that it was providing liquidity to financial markets using its usual tools of open market operations and the discount window. One week later, on August 17, the Fed announced temporary changes to its primary credit discount window facility to reduce depository institutions' uncertainty about the cost and availability of funding. In particular, the Fed reduced the primary credit rate, narrowing the spread of the rate over the fed funds target rate, and extended the allowable term of lending to as long as 30 days. The Fed later narrowed the spread of the primary credit rate over the fed funds target rate further and increased the maximum maturity of loans to 90 days.

On December 12, 2007, to further address funding pressures in short-term lending markets, the Fed announced the Term Auction Facility (TAF). Through the TAF, the Fed auctioned loans to depository institutions, typically for terms of 28 or 84 days. As explained in Armantier, Krieger, and McAndrews (2008), the facility enabled the Fed to allocated funds directly to a large number of institutions, while potentially mitigating stigma through the auction format. The TAF also had an operational advantage over the discount window because it allowed the Fed to control how much and when liquidity would be added to markets.

The Fed also established reciprocal currency arrangements, or swap lines, with the European Central Bank and the Swiss National Bank on December 12, 2007. The arrangements allowed the foreign central banks to lend U.S. dollars to banks in their jurisdictions. The provision of dollar funding was expected to reduce foreign institutions' funding rollover risk and increase the predictability of funding costs, just as the TAF was

intended to do for domestic banks. The swap lines were later extended to an additional 12 foreign central banks.

b. Liquidity Provision to Dealers

In early 2008, the secured funding markets relied on by dealers became severely impaired. Lenders of funds became increasingly concerned about losing money because of worries about the value of the collateral backing their loans as well as the credit risk of their counterparties. Lenders responded by increasing haircuts (the difference between the market value of the collateral and funds lent), by demanding greater compensation for lending against riskier collateral, or by halting lending against certain types of collateral altogether (Gorton and Metrick (2012)). As shown in Figure 2, for example, the overnight agency and agency MBS repo spreads to Treasury repo, which were historically quite narrow, started widening out in the second half of 2007, and were especially wide in early 2008.

To address liquidity pressures in the term funding markets relied on by dealers, the Fed announced on March 7 that it would initiate a series of single-tranche open market operations in which primary dealers could bid to borrow funds through repos for a term of 28 days while providing as collateral any of the types of securities eligible as collateral in conventional open market operations (that is, Treasury securities, agency debt securities, and agency mortgage-backed securities). The operations provided term funding via an auction format like the TAF, but for primary dealers.

On March 11, the Fed announced the introduction of the Term Securities Lending Facility (TSLF), through which it auctioned loans of Treasury securities to primary dealers for terms of 28 days. Because the facility involved the exchange of securities for securities, it had no effect on the supply of bank reserves and thus did not directly affect the Fed's implementation of interest rate policy. This made the TSLF unusually flexible in terms of size, allowing it to be scaled up or down quickly. The other important difference from the single tranche operations is that the facility accepted a broader range of collateral for some of its operations. As part of the TSLF, the Fed later announced the start of the Term

Securities Lending Facility Options Program, through which the Fed auctioned options on draws on the TSLF to address liquidity pressures around periods typically characterized by heightened stress, such as quarter ends.

On March 16, the same day that JPMorgan Chase agreed to acquire Bear Stearns to stave off its bankruptcy, the Fed announced the creation of the Primary Dealer Credit Facility (PDCF), through which the Fed made overnight loans to primary dealers at the discount window's primary credit rate. This was effectively the extension of discount window lending to primary dealers. The standing facility offered the flexibility of discount window lending because it was available any time, unlike the auction facilities, and it allowed for a wide range of eligible collateral, broader than either the TSLF or open market operations. The Fed later announced liquidity support for certain securities subsidiaries of Goldman Sachs, Morgan Stanley, and Merrill Lynch, and for Citigroup's London-based broker-dealer subsidiary, under terms similar to that of the PDCF.

c. Liquidity Provision to Other Market Participants

The bankruptcy of Lehman Brothers on September 15, 2008 led to an unparalleled broadening and intensification of money market disruptions. On September 16, the Reserve Primary Fund, a prime money market mutual fund with exposure to Lehman Brothers, "broke the buck" (that is, its net asset value fell below $1 per share). This led to an unprecedented flight-to-quality from high-yielding money market mutual funds to Treasury-only money market mutual funds. The investor flows, in turn, impeded the ability of commercial paper issuers to roll over their short-term liabilities. The disruptions are illustrated in Figure 3, by the striking rise in term commercial paper rates relative to OIS.

The Federal Reserve introduced several additional facilities to address the new disruptions. On September 18, the Fed announced the creation of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF). Through this facility, the Fed made loans at the primary credit rate to depository institutions and bank holding companies to finance their purchases of high-quality asset-backed commercial paper (ABCP) from money market mutual funds. The AMLF helped money funds holding

ABCP to meet redemption demands from investors and promoted liquidity in the ABCP and broader markets. The AMLF was limited to purchasing ABCP, however, while market disruptions affected commercial paper more broadly.

To address the wider problems in the commercial paper market, the Fed announced the creation of the Commercial Paper Funding Facility (CPFF) on October 7, 2008. Through the facility, the Fed provided credit to a special-purpose vehicle (SPV) that, in turn, bought newly issued three-month commercial paper from eligible issuers. The CPFF effectively represented the extension of the Fed's lender-of-last resort liquidity provision to issuers of commercial paper.

On October 21, 2008, the Fed announced the establishment of the Money Market Investor Funding Facility (MMIFF). Through the MMIFF the Fed could provide secured loans to a series of private sector SPVs to finance the purchase of certain money market instruments from eligible investors. The facility, which was never used, was thus intended to improve the liquidity of money market investors and enhance their ability to meet redemption requests and their willingness to purchase money market instruments.

Lastly, the Fed announced on November 25, 2008, its intent to create the Term Asset-Backed Securities Loan Facility (TALF). The Fed made loans through the TALF to eligible owners of certain asset-backed securities, while the U.S. Treasury Department provided credit protection to the Fed through the Troubled Asset Relief Program. The TALF supported the issuance of asset-backed securities and thereby increased credit availability and economic activity.

d. Other Actions

Aside from its use of conventional policy and liquidity facilities, the Federal Reserve took other extraordinary actions during the financial crisis. To improve market conditions, the Fed instituted programs to purchase assets directly. Under programs first announced in November 2008 and March 2009, the Fed ultimately purchased $1.25 trillion of agency

mortgage-backed securities (MBS), $172 billion of agency debt securities, and $300 billion of longer term Treasury securities by the end of March 2010.[3]

The Fed also provided support for specific institutions during the crisis to promote financial market stability. In March 2008, it provided special financing to facilitate the acquisition of Bear Stearns by JPMorgan Chase. In September and October 2008, the Fed provided support for AIG (American International Group) to assist the firm in meetings its obligations, to facilitate the orderly sale of some of its businesses, and to finance fixed-income securities it held. In November 2008 and January 2009, the Fed agreed to provide credit under certain conditions to Citigroup and Bank of America, respectively.

e. Balance Sheet Implications

The Federal Reserve's efforts to mitigate the strains in financial markets led to an unprecedented expansion of its balance sheet (Figure 4). Federal Reserve assets rose from $869 billion on August 8, 2007, to $2,256 billion on December 17, 2008. Assets increased fairly modestly through much of the first year of the financial crisis, as growth of the liquidity facilities was offset by decreases in securities held outright (the Fed's bill portfolio dropped from $277 billion on August 22, 2007, to $18 billion on September 24, 2008). In fall 2008, however, the liquidity facilities and total assets both grew sharply.

Changes in the amounts outstanding under the liquidity facilities are largely explained by the evolution of the three largest programs: the central bank liquidity swaps, the CPFF, and the TAF (Figure 5). Amounts outstanding were essentially zero before the introduction of the TAF and the liquidity swaps in December 2007. The facilities grew sharply in fall 2008--with the expansion of the TAF and the liquidity swaps, and the introduction of the CPFF--to $1,599 billion outstanding on December 10, 2008.

Outstanding amounts under the facilities subsequently declined as market conditions improved and the facilities were largely wound down. The last single-tranche

[3] In November 2010 it announced its intent to purchase an additional $600 billion in longer term Treasury securities by the end of June 2011. In September 2011 it announced its decision to extend the average maturity of its holdings of securities by purchasing long-term Treasury securities and selling an equal amount of short-term Treasury securities. In June 2012, it announced its decision to continue its program to extend the average maturity of its holdings of securities.

open market operation outstanding matured January 28, 2009; the MMIFF was not extended past its October 30, 2009, expiration; and the AMLF, central bank swap lines, CPFF, PDCF, and TSLF all expired February 1, 2010.[4] The final TAF auction occurred March 8, 2010, and the extension of credit through the TALF expired March 31, 2010, or June 30, 2010, depending on the type of securities being financed. Temporary changes to the discount window were also reversed in early 2010.

4. Liquidity Facility Effectiveness

The Federal Reserve's unprecedented liquidity provision during the crisis has spurred a growing literature into the facilities' effectiveness. Assessment of the facilities' effectiveness faces at least two challenges common to financial research. One challenge relates to data availability. There is limited price data for many securities, reflecting the opaque nature of the over-the-counter markets in which many securities trade. Data on haircuts, critical to understanding the deleveraging that occurred during the crisis, are also hard to come by (but are examined in Copeland, Martin, and Walker (2010), Krishnamurthy, Nagel, and Orlov (2011), and Gorton and Metrick (2012)). Data for particular counterparties involved in trades are even scarcer.

A second challenge concerns the extraordinary events of the financial crisis. During the crisis, the Fed eased the conventional stance of policy, expanded or introduced numerous liquidity facilities, engaged in direct purchases of assets, and provided support for specific institutions. Other policy institutions within and outside the United States took numerous additional measures. Moreover, there were a myriad of firm- and market-specific developments independent of the policy measures. The sheer number of pertinent developments and their endogenous nature makes it hard to identify the effects of any single effort or range of efforts.

Given such difficulties, it is not surprising that many of the studies on the facilities focus on changes in market prices in narrow windows around facility announcements

[4] In May 2010, the Fed reauthorized dollar liquidity swap lines with several foreign central banks through January 2011. In December 2010, authorization was extended through August 1, 2011, and in June 2011, authorization was extended through August 1, 2012.

and/or operations. Such an approach can successfully isolate the market's response to a program's effects, but assumes that prices would not have changed in the absence of the events. Moreover, the approach does not capture the full effects of a program to the extent that pertinent events occur outside the windows. In addition, even if an analysis does cleanly identify short-term effects, it does not necessarily follow that such changes would not have been observed in subsequent months or years without the facility, and it does not consider the program's longer-term effects (e.g., in subsequent crises), be they positive (e.g., decreased market fragility) or negative (e.g., increased moral hazard).

In considering the effects of the facilities as well as their operations, a further point to note is the programs' limited mandate. The facilities were not intended to address credit concerns or capital shortages. Rather, they were intended to mitigate the liquidity disruptions in financial markets by providing collateralized, short-term loans to creditworthy institutions at an interest rate higher than the normal cost of funds. It is along these dimensions that the operations of the facilities and their effects on financial markets are assessed.

a. Did the Facilities Operate as Expected?

We first assess facility effectiveness by considering whether the facilities operated in accord with lender-of-last-resort principles and whether they were able to overcome borrower aversion to central bank borrowing. That is, we consider whether the facilities provided funding at a penalty rate to the normal cost of funds (albeit not such a penalty that they would not be used at times of crisis), whether the borrowings were well collateralized, and whether the facilities were able to overcome the stigma that is thought to affect discount window borrowing. Our intent here is not to scrutinize the features of the various programs, but to ask whether the evidence from the facilities' utilization is broadly consistent with lender-of-last-resort principles.

The pattern of borrowing across the facilities as a whole, as well as most individual facilities, supports the conjecture that loan pricing was largely appropriate. Most facilities garnered significant participation at their inception, when market disruptions were acute,

but then saw participation fall off as market conditions improved. The high utilization during the crisis suggests that the pricing was not so onerous as to preclude participation and that some of the traditional hesitance to borrow from the Fed may have been reduced. The rapid decline in facility usage as market conditions improved suggests that pricing was generally set at a penalty to the normal cost of funds.

There were some exceptions to this penalty pricing rule, as might be expected given the wide range of facilities. Single-tranche open-market operations, for example, were structured as an extension of the Fed's regular open market operations and were thus intended to allocate the full quantity of offered collateral at a market determined rate. Pricing for the TAF was also market determined, which resulted in a high borrowing rate relative to the pre-crisis period at inception, but a rate which declined sharply as conditions in the funding markets improved. Nonetheless, the main finding that emerges from across the facilities, and emphasized by the pattern of amounts outstanding in Figures 4 and 5, is that lending for the facilities was suitably priced.

There is also evidence that the liquidity facility borrowings were well collateralized. While it is beyond the scope of this article to consider whether the particular haircuts imposed on collateral were appropriate, nearly all of the programs either required that borrowings be overcollateralized or that fees be imposed to provide a cushion against losses. The AMLF was an exception in that borrowings were collateralized, but not overcollateralized (that is, no haircut was applied), but asset-backed commercial paper is itself overcollateralized. The fact that the Fed profited from the facilities (Fleming and Klagge (2011)) and did not suffer any credit losses is consistent with the facilities having provided well-collateralized loans to creditworthy institutions at a penalty rate.

The issue of borrowing stigma during the crisis is addressed most directly by Armantier, Ghysels, Sarkar, and Shrader (2011). They compare participation in TAF auctions with discount window borrowing and find evidence of significant discount window stigma. Specifically, they find that banks were willing to pay an average premium of 37 basis points at the height of the crisis to borrow from the TAF rather than the discount window. They further uncover evidence rationalizing banks' hesitance to use the discount window by

finding that banks visiting the window tended to face a rise in borrowing costs and decrease in stock prices relative to banks that did not visit the window. Note that the finding of discount window stigma relative to the TAF is implicit evidence of the TAF having been able to overcome the traditional borrowing stigma.

Another study, by Krishnamurthy, Nagel, and Orlov (2011), focuses on repo funding extended by money market funds and securities lenders to the shadow banking system. It finds that firms that backed their repo financing with riskier/less liquid collateral prior to the rescue of Bear Stearns borrowed greater amounts from both the PDCF and the TSLF. The PDCF result only holds for firms relying more on "private" collateral than agency collateral, which the authors argue is consistent with there being a stigma to borrowing from the PDCF. They also uncover evidence that TSLF borrowing was cheaper than market borrowing, perhaps reflecting a stigma attached to TSLF borrowing.

b. What was the Effect of the Facilities on Financial Markets?

We next assess the effects of the facilities on financial markets. Much of the work in this area focuses on the two facilities that were introduced first during the crisis and that grew to be the largest: the Term Auction Facility and the central bank liquidity swaps. For the TAF, McAndrews, Sarkar, and Wang (2008) show that the three-month LIBOR-OIS spread tended to narrow on announcement and operation dates. They find that the cumulative effect of the program as of April 2008 was an economically meaningful 57 basis points. The effects from announcements (as opposed to operations) are the strongest statistically and are responsible for about half of the total effect.

In contrast, Taylor and Williams (2009) do not find robust evidence that the TAF had a significant effect on LIBOR-OIS spreads. One reason for the discrepancy from McAndrews, et al. is that Taylor and Williams do not consider announcement effects in their baseline specifications. Another reason is that Taylor and Williams use operation date dummy variables to explain the level of LIBOR-OIS (and not changes in LIBOR-OIS). Mcandrews, et al. and Wu (2011) point out that such a specification makes sense if one only expects to observe the effects of the TAF on operation days and not on subsequent days. Taylor and

Williams do find significant results of TAF when they replicate the approach of McAndrews et al., but they note that the announcement result is not robust to the use of alternative dependent variables (such as the term fed funds-OIS spread).

Wu (2011) also models the level of LIBOR-OIS spreads, but uses an analogous TAF dependent variable, defined to be zero for the pre-TAF days and one thereafter. The approach thus assumes a permanent effect from the introduction of the TAF and is not dependent on the precise identification of announcement days or high-frequency rate changes, but requires that exogenous variables be properly controlled for. Wu finds a permanent effect from the TAF on the three-month LIBOR-OIS spread of 50-55 basis points and a similar sized effect on other money market spreads (such as the term fed funds-OIS spread).

Christensen, Lopez, Rudebusch (2009) examine the effects of the TAF (and central bank liquidity swaps announced at the same time) by estimating a six-factor arbitrage-free model of U.S. Treasury yields, financial corporate bond yields, and term interbank rates. They find a significant shift in model estimates after the announcement of the new facilities, suggesting that the programs helped lower the liquidity premium in interbank rates. Their analysis suggests that three-month LIBOR was 70 basis points lower than it otherwise would have been from December 2007 to the middle of 2008.

Thornton (2011) notes, however, that the results in Christensen, et al. are driven by the widening of the spread between AA-rated financial bond rates and the equivalent maturity LIBOR rate. Rather than being attributable to a reduction in the liquidity premium because of the TAF, he provides support for an alternative hypothesis. Specifically, he argues that the announcement of the TAF increased the risk premium in financial and other rates because it was interpreted as signaling that the crisis was worse than previously thought. After controlling for risk spreads, he finds that the TAF appears to have had little effect on the three-month LIBOR-Treasury bill spread.

In addition to studies that jointly examine the effects of the TAF and central bank liquidity swaps, several studies assess the swaps by themselves. Fleming and Klagge (2010) and Goldberg, Kennedy, and Miu (2011) characterize the origins of the swaps program, how

it worked, and its effects, broadly finding that it eased strains in dollar funding markets. Baba and Packer (2009) examine the effects more formally, relating dislocations in the foreign exchange swap market to dollar auctions by foreign central banks as well as key changes in central banks' commitment to the program. They find that the Fed's commitment to unlimited swap lines with certain foreign central banks and the dollar auctions themselves ameliorated the dollar shortage in the swap market after, but not before, the failure of Lehman Brothers.

A couple studies exploit the cross-section of countries whose central banks participated in the swap program. Aizenman and Pasricha (2010) focus on the extension of the swap lines to emerging markets and find that the exposure of U.S. banks is the most important selection criterion. They find credit default swap spreads of the four emerging markets that received swap lines declined more than those of other emerging markets upon announcement, albeit not significantly so (note the small sample size). Rose and Spiegel (forthcoming) examine the effects of dollar auctions on CDS spreads for a large cross-section of countries and find that countries with greater exposure to the U.S. through trade or financial channels benefitted most. Their results for many of the swap line announcements are similar.

In contrast to the work on facilities targeted to banks' liquidity concerns, there has been little work on facilities set up for dealers. No studies known to the author have examined single-tranche open market operations, perhaps reflecting the relatively small size of the program (peaking at $80 billion), as well as the limited attention these operations received given that they were executed as a part of the Fed's usual open market operations. For the PDCF as well, the author knows of no studies that have formally examined the program's effects, although in their descriptive article, Adrian, Burke and McAndrews (2009) note that credit default swap spreads of primary dealers declined for about three months following the program's introduction. Work on the PDCF has likely been curbed by the limited program information released in real time, as compared to facilities such as the TAF for which the Fed released extensive information in real time.

The best empirical evidence for the dealer facilities is for the TSLF, and it suggests that the program was effective at mitigating strains in secured funding markets. Fleming, Hrung, and Keane (2009) characterize the TSLF and find that the initial operations were associated with a narrowing of repo spreads between less liquid and more liquid collateral. Fleming, Hrung, and Keane (2010) show statistically that changes in the amount outstanding under the facility are negatively related to changes in repo spreads. Interestingly, both studies show that the narrowing of spreads emanated more from an increase in Treasury repo rates than from a decrease in repo rates on less liquid collateral, suggesting that much of the effects of the facility came through easing the shortage of liquid Treasury collateral.

Duygan-Bump, Parkinson, Rosengren, Suarez, and Willen (forthcoming) provide some of the most convincing evidence on the effects of the liquidity facilities in their study of the AMLF. Unlike other studies, which mostly examine aggregate data, their study uses detailed transactions and rate data to exploit both time series and cross-sectional variation using a differences-in-differences approach. They show that facility participation was more likely among funds with larger redemptions and with a larger share of asset-backed commercial paper in their portfolios. They further find that money market mutual fund outflows decreased more for funds that held more eligible collateral. In addition, they show that yields on eligible commercial paper decreased significantly relative to yields on comparable but ineligible paper.

Adrian, Kimbrough, and Marchioni (2011) overview the CPFF and offer a preliminary analysis of its effects. They find that the start of the CPFF precipitated a rise in term commercial paper issuance as redemption pressures eased. The further find that the expansion of the CPFF was accompanied by a narrowing of the spreads between commercial paper rates and comparable OIS rates. They note while the timing suggests the program had meaningful effects, further work is needed to determine the extent of such effects.

Ashcraft, Garleanu, and Pedersen (2010) model the effects of liquidity facilities with haircuts and examine empirically the expansion of the TALF to include existing asset-backed securities. They find that required rates of return on commercial mortgage-backed

securities declined when the program was announced, increased when a rating agency change made many securities ineligible for the program, and declined again when the program was implemented. Yields of both eligible and ineligible securities reacted to program news, consistent with the idea that the program had broad benefits. They also find that yields of individual securities rose when it became known that those particular securities were ineligible for the program, and that this reaction was particularly strong when capital constraints were tight.

Campbell, Covitz, Nelson, and Pence (2011) uncover broadly similar results in their evaluation of the TALF. Specifically, they find that TALF announcements substantially affected the pricing of highly rated auto asset-backed securities and commercial mortgage-backed securities. However, they find less evidence that the acceptance or rejection of particular securities from the TALF affected the pricing of those securities. They conclude that the TALF may have improved market liquidity and functioning as a whole without providing substantial subsidies to individual securities.

c. Areas for Further Research

The review of extant work immediately suggests that greater quantitative evaluation of the liquidity facilities is warranted. As noted, there is little or no research assessing some of the programs (i.e., single-tranche open market operations) and only descriptive work assessing others (e.g., PDCF), despite their size and importance. For other facilities, the existing work is mostly limited in focus. Research on the TSLF, for example, is limited to the analysis of repo rates for relatively liquid securities, and does not consider the effects on haircuts or on rates for less liquid securities.

In addition, few studies to date have examined which particular institutions participated in the various liquidity programs and how their disparate participation relates to firm characteristics and performance. This likely reflects the absence until after the crisis of publicly available institution-specific participation data. When the programs were operating, the Fed released aggregate quantity and rate data for the various facilities, but

not information on transactions with specific counterparties. Moreover, there was little expectation at the time that transaction-level data would ever be released.

Such transaction-level data are now available. In December 2010, in compliance with the Dodd-Frank Act, the Fed released transaction-level data for all of the new liquidity programs. Data for each loan include the borrower, the date the loan was made, the interest rate, collateral information, and other terms. Similar information is supplied for swap line draws and repayments. Transaction-level data on discount window loans were subsequently released in March 2011 and data for single-tranche open market operations were released in July 2011.

For illustrative purposes, summary transactions information for the TAF and PDCF is reported in Tables 2 and 3. Table 2 reports borrowing statistics for the 10 most frequent borrowers from the TAF -- all of which turn out to be New York branches of foreign banks -- and all 416 borrowers as a group. The most frequent borrower was Mitsubishi UFJ Trust and Banking, with 55 program loans. Seven institutions borrowed the maximum of $15 billion on a cumulative of 30 occasions, including Bank of America, Barclays Bank PLC New York Branch, Citibank, FIA Card Services, JPMorgan Chase Bank, Wachovia Bank, and Wells Fargo Bank. Sixty-five (65) institutions borrowed from the TAF on just one occasion. Across all borrowings (and on an unweighted basis), loans accounted for 57% of posted and available collateral and investment-grade securities the remaining 43%.

Table 3 shows summary statistics for each dealer's borrowing activities from the PDCF as well as all dealers as a group. Citigroup Global Markets was the most frequent borrower with 174 program loans, and Barclays Capital had the single largest loan, of $48 billion. Lehman Brothers was an infrequent borrower, with only seven pre-bankruptcy loans (and three after), and the last of the seven on April 16, 2008, almost five months before its bankruptcy. Several primary dealers rarely or never accessed the facility. Across all program loans (and on an unweighted basis), investment grade securities accounted for 55% of posted collateral, high-yield securities 13%, securities for which ratings were unavailable 17%, and equities 15%.

One potential use of the new data is to better understand which firms participated in the liquidity programs and why. Did firms borrow from the Fed because they needed the liquidity or did they borrow because liquidity was available at advantageous rates? As mentioned, there is some early work exploring these issues, including the Duygan-Bump, Parkinson, Rosengren, Suarez, and Willen (forthcoming) and Krishnamurthy, Nagel, and Orlov (2011) studies discussed earlier, both of which seem to support the conjecture that usage was greatest among institutions that needed liquidity. In addition, Acharya, Fleming, Hrung, and Sarkar (2011) find that firms with higher leverage and worse stock price performance over the crisis were more apt to bid in TSLF operations, likely to bid higher rates, and tended to bid for larger amounts. The public release of the transactions data should spur further work along these lines.

Another use of the new data is to better understand stigma. Armantier, Ghysels, Sarkar, and Shrader (2011)) use TAF transaction data in their study of discount window stigma and relate stigma to firm characteristics and policy changes. Stigma is thought to have been mitigated in some of the new facilities because of their structure, but little work has examined this issue aside from the abovementioned study and the work of Krishnamurthy, Nagel, and Orlov (2011). The new data provide an opportunity to more fully characterize stigma across the facilities and to better understand what program features, market conditions, and firm characteristics drive it.

Aside from better understanding the utilization and effectiveness of the facilities, the new data also provide an opportunity to test hypotheses about the effects of data disclosure. Is disclosure harmful? If so, how does this process work? Is there evidence that firms that borrowed during the crisis were harmed when information about their borrowings was released? If not, then why might firms be hesitant to borrow in the future with the knowledge that their names will only be released with a lag? The work of Fahlenbrach, Prilmeier and Stulz (forthcoming) suggests a possible answer, as they find that banks that performed worse during the 1998 crisis did so as well during the recent financial crisis. Perhaps then the market penalty for central bank borrowing in the recent crisis will be observed the next time concerns about financial institutions' health become acute.

5. Conclusion

The Federal Reserve initiated or expanded numerous liquidity facilities during the financial crisis of 2007-2009 in accord with its lender-of-last-resort role. The evidence supports the conjecture that the facilities were structured in line with time-honored principles of central bank liquidity provision: short-term lending against collateral at a penalty rate. The evidence uncovered to date also broadly supports the conclusion that the programs were effective at mitigating the strains in financial markets. New transaction-level data now provide an unusual opportunity to further understanding of liquidity facility utilization and effectiveness.

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Table 1 -- Federal Reserve Liquidity Facilities during the Crisis

Facility	Date Announced	Eligible Borrowers	Maximum Amount Outstanding
Discount window	Ongoing	Depository institutions	111
Term Auction Facility	December 12, 2007	Depository institutions	493
Central bank liquidity swaps	December 12, 2007	Banks	583
Single-tranche open market operations	March 7, 2008	Primary dealers	80
Term Securities Lending Facility	March 11, 2008	Primary dealers	236
Primary Dealer Credit Facility	March 16, 2008	Primary dealers	147
Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility	September 18, 2008	Depository institutions	152
Commercial Paper Funding Facility	October 7, 2008	Commercial paper issuers	351
Money Market Investor Funding Facility	October 21, 2008	Money market investors	0
Term Asset-Backed Securities Loan Facility	November 25, 2008	Asset-backed securities investors	48

Notes: Maximum amounts outstanding in billions of dollars based on weekly data as of Wednesday. Primary Dealer Credit Facility includes other broker-dealer credit. Central bank liquidity swaps are conducted with foreign central banks which then lend to banks in their jurisdiction.

Table 2 – Most Frequent Term Auction Facility Borrowers

Institution	Number of Borrowings	Average Amount Borrowed	Maximum Amount Borrowed
Mitsubishi UFJ Trust and Banking Corp.	55	0.4	1.2
Sumitomo Mitsui Banking Corp.	49	1.2	2.8
Mizuho Corporate Bank Ltd.	47	1.1	3.5
Arab Banking Corp.	46	0.6	1.4
Bayerische Hypo und Vereins Bank	43	0.8	2.2
Bank of Scotland PLC	40	4.5	9.0
DZ Bank AG Deutsche Zentral	38	1.0	3.0
Barclays Bank PLC	37	5.1	15.0
Bayerische Landesbank	37	2.9	7.0
Dresdner Bank AG	37	3.3	7.5
All 416 program borrowers	4214	0.9	15.0

Notes: New York branches were borrowing entities for all 10 institutions listed. Average and maximum amounts borrowed by institutions are per operation and in billions of dollars. Maximum amounts borrowed by institutions at a given time can and do exceed the per operation maximums because of overlapping borrowing periods for the various operations.

Table 3 – Primary Dealer Credit Facility Borrowing

Dealer	Number of Borrowings	Average Amount Borrowed	Maximum Amount Borrowed
Citigroup Global Markets Inc.	174	10.1	18.6
Morgan Stanley & Co. Inc.	122	11.2	47.6
Banc of America Securities LLC	118	5.4	11.0
Mizuho Securities USA Inc.	108	0.4	2.2
Merrill Lynch Government Securities Inc.	99	15.0	33.2
Countrywide Securities Corp.	75	1.0	1.7
Barclays Capital Inc.	74	5.5	47.9
Bear, Stearns & Co., Inc.	69	13.9	28.5
Cantor Fitzgerald & Co.	61	0.5	0.7
Goldman, Sachs & Co.	52	8.3	18.0
BNP Paribas Securities Corp.	43	1.5	4.6
Lehman Brothers Inc.	10	8.3	28.0
UBS Securities LLC	8	4.4	6.5
J.P. Morgan Securities Inc.	3	1.0	3.0
Credit Suisse Securities (USA) LLC	2	0.8	1.0
Daiwa Securities America Inc.	1	0.4	0.4
Deutsche Bank Securities Inc.	1	0.5	0.5
Dresdner Kleinwort Securities LLC	1	0.1	0.1
All primary dealers	1021	7.2	47.9

Notes: Amounts in billions of dollars. Excludes other broker-dealer credit (that is, lending to the London-based subsidiaries of broker-dealers). Not listed are dealers that never borrowed from the facility, two of which (Greenwich Capital Markets, Inc. and HSBC Securities (USA) Inc.) were primary dealers throughout the program, and three of which (Jefferies & Company, Inc., Nomura Securities International, Inc., and RBC Capital Markets Corp.) became primary dealers late in the life of the program, in June or July 2009.

Figure 1 -- LIBOR-OIS Spreads

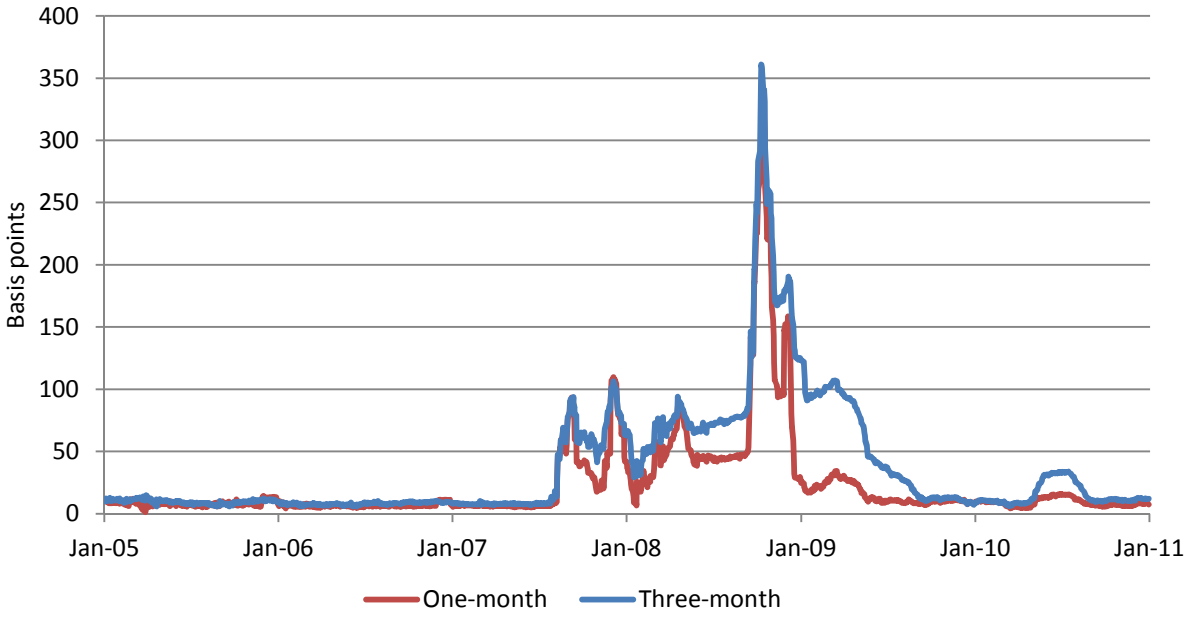
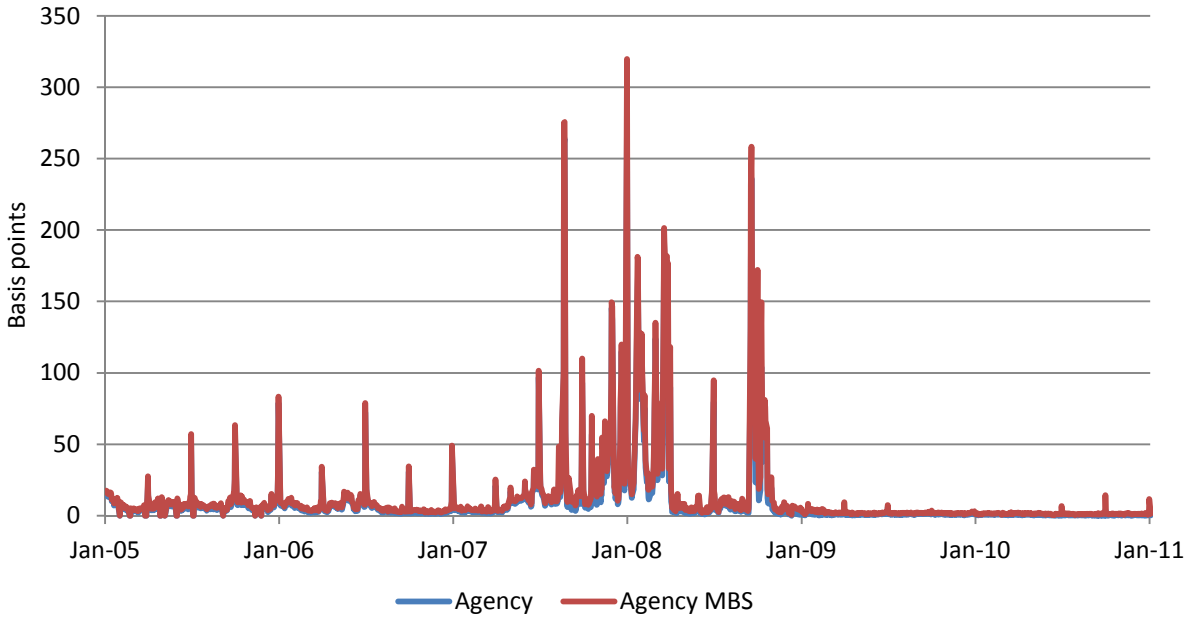


Figure 2 -- Repo Spreads



Note: The figure plots the overnight agency and agency MBS repo spreads to the overnight Treasury repo rate.

Figure 3 -- One-Month Commercial Paper-OIS Spreads

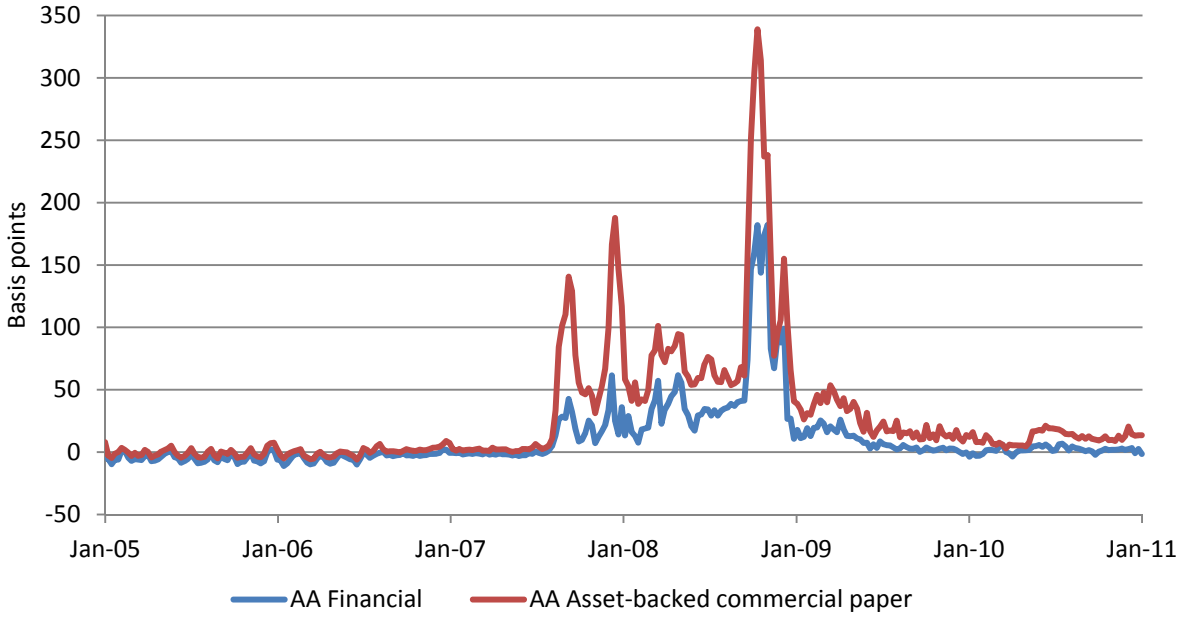


Figure 4 -- Federal Reserve Assets

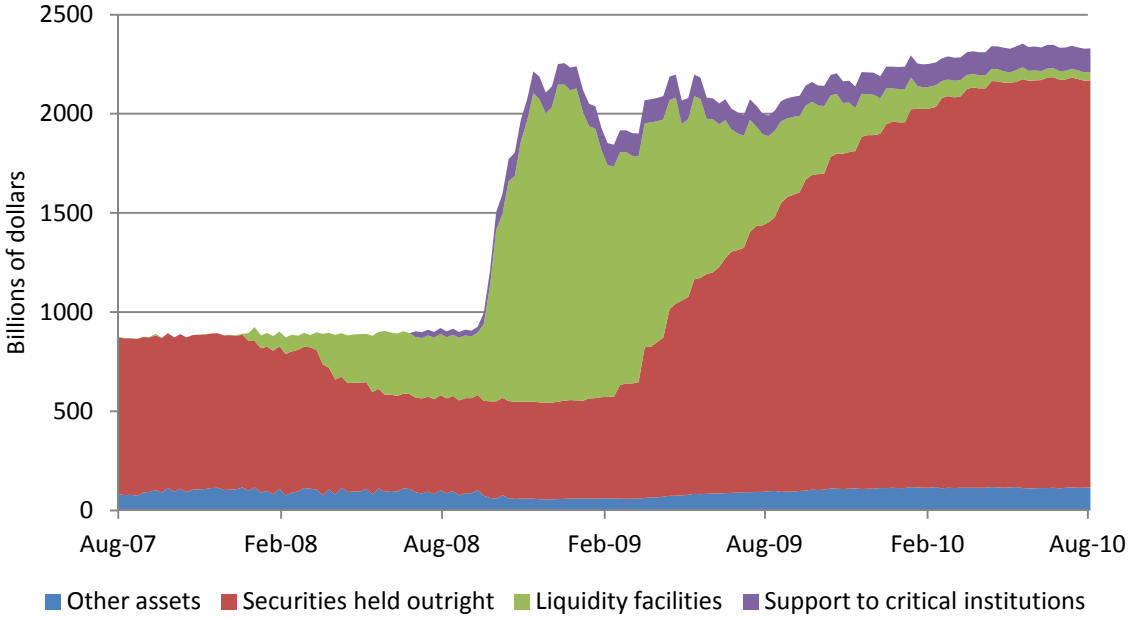
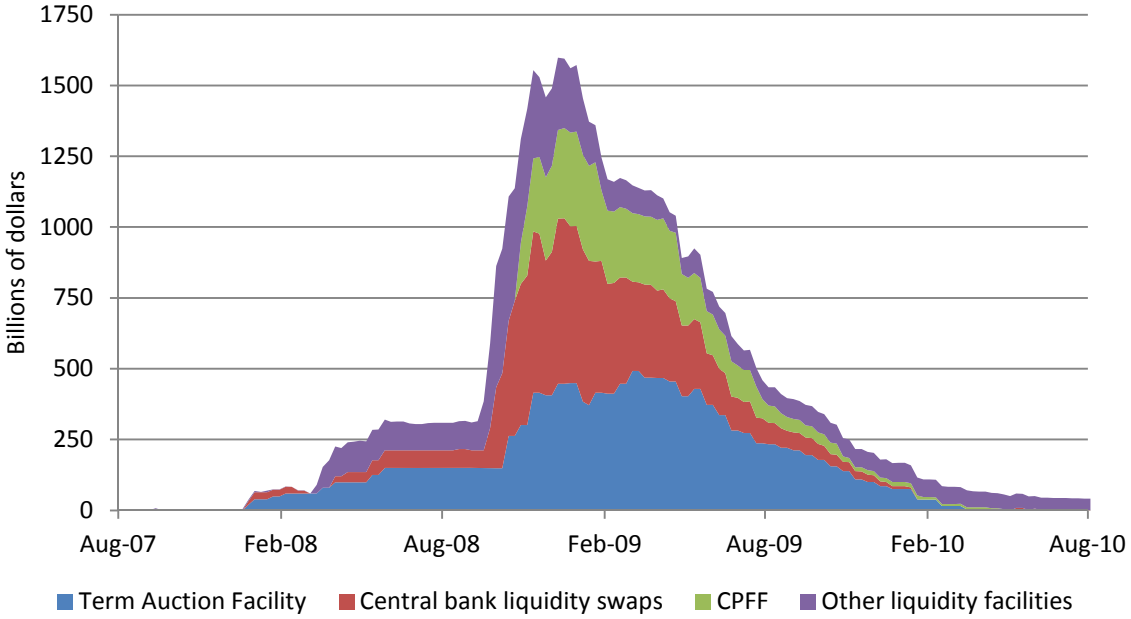


Figure 5 -- Federal Reserve Liquidity Facilities



Note: The figure plots lending of funds against collateral via Federal Reserve liquidity facilities and excludes lending of Treasury securities against other collateral via the Term Securities Lending Facility.