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Special Issue:
Federal Reserve Policy Responses to the Financial Crisis

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Overview

I am very pleased to introduce this set of papers describing several of the monetary policy programs that the Federal Reserve developed to respond to the recent financial crisis. The Federal Reserve's response to the financial crisis that began in 2007 was extraordinary in several dimensions. The expansion of the Fed's balance sheet—initially to provide liquidity to financial institutions and markets and later to purchase long-term assets—was enormous. In addition, the programs included an unprecedented expansion of Fed counterparties, of the collateral eligible for borrowing from the Fed, and of the types of assets purchased for the Fed's portfolio.

The first two papers in this volume examine two of the Federal Reserve's innovative lender-of-last-resort (LOLR) facilities created during the crisis: Linda S. Goldberg, Craig Kennedy, and Jason Miu analyze the central bank dollar swap facilities (and the associated provision of U.S. dollar liquidity by foreign central banks), while Tobias Adrian, Karin Kimbrough, and Dina Marchioni consider the Commercial Paper Funding Facility (CPFF). These facilities, along with other crisis-related liquidity programs such as the Term Auction Facility, the Primary Dealer Credit Facility, the Term Securities Lending Facility, and the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility, allowed the Federal Reserve to provide LOLR funding to broad swaths of the financial system.[1] Collectively, they vastly expanded the types of financial institutions, the geographic location of financial firms, and the classes of collateral eligible for borrowing from the Federal Reserve.

Lender of last resort is a—if not the—defining characteristic of central banking.[2] In normal times, the Federal Reserve is the LOLR only to depository institutions located in the United States through its standing discount window or primary credit facility. During the crisis, traditional discount window lending to banks was insufficient to stem contagion and liquidity runs in the financial system, particularly in funding markets and among financial institutions beyond traditional banking. Liquidity provided to banks was not distributed to the rest of the financial system because of balance-sheet constraints at the largest financial institutions and counterparty credit risk concerns. The central bank swap lines and the CPFF were designed to allow the Federal Reserve to make liquidity available to foreign banks outside the United States and to the commercial paper market, respectively.

While the new Fed facilities shared a common goal—to ease financial market conditions—the papers in this volume make clear that each facility was carefully designed to address the specific dislocations or liquidity problems in particular markets, and to do so in a way that ensured that the Federal Reserve's lending was appropriately secured. For example, the central bank swap lines directly addressed the excess demand for/shortage of U.S. dollar short-term funding outside the United States, while the CPFF was specifically designed to

[1] See Armantier, Krieger, and McAndrews (2008), Adrian, Burke, and McAndrews (2009), Fleming, Hrung, and Keane (2009), and Duygan-Bump et al. (2010).

[2] Many central banks, including the Federal Reserve, were created after financial crises in which private financial market participants were unable to provide liquidity necessary to maintain normal financial and banking functions.

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support term issuance of commercial paper when that market became distressed in the aftermath of the Lehman Brothers bankruptcy. Despite their different designs, the two facilities shared a couple of common traits. Both were structured to carefully manage counterparty risk and both were priced to be attractive facilities only during periods of market stress. This latter characteristic was important in allowing for an orderly winding down of the facilities over time.

In the volume's third paper, Joseph Gagnon, Matthew Raskin, Julie Remache, and Brian Sack discuss the implementation and impact of the Federal Reserve's large-scale asset purchase (LSAP) programs implemented through spring 2010. While the broad policy purpose of the LSAPs was also to ease financial conditions, the purchase programs were aimed at directly lowering the cost of credit to households and businesses rather than at easing funding conditions for financial intermediaries. By purchasing large quantities of agency debt, agency mortgage-backed securities (MBS), and U.S. Treasury securities, the programs aimed to directly reduce long-term interest rates and thus reduce the cost of borrowing. As such, the LSAPs posed different policy design and implementation issues, including the size and timing of purchases. While the purchase programs themselves were temporary, their impact on asset prices (and on the Federal Reserve's balance sheet) has been more sustained. Indeed, the paper concludes that the purchases completed through spring 2010 lowered the ten-year term premium by 30 to 100 basis points. In addition, it finds that the purchases had even larger effects on long-term agency debt and agency MBS yields by improving market liquidity and removing assets with high prepayment risk from private portfolios.

The three papers discuss the policy intent of the liquidity programs and the asset purchases, how various elements of program design and implementation were chosen in order to achieve those policy goals, and the challenges inherent in the designs. The papers also provide an early read on the impact and policy effectiveness of each of the facilities. As such we hope that these studies can serve both as historical references on the structure, design, and implementation of these extraordinary programs and as preliminary assessments of the programs' contributions to alleviating market stresses and allowing the financial system to begin a long road back to its role in credit formation and intermediation. We also hope that researchers and central bankers will study and evaluate these policy programs in the coming years.

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Linda S. Goldberg, Craig Kennedy, and Jason Miu

Central Bank Dollar Swap Lines and Overseas Dollar Funding Costs

1. Introduction

In the decade prior to the financial crisis, the dollar-denominated assets of foreign banks, especially institutions in Europe, increased dramatically. But with the onset of the crisis in 2007, these banks saw their access to dollar funding come under tremendous stress—with potentially dire consequences for financial markets and real activity associated with banking.

The progression of market stresses led the Federal Reserve in December 2007 to establish central bank (CB) dollar swaps: reciprocal currency arrangements with several foreign central banks that were designed to ameliorate dollar funding stresses overseas. These arrangements expanded as the crisis continued throughout 2008 and they remained in place through the end of 2009, becoming an important part of global policy cooperation.

In this article, we provide an overview of the CB dollar swap facilities, discuss the changes in breadth and volume as funding conditions (both in the market and through the facilities) evolved, and assess the economic research documenting the efficacy of the swaps. We conclude that the CB dollar swap facilities are an important tool for dealing with or minimizing systemic liquidity disruptions, as demonstrated in the reintroduction of the swaps in May 2010.

We begin in Section 2 by describing the dollar funding needs of foreign banks and examining the private cost of dollars before, during, and after the crisis. Two measures are used to show the increased cost of dollar funds in private markets during the crisis. The first is the spread between the London interbank offered rate (Libor) and the overnight index swap (OIS) rate. The second measure is the foreign exchange (FX) swap implied basis spread, which reflects the cost of funding dollar positions by borrowing foreign currency and converting it into dollars through an FX swap.

Additional evidence of disruptions to dollar markets is drawn from the intraday federal funds market. We compare the average price of federal funds during morning hours with the average price during afternoon trading. The differential in cost was normally close to zero in the precrisis period through August 2007 and thereafter evolved to reflect a substantial premium paid for federal funds acquired in morning trading. This "morning premium" persisted through December 2008, reaching elevated levels following the bankruptcy of Lehman Brothers. Among the explanations is the view that this spread can be interpreted partially as a "European premium" that evolved over the course of the crisis as a result of dollar demand by European banks lacking a natural dollar deposit base for meeting dollar funding needs.

In Section 3, we provide a history of the CB dollar swap facilities. After starting in 2007, the Federal Reserve's program for providing dollars to foreign markets evolved extensively with respect to both the number of countries with swap agreements and the amount of dollars made available abroad. The tenor of funds made available through the dollar auctions also evolved over time, increasing from up to one month

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initially to up to three months six months later, ultimately returning to primarily shorter tenors.

At the program's peak, longer term swaps dominated the total amount outstanding. Net dollars outstanding through the CB dollar swaps peaked at nearly $600 billion toward the end of 2008, as banks hoarded liquidity over year-end, although some of this demand for dollars began to unwind following year-end. Amounts outstanding at the dollar swap facilities declined to less than $100 billion by June 2009, to less than $35 billion outstanding by October 2009, and to less than $1 billion by the time the program expired on February 1, 2010.[1]

In Section 4, we show the differential costs of accessing dollars at the official liquidity facilities, with the effective "all-in" cost of dollars at the various central banks deriving from the specific facility designs and collateral policies. We show that, while funds obtained through the dollar swap facilities were competitively priced in the early stages of the crisis, the dollars acquired through overseas dollar swap facilities eventually cost more than those from the Federal Reserve's Term Auction Facility (TAF) or, as money market functioning improved, from the private market for most borrowers.

Funds obtained through dollar swap facilities were typically priced close to 100 basis points higher than the dollars that banks, including some foreign institutions in the United States, obtained at the TAF. Indeed, with funds at the TAF priced below indicative market rates for many banks, and with the minimum bid rate at the TAF the same as the rate of interest on excess reserves, participation in the TAF remained broad through much of 2009. In contrast, the dollar auctions of other central banks had dollars priced above the market rates that were available to many banks. Overall, taking into account the consequences of the auction structures and collateral considerations, we observe that the continued participation of some banks in the CB dollar swap auctions through the first half of 2009 reflected persistent pockets of supply shortages in the dollar markets. Credit tiering among banking counterparties continued, as did some self-selection of less creditworthy banks that continued to seek liquidity from the central banks auctioning dollars.

Section 5 presents evidence of the dollar swap facilities' effects on liquidity conditions in financial markets in the United States and abroad. First, we share anecdotal accounts from market participants—including dealers, brokers, and bank treasurers—who argue that the CB dollar swaps contributed to improved market conditions. Second, we argue that, despite the overall improvement, credit tiering remained for banks seeking access to liquidity. One piece of evidence comes from the Euro Interbank Offered Rate (Euribor) panel, where the FX swaps' implied basis spreads on dollars were quite different across banks with different strength ratings. By comparing the interest cost of euros for stronger, more moderate, and lower rated financial institutions in Europe, we conclude that the degree of credit tiering peaked in November 2008 and remained elevated well into the third quarter of 2009.

Third, we discuss the key findings, as well as the limitations, of a range of relevant econometric studies of the CB auctions' effects during the crisis. The main methodology is a type of event study that tracks the consequences for financial variables of announcements about liquidity facilities, whether these pertain to amounts to be offered, scope of access, or actual auction dates. Based on the effects on financial market spreads, the studies conclude that the TAF and the CB dollar swaps played important roles in reducing the cost of funds, especially when dollar liquidity conditions were under the most stress. While the results are compelling, we note the difficulty in using such studies as conclusive metrics of market effects.

We conclude in Section 6 with more forward-looking comments on the importance of currency swap facilities as part of a central bank's toolbox for managing and resolving crises.

2. Pressures in Dollar Funding Markets

In this section, we provide an overview of the initial pressures in dollar funding markets and the evolution of these pressures over time. We consider some measures of the cost of funds across markets and tenors, showing how the measures evolved over the period covered by the CB dollar swaps.

2.1 Demand for Dollars

To provide perspective on the pressures banks faced in the crisis period, we begin with the issue of how many U.S. dollars foreign banks needed and how these dollar needs were satisfied prior to the crisis. In brief, the high level of dollar-denominated assets that European banks were exposed to, both on and off balance sheet, and the banks' heavy reliance on short-term, wholesale markets to fund these assets exacerbated the significant strains in funding markets during 2008 and into 2009.

The foreign currency exposures of European banks had grown significantly over the decade preceding the crisis. Dollar

[1] This expiration date refers not to the maturity but to the last day for initiation of a swap. The Bank of Japan had a balance of $100 million in twenty-nine-day funds, initiated on January 14, 2010, that matured on February 12, 2010. We do not explore here the reintroduction of the CB dollar swaps in May 2010.

exposures accounted for half of the growth in the banks' foreign exposures over the 2000-07 period (McGuire and von Peter 2009a). The on-balance-sheet dollar exposures of euro area, United Kingdom, and Swiss banks were estimated to exceed $8 trillion in 2008, of which $1.1 trillion to $1.3 trillion was funded through short-term sources. The growth in dollar exposures can be attributed to a number of factors. Among them are differences in the bank regulatory framework that allowed European banks to invest in many of the highly rated, dollar-denominated structured finance products that proliferated at the time.[2] In addition, the continuing globalization of capital markets increasingly provided investment opportunities in nondomestic currencies for banks and investors globally.

Prior to the crisis, dollar exposures were funded from a range of sources, detailed in a series of articles published by the Bank for International Settlements. As shown by McGuire and von Peter (2009a, b), key sources of funds were money market funds ($600 billion to $1 trillion), the monetary authorities ($500 billion), and the foreign exchange swap market ($700 billion). Banks also turned to interbank borrowing, flows from U.S.-based affiliates, and other sources.[3] Off-balance-sheet exposures to other contingent lines of credit and wholesale-funded conduits likely intensified the demand for dollars among European financial institutions. European banks (and other non-U.S. banks) lack a dollar-denominated retail deposit base and had grown increasingly reliant on wholesale funding sources to meet these expanding U.S. dollar liquidity needs.

Nearly all of these funding sources came under extreme stress in fall 2008 as escalating credit and liquidity concerns evolved into a much broader systemic issue after the failure of Lehman Brothers. In particular, the offshore wholesale market for dollars—that is, the Eurodollar market—and the FX swap market experienced particularly heightened strains. These strains were evident in the commonly cited spread between Libor and the OIS and the spread between the FX swap implied dollar funding cost and Libor, both of which reached historically wide levels in September 2008. The short-term nature of many of these funding sources and the accompanying "rollover" risk increased the potential for stressed banks to engage in widespread sales of dollar-denominated assets and contributed to a vicious cycle of downward pressures on asset prices.

[2] For example, many international bank regulators focused on capital as a percentage of risk-weighted assets, while U.S. and a few other international regulators included capital as a percentage of unweighted assets as well. As such, banks domiciled in regulatory regimes with a focus on risk-weighted assets were able to accumulate significant amounts of highly rated securities.

[3] Baba, McCauley, and Ramaswamy (2009) and McGuire and Von Peter (2009a, b) discuss exposures to U.S. dollar funding. Cetorelli and Goldberg (2008, 2010) address the international transmission of shocks that can occur when managing global bank liquidity through internal capital markets.

2.2 Foreign Exchange Swap Basis

One metric used to measure funding stress in foreign exchange markets is the *foreign exchange swap basis.* To arrive at this metric, analysts take an implied measure of dollar funding from a foreign exchange swap using the uncovered interest rate parity formula and compare it with Libor. A foreign exchange swap is a contract combining an FX spot and forward transaction and whose price, according to the uncovered interest rate parity, is derived from the differential between interest rates in the domestic currency and the foreign currency.

For example, consider the cost of borrowing euros in unsecured markets and converting them to dollars and then comparing that with borrowing dollars directly in the unsecured markets. This cost is defined as:

$$Basis_t^{eur,\$} \equiv \frac{F_{t,t+s}}{S_t}(1 + r_t^{eurLibor}) - (1 + r_t^{\$\,Libor}),$$

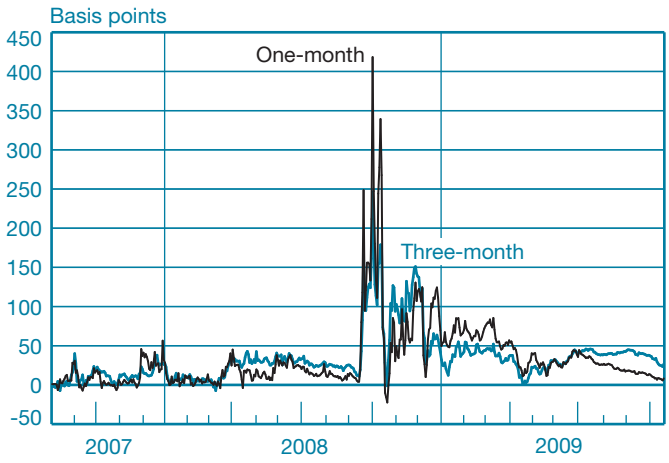
where S_t is the foreign currency spot rate at time t, $F_{t,\,t+s}$ is the foreign currency forward rate contracted at time t for delivery at time $t+s$, and $r_t^{eurLibor}$ ($r_t^{\$\,Libor}$) is the uncollateralized euro (dollar) interest rate from time t to time $t+s$.

Normally, arbitrage would drive the basis to zero given that firms would choose the more attractive dollar funding option of either borrowing at dollar Libor or borrowing euros and swapping them into dollars. For example, if the FX basis is greater than zero, arbitragers could borrow dollars unsecured at a relatively low interest rate and then lend the dollars through an FX swap at a relatively higher implied interest rate. Yet, with the dollar shortage during the crisis, arbitragers were unable to borrow sufficient dollars in the unsecured market to take advantage of this opportunity. Consequently, because of the dollar shortage, non-U.S. banks faced market-based dollar funding costs that were higher than the dollar Libor rates would suggest.

As noted by Baba, McCauley, and Ramaswamy (2009) and Coffey, Hrung, and Sarkar (2009), there was a substantial deviation from this pricing during the crisis period: The cost of borrowing euros at the euro Libor and swapping the euros for dollars was higher than borrowing dollars at the dollar Libor. The history of the FX basis for one- and three-month funds shows that the premium paid for dollars in the FX swap market rose relative to normal levels in August 2007 but then soared to extremes of more than 400 basis points in October 2008 (Chart 1). The dislocations were broad-based across funding tenors and were also evident in other FX swap currency pairs, such as the dollar/yen.

Chart 1

Euro-U.S. Dollar Implied Swap Basis Spread

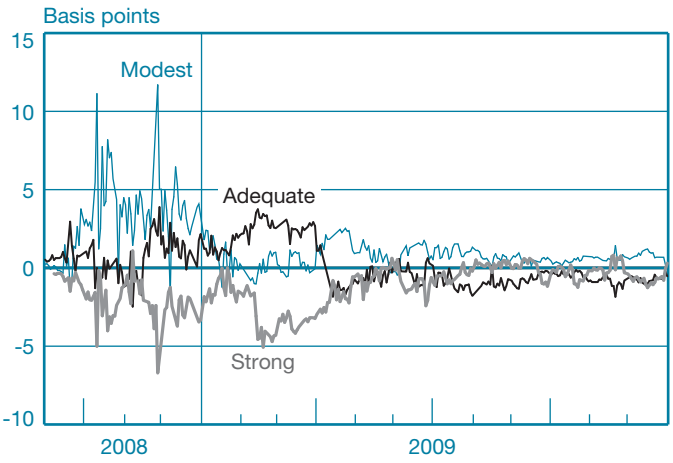


Sources: Reuters; Federal Reserve Bank of New York staff calculations.

Chart 2

Average Borrowing Rate Relative to Euribor Reference Rate, by Bank Category

One-Month Tenor



Sources: Euribor; Bloomberg; Moody's (bank financial strength ratings).

Note: Panel banks' historical data are available starting September 2008.

2.3 Tiering in Costs of Dollar Funds

Since the FX swap basis is an average implied premium paid for dollar funds in the FX swap market relative to Libor, it does not fully capture the fact that different market participants likely have varying degrees of access to the unsecured markets—both in the amounts and in the rates at which counterparties would be willing to lend. For example, if a given bank can borrow euros at Euribor (a daily reference rate for the euro interbank market) but can borrow dollars only at Libor + 20 basis points in the unsecured markets, then the FX basis for that bank would be the implied U.S. dollar funding cost compared with (Libor + 20) rather than Libor, resulting in a smaller FX basis. This similarly applies to a bank's access to the unsecured euro cash markets used in calculating the implied U.S. dollar funding cost.

Our discussion of the FX basis emphasizes that the first part of the transaction reflects the cost of euros, in terms of interest rates by which companies in the euro area acquire liquidity before converting it into dollars through swap markets. However, the aggregate measure for $r_t^{eurLibor}$ is an average across a range of institutions bidding for euros in private markets. A closer look at the underlying data reveals that, as the crisis intensified, a pattern of deep and persistent implied credit tiering emerged within Euribor quotes. While broader market conditions may appear to have returned to close to normal conditions in mid-2009 when measured by indicators such as Libor-OIS spreads, these more detailed data, combined with anecdotal evidence, show that credit tiering was still very much in operation even after the CB dollar swaps were in effect and in the uncapped format. Credit tiering within the euro borrowing market would likely extend to the cost of European banks acquiring dollars through private swap transactions.

Some evidence on this point comes from panel data related to the Euribor, whose rate is determined by a panel consisting of forty-three major banks, nearly all of them European. (By comparison, Libor's panel consists of only sixteen banks.) Each bank submits the interest rate it believes one prime bank is quoting to another prime bank in the euro market for tenors ranging from one week to one year.[4] The Euribor is calculated by averaging the middle 70 percent of the panel banks' reported borrowing rates. Historical data are available for the panel banks' contribution to Euribor beginning in September 2008.[5]

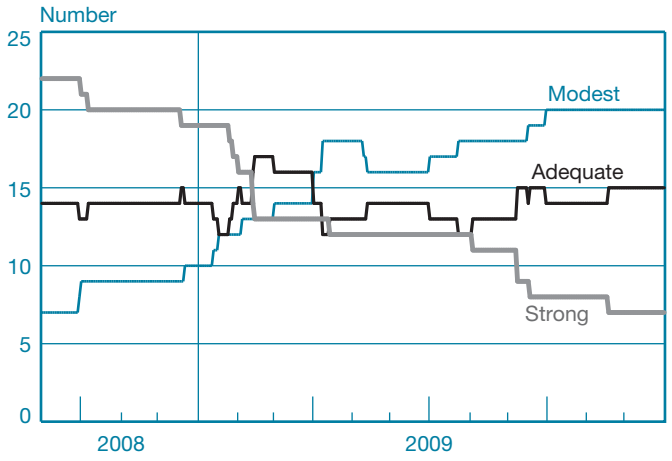
To check for credit tiering in the euro lending market, we classify each of the forty-three banks at each date based on its bank financial strength rating (BFSR). A bank's BFSR, which is reported by Moody's and ranges from A to E, is meant to reflect the bank's intrinsic soundness.[6] Each bank was classified as stronger (B- or higher), adequate (C or C+), or modest (C- or lower). Using a range of tenors, we examine each bank category's average borrowing rate relative to the Euribor

[4] Tenors include one week, two weeks, three weeks, and periods ranging from one month to twelve months.

[5] Historical data are available at http://www.euribor.org/html/content/euribor_data.html.

[6] The rankings take five factors into consideration: franchise value, risk positions, regulatory environment, operational environment, and financial fundamentals. See http://www.moodys.com/cust/content/Content.ashx?source=StaticContent/Free%20Pages/Products%20and%20Services/Static%20Projects/GBRM/pdf/Global_Bank_Rating_Methodology-Brochure.pdf.

Chart 3
Number of Banks in Each Category of Euribor Panel



Sources: euribor.org; Bloomberg; Moody's (bank financial strength ratings).
Note: Panel banks' historical data are available starting September 2008.

reference rate. Our results are presented in Chart 2, which shows each bank category's average borrowing rate relative to the Euribor reference rate using the one-month tenor. The construction is based on each bank's BFSR on each date (banks move between categories when a rating change warrants it). The number of banks in each category is shown in Chart 3.

Chart 2 shows that stronger banks, on average, were able to borrow euros on more favorable terms than were the more modest or adequate banks during the crisis period. Credit tiering was especially pronounced during late 2008 and early 2009, peaking in late November 2008. Although the chart reflects only one-month tenor spreads, the borrowing rate spread between the categories is similar for all maturities. The shorter tenors, such as one week, displayed smaller spreads, which we interpret as less credit tiering.

2.4 The Federal Funds Market

Another, albeit less standard, indicator of dollar market pressures comes from the intraday market for federal funds. To explore this intraday market, we use data on the hourly effective federal funds rate (HEFFR), which is the overnight rate at which depository institutions lend dollars to one another at each hour.[7] Using hourly data over each of the days spanning August 2002 through October 2009, we explore whether there is a differential cost of dollar funding during periods when European markets were open and dollar demands were most acute, compared with after the European markets closed. Owing to time zone differences, European institutions participate in dollar funding markets before 1 p.m. Eastern Standard Time. If there is a European premium to obtaining dollars, one would expect dollar funding costs to be higher in the morning (earlier than 1 p.m.), when European institutions are participating, than in the afternoon (1 p.m. and later).

When markets are functioning normally, the difference between the morning HEFFR average and the afternoon HEFFR average should be small. The effective federal funds rate should not change drastically in the same direction during the day. Indeed, this is the pattern seen in daily data over the six-year interval from 2002 through July 2007. The difference between the morning average and afternoon average hovered around zero basis points. By contrast, we observe that after the crisis began, the difference between the morning average and the afternoon average became greater and was commonly positive. The morning premium in the HEFFR was most striking in the period between late September and early October 2008, after Lehman's collapse. This premium peaked in October and then abated in 2009.

One explanation for this pattern is that the morning premium actually reflected a "European premium," which arose from a structural shortage of dollars. Of course, other factors could have played a significant role in the deviations between morning and afternoon federal funds rates during the crisis. Most notable was the tendency for U.S. banks to build a precautionary buffer of funding in the morning and then lend those funds to the market in the afternoon as banks became more certain of their actual funding needs.

3. Evolution of CB Dollar Swap Facilities

As pressures in the U.S. dollar funding markets built in late 2007 and continued through 2008, non-U.S. banks began to report difficulty accessing dollars through the FX swap and other short-term interbank funding markets. The Federal Reserve and foreign central banks held expanded discussions on ways to address the disruptions in dollar funding markets and the more broad-based dysfunction occurring in money markets. The idea of using a CB swap facility to address money market dysfunction and achieve broader financial stability contrasted with the goals of most prior CB swap agreements, which had been used primarily as tools of foreign exchange policy.

[7] The HEFFR is a proprietary calculation of ICAP (an inter-dealer money broker) and is not publicly available, so we describe the difference between morning and afternoon effective rates without presenting these data.

Table 1

Timeline of Dollar Swap Announcements

Date	Event	New Participants	Total Authorization (Billions of Dollars)	Terms Extended	Expiration Extended
2007					
December 12	Federal Reserve establishes six-month dollar swap agreements with ECB ($20 billion) and SNB ($4 billion); auction tenors are twenty-eight days.		24		
2008					
March 11	Lines are expanded with ECB (to $30 billion) and SNB (to $6 billion).		36		
May 2	Lines are expanded with ECB (to $50 billion) and SNB (to $12 billion); agreement is extended to January 30, 2009.		62		x
July 30	Line is expanded with ECB (to $55 billion); ECB and SNB add eighty-four-day auctions.		67	x	
September 18	Lines are expanded with ECB and SNB (to $110 billion and $27 billion, respectively). Facilities are established with BoJ, BoE, and BoC (in amounts of $60 billion, $40 billion, and $10 billion, respectively).	x	247		
September 24	Dollar swap is established with RBA ($10 billion), Danmarks Nationalbank ($5 billion), Sveriges Riksbank ($10 billion), and Norges Bank ($5 billion).	x	277		
September 26	Lines are expanded with ECB and SNB (to $120 billion and $30 billion, respectively).		290		x
September 29	Lines are expanded with ECB (to $240 billion), SNB (to $60 billion), BoC (to $30 billion), BoE (to $80 billion), BoJ (to $120 billion), Danmarks Nationalbank (to $15 billion), Norges Bank (to $15 billion), RBA (to $30 billion), and Sveriges Riksbank (to $30 billion). Agreements are extended until April 30, 2009.		620		
October 13	Dollar swaps are expanded with ECB, SNB, and BoE to accommodate quantity demanded; BoJ considers doing the same.		No prespecified limit		
October 14	Dollar swap is expanded with BoJ to accommodate quantity demanded.		No prespecified limit		
October 28	Swap line is extended to RBNZ ($15 billion).	x	No prespecified limit		
October 29	Lines are extended to Brazil, Mexico, Korea, and Singapore (up to $30 billion each); lines are authorized until April 30, 2009.	x	No prespecified limit		
2009					
February 3	Swap agreements are extended until October 30, 2009.		No prespecified limit		x
April 6	Federal Reserve announces arrangement with BoE, ECB, BoJ, and SNB to provide foreign currency liquidity to U.S. institutions.		No prespecified limit		
June 25	Swap agreements are extended until February 1, 2010.		No prespecified limit		x
2010					
February 1	Swap agreements expire.				

Source: Board of Governors of the Federal Reserve System.

Notes: The four central banks with no prespecified limit as of October 2008 offered dollar liquidity at a fixed price, which, along with collateral constraints, served to limit demand. ECB is European Central Bank, SNB is Swiss National Bank, BoJ is Bank of Japan, BoE is Bank of England, BoC is Bank of Canada, RBA is Reserve Bank of Australia, RBNZ is Reserve Bank of New Zealand.

3.1 Main Developments in CB Swaps

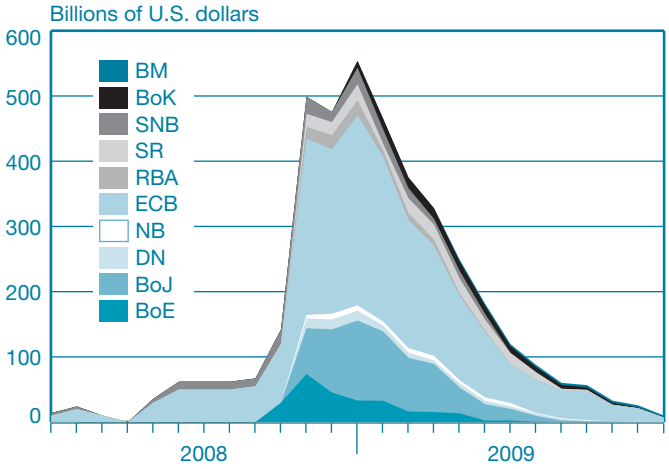
In December 2007, the Federal Reserve established temporary reciprocal currency arrangements with the European Central Bank (ECB) and the Swiss National Bank that allowed for the two institutions to draw up to $20 billion and $4 billion, respectively. The initial auctions were fully subscribed. Despite an easing of pressures in early 2008, funding pressures and use of the swap lines again escalated in March 2008 as Bear Stearns neared its acquisition by JPMorgan.

Table 1 describes the sequence of events in the Federal Reserve's swap facilities with foreign central banks. Expansion of the dollars made available through the swap facilities proceeded in stages, first through increases in the size of the lines and then through extensions, through July 2008, of the tenors for auctions held by the European Central Bank and the Swiss National Bank.

Ultimately, fourteen foreign central banks entered into swap arrangements with the Federal Reserve. From an initial aggregate of $24 billion in December 2007, the amount authorized grew to nearly $620 billion following the bankruptcy of Lehman Brothers. The quantity was soon "uncapped" for several central bank swap counterparties on October 13, 2008, as markets experienced extreme pressures. The dramatic move to uncapped, full-allotment auction formats was made by the European Central Bank, the Swiss National Bank, the Bank of Japan, and the Bank of England. Under the full-allotment auction format, the Federal Reserve made dollars available to these four central banks in quantities not subject to prespecified limits. The foreign central banks, in turn, made dollar loans to financial institutions within their jurisdictions and took on the related collateral and counterparty risks, although the Federal Reserve engaged in swap transactions only with the foreign central banks. The swap lines were a coordinated effort among central banks to address elevated pressures in global short-term U.S. dollar funding markets and to maintain overall market stability.

Chart 4 shows the contributions of various central banks to the overall size of swaps outstanding by the Federal Reserve. Clearly, the European Central Bank, the Bank of Japan, and the Bank of England consistently made up the majority of drawdowns on the reciprocal currency arrangements. According to monthly balances published by the Federal Reserve, peak CB dollar swap balances reached $291 billion for the European Central Bank (December 2008), $122 billion for the Bank of Japan (December 2008), and $74 billion for the Bank of England (October 2008). Overall use of the swap lines climbed rapidly in October 2008, peaked in December 2008, and declined dramatically through the first half of 2009.

Chart 4
Central Bank Dollar Swap Amounts Outstanding



Source: Board of Governors of the Federal Reserve System, "Credit and Liquidity Programs and the Balance Sheet."

Note: BM is Banco de México, BoK is Bank of Korea, SNB is Swiss National Bank, SR is Sveriges Riksbank, RBA is Reserve Bank of Australia, ECB is European Central Bank, NB is Norges Bank, DN is Danmarks Nationalbank, BoJ is Bank of Japan, BoE is Bank of England.

While the CB dollar swaps with foreign central banks differed primarily in size, the auctions conducted by the foreign central banks differed in the formats used for distributing the U.S. dollars. Each central bank worked closely with the Federal Reserve to structure auctions used for distributing the dollars to domestic institutions. Structuring these auctions took into account a variety of factors, including the central banks' in-depth knowledge of their own domestic funding markets and financial institutions as well as their operating guidelines with respect to accessing their liquidity facilities and establishing acceptable collateral.

Box 1 broadly defines the various possible choices for the auction structures. For example, auctions can be competitive or noncompetitive. Within the competitive auction classifications, pricing can be either at a single common price or at multiple prices, depending on the structure of bids. Though the noncompetitive, fixed-rate auctions are fully allotted, the use of a higher spread to OIS and potential constraints on banks' availability of collateral may limit the demand for dollars.

Table 2 presents details on the dollar auctions conducted by foreign central banks. On the quantity side, as we observed, four central banks after October 2008 did not have prespecified limits on the amounts that could be drawn, while ten other countries were authorized to access up to $15 billion or $30 billion from the Federal Reserve. With the move to uncapped quantities in

Box 1

Auction Types

In general, auctions can have either competitive or noncompetitive formats. Pricing conventions can be described as 1) single price, 2) multiple price, or 3) fixed-rate, full-allotment.

Format	Pricing	Description
Competitive	Single-price	Bids are accepted from the highest interest rate bid on down, until the total auction size is allotted. All allocations are made at the lowest accepted bid rate.
	Multiple-price	Bids are accepted from the highest interest rate bid on down, until the total auction size is allotted. All allocations are made at the respective bid rates of "winning" bidders.
Noncompetitive	Fixed-rate, full-allotment	The interest rate is fixed, and all bids received are satisfied subject to collateral requirements.

October 2008, the European Central Bank, the Bank of Japan, the Swiss National Bank, and the Bank of England had fixed-rate, full-allotment auctions, in which they provided dollars to their constituent depository institutions at a fixed interest rate of approximately 100 basis points over OIS. This cost of funds implied that overseas extensions of dollars were priced at a premium relative to the expected stance of U.S. monetary policy over the intervals that dollar swaps were extended. The Bank of England, the European Central Bank, and the Swiss National Bank coordinated their auctions such that they used the same tender rate and held their auctions simultaneously. Danmarks Nationalbank and Sveriges Riksbank had single-price, competitive auctions. The remaining central banks that drew on the CB dollar swaps with the Federal Reserve established multiple-price competitive auctions. Other central banks auctioned dollars competitively, with minimum bid rates ranging from OIS + 50 basis points to Libor + 50 basis points. Four of the fourteen facilities—with Canada, New Zealand, Brazil, and Singapore—were never drawn on.

On April 6, 2009, the Federal Open Market Committee of the Federal Reserve announced that it had established foreign currency swap facilities with the European Central Bank, the Bank of Japan, the Swiss National Bank, and the Bank of England. These facilities were designed to enable the Fed to provide foreign currency liquidity to U.S. institutions should the need arise. This facility essentially mirrored the existing U.S. dollar liquidity facility and was never drawn on by the Federal Reserve. It expired concurrently with the dollar swaps on February 1, 2010.

Table 2

Details on Dollar Auctions by Central Banks, October 2008 through February 1, 2010

Central Bank	Line Size (Billions of Dollars)	As-of Date (2008)	Range of Tenors Offered since Inception	Minimum Bid Rate	Notes	Current Auction Format
European Central Bank	Full allotment	October 13	Overnight, one-week, one-month, three-month	USD OIS + 100 bp	Prior to introduction of fixed-rate, full-allotment on October 13, auction used minimum bid of OIS, same as TAF.	Noncompetitive, fixed-rate, full-allotment
Swiss National Bank	Full allotment	October 13	Overnight, one-week, one-month, three-month	USD OIS + 100 bp	Prior to introduction of fixed rate, full allotment on October 13, auction used minimum bid of OIS, same as TAF.	Noncompetitive, fixed-rate, full-allotment
Bank of England	Full allotment	October 13	Overnight, one-week, one-month, three-month	USD OIS + 100 bp	Prior to introduction of fixed rate, full allotment on October 13, auction used minimum bid of OIS, same as TAF.	Noncompetitive, fixed-rate, full-allotment
Reserve Bank of Australia	$30	September 29	One-month, three-month	USD Libor	In mid-April 2009, minimum bid rate was changed from OIS + 50 bp.	Competitive, multiple-price
Reserve Bank of New Zealand	$15	October 28	Not drawn			
Bank of Japan	Full allotment	September 29	One-month, three-month	USD OIS + 100 bp	Prior to introduction of fixed-rate, full-allotment on October 13, auction used minimum bid of OIS, same as TAF.	Noncompetitive, fixed-rate, full-allotment
Bank of Canada	$30	September 29	Not drawn			
Danmarks Nationalbank	$15	September 29	One-month, three-month	Libor + 50 bp	On February 10, 2009, minimum bid rate was changed from OIS + 50 bp.	Competitive, single-price
Sveriges Riksbank	$30	September 29	Three-month	USD OIS + 50 bp		Competitive, single-price
Norges Bank	$15	September 29	One-month, three-month	TAF stop-out + 50 bp		Competitive, multiple-price
Bank of Korea	$30	October 29	Three-month	USD OIS + 50 bp		Competitive, multiple-price
Banco do Brasil	$30	October 29	Not drawn			
Banco de México	$30	October 29	Three-month	USD OIS + 50 bp		Competitive, multiple-price
Monetary Authority of Singapore	$30	October 29	Not drawn			

Source: Board of Governors of the Federal Reserve System.

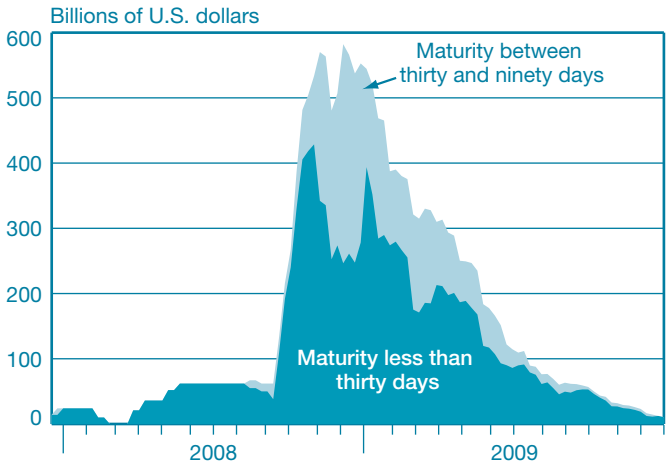
Notes: Collateral eligibility for these auctions matches criteria for domestic open market operations. As of June 25, 2009, all central bank dollar swaps were extended through February 1, 2010. Overnight funds auctions were eliminated as of November 7, 2008. Minimum bid rates are calculated from the most recent auction announcements and results. Libor is the London interbank offered rate; OIS is the overnight index swap rate; TAF is the Federal Reserve's Term Auction Facility; bp is basis points.

3.2 Evolution of Outstanding Balances and Tenors

In addition to changes in the terms and quantities, the composition of loan tenors extended through the CB dollar swaps evolved considerably over time (Chart 5). Clearly, the largest and most dramatic run-ups in use of the dollar swaps occurred at the end of October 2008, as the size and scope of the facilities broadened rapidly amid escalating market tensions and the approaching year-end. Most of this expanded borrowing took place through three-month operations, the longest on offer, as liquidity available in the market quickly contracted to encompass only the shortest tenors. Most of the demand came from the fixed-rate, full-allotment operations, which constituted around 85 percent of outstanding swaps by December 31, 2008.

In part, the evolution of tenors shown in Chart 5 resulted from the changing offerings of maturities made available by the various central banks. The initial auctions by the European Central Bank and the Swiss National Bank, held between December 2007 and July 2008, provided only twenty-eight-day funds. On July 30, 2008, the scope was expanded to cover three-month (eighty-four-day) funding, adding a broader array of tenors, including one-week and overnight, introduced in October. The large, discrete jumps in outstanding dollar balances coincided with the first two full-allotment eighty-four-day dollar auctions on November 6, 2008, and December 4, 2008; together, these auctions accounted for an additional $129 billion and $114 billion, respectively. Financial institutions accumulated liquidity in advance of the 2008 year-end, but after this "risk event" participating banks partially unwound their outstanding balances as their precautionary dollar needs declined. Net outstanding balances likewise declined when these two operations matured on January 29, 2009, and February 26, 2009, respectively.

Chart 5
Central Bank Dollar Swap Amounts Outstanding, by Loan Term



Source: U.S. Treasury Department, "U.S. International Reserve Position."
Note: Data are weekly.

Table 3 shows how the demand for dollars unwound over the course of the auctions, presenting each central bank's net outstanding position with the CB dollar swap balance at year-end 2008 and at the end of second-quarter 2009. In total, the CB dollar swaps outstanding declined nearly $440 billion between December 31, 2008, and June 30, 2009. The decline in position by the European Central Bank (to $231.45 billion) accounted for more than half of this total drop, followed by

Table 3
Net Outstanding Positions by Foreign Central Bank

	Billions of Dollars			Percent	
	December 31, 2008	June 30, 2009	Change	Change	Contribution to Total Change
European Central Bank	291.35	59.90	-231.45	-79	53
Swiss National Bank	25.18	0.37	-24.81	-99	6
Bank of England	33.08	2.50	-30.58	-92	7
Bank of Japan	122.72	17.92	-104.79	-85	24
Reserve Bank of Australia	22.83	0.24	-22.59	-99	5
Sveriges Riksbank	25.00	11.50	-13.50	-54	3
Norges Bank	8.23	5.00	-3.23	-39	1
Danmarks Nationalbank	15.00	3.93	-11.07	-74	3
Bank of Korea	10.35	10.00	-0.35	-3	0
Banco de México	0.00	3.22	3.22	—	-1

Source: Federal Reserve Bank of New York, "Treasury and Federal Reserve Foreign Exchange Operations" quarterly reports.

reduced balances for the Bank of Japan ($104.79 billion) and the Bank of England ($30.58 billion). Banco de México actually had increases in swap amounts outstanding, but primarily because of the timing of its first auction in early 2009.

4. CB Dollar Swap Facilities and the TAF

The dollar swaps with foreign central banks were only one of the many dollar liquidity facilities established during the financial crisis. Indeed, the auctions associated with the initial CB dollar swaps announced on December 12, 2007, were coordinated with the TAF auctions in the United States, which periodically provided term funding to eligible depository institutions in sound condition.[8]

4.1 Comparison and Relationship to the TAF

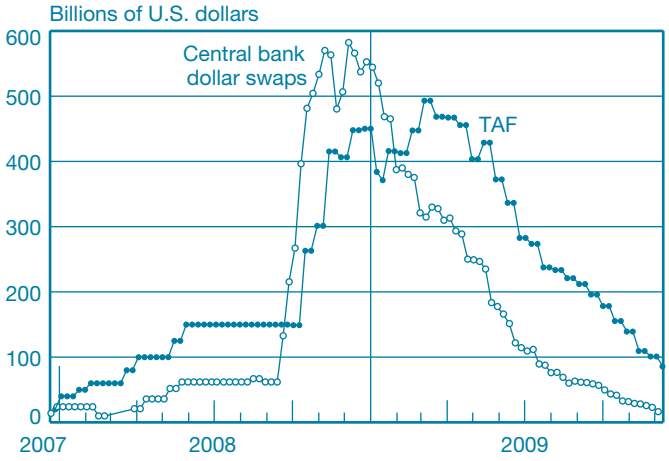
The TAF uses a competitive, single-price auction, which accepts bids at the highest interest rate on through to successively lower rates. When necessary, bids at the lowest accepted interest rate are prorated. All participants whose bids have been accepted are awarded funds at the same interest rate, which is the lowest interest rate at which bids were accepted, regardless of the rates at which participants bid for funds. Known as the "TAF stop-out rate," this is also the fixed rate at which the European Central Bank and the Swiss National Bank allotted funds at their CB dollar swap operations prior to the fixed-rate, full-allotment structure.

The structure and functioning of the reciprocal currency arrangements are intertwined with the TAF in the sense that they would facilitate the extension of term dollar liquidity—but this time to banks in overseas jurisdictions. As we observed, the schedules for the twenty-eight-day and eighty-four-day dollar auctions conducted by the European Central Bank, the Bank of England, the Swiss National Bank, and the Bank of Japan largely coincided with the similar-tenor TAF operations.

Box 2 shows the basic schedule for a representative twenty-eight- or eighty-four-day TAF auction and swap between the European Central Bank and the Federal Reserve. A typical sequence of events has the Federal Reserve conducting its TAF auction first, but not communicating the results until the European Central Bank, the Swiss National Bank, the Bank of England, and the Bank of Japan have held their operations for the same tenor.

[8] An overview of the TAF is provided in Armantier, Krieger, and McAndrews (2008).

Chart 6
TAF and Central Bank Dollar Swaps Net Outstanding



Sources: Federal Reserve Statistical Release H.4.1, "Factors Affecting Reserve Balances"; U.S. Treasury Department, "U.S. International Reserve Position."

Note: TAF is the Federal Reserve's Term Auction Facility.

While these schedules were closely related, the CB swaps were not an exact international replica of the TAF format. Unlike the fixed-rate, full-allotment structure of several of the foreign central banks' dollar auctions held since October 2008, at the TAF auction a predetermined fixed supply of dollar funds was offered at each preannounced date.[9] In practice, each TAF auction held since the auction sizes were increased to $150 billion on October 6, 2008, was undersubscribed. Thus, the cost of dollars at these auctions fell to the minimum bid rate.[10]

It is interesting to compare the outstanding balances at dollar swap facilities with the pattern of demand observed at the TAF. Outstanding TAF balances expanded through the fall of 2008, but declined little thereafter (Chart 6). Indeed, despite a reduced rollover of positions in January and February 2009, some of the TAF participants increased their net outstanding balances in March and April 2009. With TAF funds priced more attractively relative to market rates (a point expanded on below), a different set of incentives was presented to financial institutions choosing among alternative official and private funding sources.

[9] For details on the TAF auction process, see http://www.federalreserve.gov/monetarypolicy/taffaq.htm.

[10] The minimum bid rate was the OIS until the Federal Reserve cut rates to a range of 0 to 25 basis points in December 2008. Thereafter, the minimum bid rate became the interest rate paid on excess reserves.

Box 2

A Representative Twenty-Eight-Day or Eighty-Four-Day U.S. Dollar Auction by the Federal Reserve and the European Central Bank

Monday	
10 a.m.	The Federal Reserve releases the minimum bid rate.
11 a.m.	TAF operation "opens" for bidding.
12:30 p.m.	TAF operation "closes" bidding.
5:00 p.m.	The Federal Reserve Bank of New York sends the European Central Bank, the Bank of Japan, the Bank of England, and the Swiss National Bank the OIS rate to use in conducting their full-allotment tenders.

Tuesday	
3:45 a.m.	Bidding at the European Central Bank closes.
5:00 a.m.	The European Central Bank releases the results of operations.
10:00 a.m.	The Federal Reserve releases TAF results.

Notes: Times are Eastern Standard. TAF is the Federal Reserve's Term Auction Facility; OIS is the overnight index swap rate.

4.2 Direct Costs of Funds across TAF and CB Dollar Swaps

In fall 2007, costs in the short-term funding markets—as reflected, for example, in Libor rates—were historically high relative to the expected path of policy rates as measured by the OIS. When the TAF was introduced in December 2007, dollar liquidity was made available to firms within the United States—including those foreign banking organizations with access to Federal Reserve liquidity facilities—and to some financial institutions abroad that could also access dollars through the European Central Bank or the Swiss National Bank. Various studies of the effectiveness of the TAF (discussed further in Section 5) have pointed to the subsequent and ongoing "normalizing" of the Libor rate as evidence that the TAF and swap facilities were effective in restoring liquidity and confidence in short-term funding markets.[11] However, both the one-month Libor and the TAF stop-out rates still increased significantly relative to the expected path of policy rates after Lehman's failure in September 2008 (Chart 7).

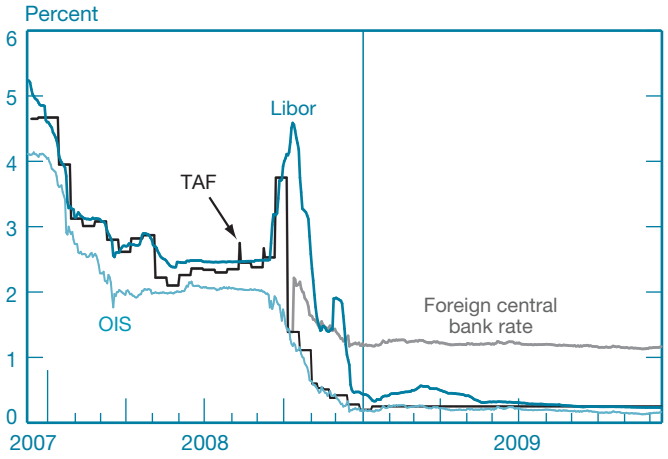
The cost of collateralized funds provided through the TAF and the CB dollar swap facilities, which initially allotted dollars at the TAF stop-out rate, tracked Libor closely until September 2008. However, the cost of dollars at these two facilities diverged after Lehman's collapse as the auction types and pricing diverged. The TAF rates stopped out substantially below Libor, instead closely following OIS rates, as the available TAF funds were increased shortly after Lehman's bankruptcy.

On October 13, 2008, four foreign central banks introduced the fixed-rate, full-allotment format for their dollar auctions. The evolution of these four central banks' auction prices is shown in Chart 7 as the foreign central bank rate. The change

[11] See, for example, McAndrews, Sarkar, and Wang (2008).

Chart 7

TAF Stop-Out Rate, One-Month OIS, and One-Month Libor



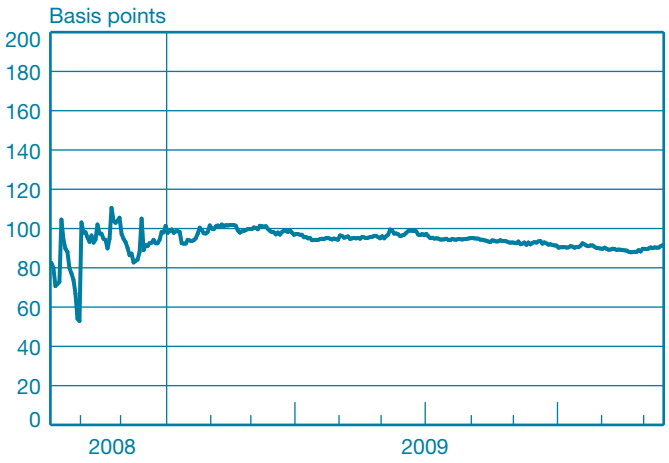
Sources: Bloomberg (OIS, Libor); Board of Governors of the Federal Reserve System (TAF).

Note: TAF is the Federal Reserve's Term Auction Facility, OIS is the overnight index swap rate, Libor is the London interbank offered rate.

in pricing for these four central banks, to a fixed rate of approximately 100 basis points over OIS, and the decline in TAF stop-out rates made the cost of dollars from these foreign central bank swap facilities available at a higher rate relative to funds at the TAF (Chart 8). In part, the pricing of the fixed-rate, full-allotment CB swap programs ensured that the facility was available to meet dollar funding demands without hindering the eventual recovery of liquidity in the private Eurodollar or foreign exchange swap markets. This structure also reinforced the existence of the CB dollar swaps as backstop liquidity facilities.

Chart 8

Central Bank Dollar Swap Less TAF Stop-Out Rate

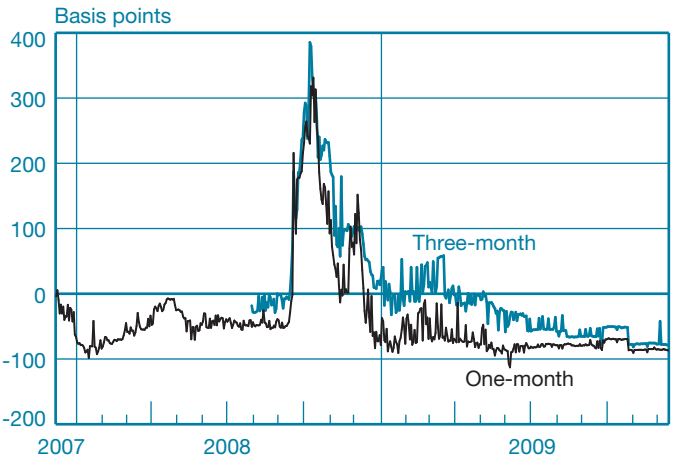


Sources: Bloomberg (OIS); Board of Governors of the Federal Reserve System (TAF).

Notes: TAF is the Federal Reserve's Term Auction Facility, OIS is the overnight index swap rate. Prior to October 13, 2008, the European Central Bank, the Bank of England, the Swiss National Bank, and the Bank of Japan used the TAF stop-out rate and allocated funds to bidders on a prorated basis. After October 13, these banks switched to fixed-rate, full-allotment operations at OIS + 100 basis points.

Chart 9

Eurodollar Rates Less Dollar Swap Fixed Rate of OIS



Source: Bloomberg (U.S. dollar offshore deposit rate, OIS).

Notes: OIS is the overnight index swap rate. The three-month operation was introduced July 30, 2008.

For some overseas depository institutions, the swap facilities, despite carrying a penalty rate relative to the TAF, remained attractive as long as the cost of funds remained advantageous compared with dollars obtainable in the market. That is, the swap facilities remained attractive to a financial institution as long as its cost of borrowing in the market was more than 100 basis points over OIS. Chart 9 shows the spreads between one- and three-month Eurodollars relative to the fixed rate of approximately OIS + 100 basis points. Negative values indicate when the average cost of private-market dollar funds was less expensive than the funds available through the central bank auction facility.

As we noted, dollars obtained through the TAF and the CB swap dollars were priced comparably to private-market funds as measured by Libor prior to September 2008. Thereafter, the swap funds were considerably less expensive than private-market funds during the height of the crisis as the spread between Libor and OIS widened dramatically. However, by this measure, through first-quarter 2009, only three-month funds remained available more cheaply than private-market funds from central bank sources (though they were still more expensive than through the TAF). CB dollar swaps would still be attractive to those depository institutions that had limited or no access to dollars near the Libor fixings. By contrast, the availability of competitively priced TAF funds continued to keep demand for dollars directly from the Federal Reserve higher and steadier. Private-market costs of dollars as measured by Libor were higher than TAF costs.

4.3 Indirect Costs Associated with Collateral Requirements[12]

Availability of eligible collateral and the "haircuts" on different types of collateral influenced the effective cost of funds and dollar demand at the respective dollar facilities. For example, there were additional haircuts for foreign exchange risks when banks pledged non-dollar-denominated collateral at a foreign central bank, adding to the cost of borrowing dollars. These collateral requirements in the United States and abroad could have impinged on the choice of where to access dollars—for example, from foreign central banks or the TAF. Access to the TAF, however, would be permitted only if a foreign-owned bank had an eligible affiliate in the United States.[13]

The availability of eligible collateral can be a constraint on foreign participation in the TAF. In order to participate in the TAF, a credit institution could pledge assets located in the United States, or assets located in an International Central Securities Depository (ICSD), such as Euroclear Bank (Belgium) and Clearstream Banking Luxembourg.

However, a number of factors limit the availability of eligible collateral located in the United States as well as in

[12] The authors thank Sergio Grittini of the European Central Bank for insightful contributions to this section.

[13] As noted by the Bank for International Settlements (2008), several central banks during the crisis widened, either temporarily or permanently, the range of eligible collateral—and, in some cases, counterparties—in order to facilitate an effective distribution of central bank funds. The BIS Committee on Payment and Settlement Systems also explores the arrangements through which alternative central banks accept foreign collateral (Bank for International Settlements 2006).

Europe, possibly constraining foreign participation in the TAF. Some foreign banks' portfolios of Federal Reserve–eligible assets located in the United States were relatively small. Moreover, prudent liquidity management practices for some banks require that part of those assets be left unencumbered to enable access to the discount window on short notice and to enhance the bank's rating.

In addition, the Federal Reserve applies stringent eligibility criteria that limit the pool of assets located in the ICSDs. Specifically, the eligible assets included foreign government debt, German Jumbo Pfandbriefe, international agency debt, foreign government agency debt, municipal bonds, and corporate bonds. Asset-backed securities and bank loans were not eligible as collateral for the TAF when they were located in Europe, but were eligible when they were located in the United States.

Furthermore, non-dollar-denominated instruments must have a market price from a recognized pricing source and a AAA rating; the exception is government debt, for which the rating threshold is lower (Standard and Poor's BBB- and Moody's Baa3). Finally, as with assets located in the United States, not all eligible assets located in Europe could be used to participate in the TAF, given the need to leave a portion unencumbered or available for other purposes (for example, for participating in the Eurosystem's euro-providing operations).[14]

In addition, a U.S.-based entity of a foreign banking group participating in the TAF could be different from the entity that owns the assets deposited in the ICSDs (for example, European Union–based). Meeting collateral requirements of the TAF would require one entity to transfer the ownership title on the assets to the other entity through an intragroup transaction (for example, a repo or a bond lending operation). Moreover, considering the potentially small amount of eligible and usable assets located in the two ICSDs, some foreign banks reportedly decided not to invest resources to address these legal and organizational issues and thus were unable to use the eligible assets deposited in the ICSDs.

Haircuts also affect the relative attractiveness of facilities. Different haircuts apply to collateral accepted by the Federal Reserve and the European Central Bank. For comparison purposes, we focus on the subset of assets eligible in both operations. Assets located in the United States were not eligible to be pledged at the operations carried out by the European Central Bank, because the latter requires that the assets be deposited or registered (issued) in the European Economic Area[15] and held and settled in the euro area. In contrast, most of the assets in the ICSDs that are eligible to be used as collateral in the TAF are also eligible for the European Central Bank dollar facility.

The lendable value for these assets differs according to the central bank to which they are pledged. In particular, the lendable value for a given amount of euro-denominated assets located in an ICSD was typically *higher* in the twenty-eight-day TAF than in any European Central Bank dollar auction. This was mainly because, compared with the Federal Reserve, the European Central Bank applied significantly higher additional initial margins to account for foreign exchange rate risk as part of its risk management framework. Specifically, the European Central Bank's additional haircuts were 10, 12, 17, and 20 percent for dollar operations with durations of one, seven, twenty-eight, and eighty-four days, respectively, whereas the Federal Reserve's additional FX haircuts ranged from 2 percent to 5 percent, according to the residual maturity of the debt instruments.[16] As a result, there were two margins for haircuts: margins based on the security type and an additional margin if the collateral was denominated in foreign currency.

The relationship between lendable values in the TAF and the ECB dollar facility changed when eighty-four-day funds were considered. In fact, a bank would be able to borrow more against euro-denominated assets located in an ICSD in the eighty-four-day ECB dollar auctions than in the TAF. This can occur because, on July 30, 2008, the Federal Reserve introduced an additional collateral requirement for advances of more than twenty-eight days. Under this requirement, the total amount of term primary credit and TAF credit with original or remaining term to maturity exceeding twenty-eight days could not exceed 75 percent of the lendable value of an individual depository institution's available collateral.[17]

All else equal, the differences in the haircut regimes reinforced the relative attractiveness of the twenty-eight-day TAF compared with the ECB dollar auctions while lowering the relative attractiveness of the eighty-four-day TAF compared with the ECB dollar auctions. The haircut differences across

[14] Foreign-owned but globally oriented banks reported that legal and operational issues could hinder the use of eligible assets deposited with the ICSDs. In particular, the one-off legal preparatory work that is needed to pledge these assets in the TAF could have initially delayed foreign banks' participation in the facility.

[15] The European Economic Area includes the twenty-seven member states of the European Union and Iceland, Liechtenstein, and Norway.

[16] For example, the lendable value for euro-denominated foreign government debt located in an ICSD at a twenty-eight-day TAF was between 85 percent and 92 percent of the asset's market value, depending on the residual maturity of the debt instrument. The lendable value of the same instrument at the ECB dollar auction was instead between 76 percent and 83 percent of the asset's market value, depending on the structure of the debt instrument (fixed or zero-coupon) and its residual maturity. The lendable value of euro-denominated German Jumbo Pfandbriefe (another relevant asset class) at a twenty-eight-day TAF was between 85 percent and 92 percent of the asset's market value, depending on the residual maturity, while the corresponding values at the ECB dollar auction were between 73 percent and 82 percent.

[17] For example, this additional collateral requirement lowered the lendable value for euro-denominated foreign government debt and German Jumbo Pfandbriefe located in an ICSD at an eighty-four-day TAF to between 64 percent and 69 percent of the asset's market value, depending on the residual maturity of the debt instrument.

Box 3

Collateral and Haircuts at Dollar Auctions by the Federal Reserve and the European Central Bank

- Define h^{FRS} and h^{ECB} as the haircuts on comparable collateral, as applied by the Federal Reserve and the European Central Bank (ECB).
- Define r^{TAF} and r^{ECB} as the cost of funds at the Federal Reserve's Term Auction Facility (TAF) and the ECB's dollar swap facility.
- Define r^m as the market rate on uncollateralized funds. For a bank with $1 of eligible collateral, the cost of borrowing $1 is—
  at the TAF: $(1-h^{FRS}) * r^{TAF} + h^{FRS} * r^m$;
  at the ECB dollar swap facility: $(1-h^{ECB}) * r^{ECB} + h^{ECB} * r^m$.

The total cost of $1 borrowed at the TAF is below the cost at the European Central Bank provided that $(1-h^{FRS}) * r^{TAF} + h^{FRS} * r^m < (1-h^{ECB}) * r^{ECB} + h^{ECB} * r^m$.

Example: Assume $h^{FRS} = 0.36$, $h^{ECB} = 0.24$. The inequality that must be satisfied for the TAF to be less costly than the ECB funds becomes $r^m < 6.33 r^{ECB} - 5.33 r^{TAF}$.

On May 11, 2009, with $r^{ECB} = \text{OIS} + 100 = 1.197$ and $r^{TAF} = 0.25$, $r^m < 6.3$ percent.

assets can be viewed in terms of a supplemental interest rate differential favoring the TAF. If the lendable value for an asset was 64 percent at the TAF and 76 percent at the ECB dollar auction (as it is for foreign government bonds in eighty-four-day operations), in May 2009 a bank would have found it profitable to borrow at the ECB dollar auction at OIS + 100 basis points instead of at the TAF at 0.25 percent only if its private-market funding costs were more than 6.3 percentage points (Box 3). The facilities complement each other, with collateral a necessary but not necessarily exclusive determinant of the location of facilities used for supplementing liquidity.

5. Effects of CB Swaps on Dollar Funding Markets

The implementation and expansion of the swap lines between the Federal Reserve and the various foreign central banks significantly ameliorated the cost of dollars shown in the Libor-OIS spread and the FX basis spread, even if these costs remained elevated by historical measures.[18] In this section, we consider evidence from our discussions with market participants, from data on the cost of funds to different market segments, and from formal econometric studies.

[18] The Federal Reserve established other facilities in addition to the TAF to address the freezing of money markets, including the Commercial Paper Funding Facility and the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility. Meanwhile, the U.S. Department of the Treasury implemented the Temporary Guarantee Program for Money Market Funds and the Temporary Liquidity Guarantee Program. Similar efforts were undertaken globally by fiscal and monetary authorities.

5.1 Discussions with Market Participants

Liquidity conditions in the FX swap market improved considerably following the height of market stresses in late 2008. At that point, the FX basis spread narrowed from its widest level. By late spring 2009, bid-ask spreads for both euro/dollar and dollar/yen FX forwards had converged toward more typical levels, although trade sizes remained a fraction of the typical precrisis trade size.

Dealers, brokers, and bank treasurers attributed these improvements to several factors. First, the demand for dollar funding diminished as foreign banks continued to write down many of their dollar-denominated credit-related assets, reducing the value of assets that needed funding. Second, the biggest suppliers of dollars in FX swaps (mostly large U.S. banks) began to grow more comfortable with their access to dollars, which increased their willingness to supply foreign banks with dollars in exchange for foreign currency. Third, global financial institutions became more conservative in their liquidity management practices—partly in anticipation of tighter regulation, which may have reduced their reliance on short-term cross-currency funding. These observations were consistent with anecdotal reports that the overall volume of activity in the FX swap market remained well below precrisis levels. Despite the significant improvement, liquidity conditions in the FX swap market remained notably impaired by historical measures through spring 2009.

Similarly, conditions in the Eurodollar market showed nascent signs of improvement beginning at the end of December 2008 after increases in the authorized sizes of the Federal Reserve's TAF and the CB swap lines. These

improvements continued until a renewed sense of concern in the financial sector emerged early in 2009. However, spillovers to the dollar funding markets were more limited given the existence of a strong backstop provided by the CB dollar swaps. After early March 2009, the process of "normalization" continued almost uninterrupted. The entire Libor curve shifted lower and flattened, as the three-month Libor-OIS spread narrowed to levels prevailing before the Lehman bankruptcy. Market participants also reported increasing activity in tenors beyond one month, a sign of significant improvement from late 2008.

Expectations of future market conditions also improved. The expected three-month Libor-OIS spread (as reflected in the spread between forward rate agreements and forward OIS rates) narrowed significantly, the rates implied in the 2009 and 2010 Eurodollar futures contracts declined significantly, and the implied rates for three-month Libor fixings fell below 1 percent for all contracts through June 2010.

5.2 Econometric Analyses

In this section, we interpret the econometric evidence exploring the role of the TAF and the CB swaps in bringing down the cost of funds, especially when dollar liquidity conditions were at their most stressed. Formal econometric testing has identified some of the effects of the TAF and the CB dollar swaps on market liquidity. In general, these studies begin with high-frequency data (generally daily) on financial market indicators—for example, Libor-OIS spreads or FX basis swaps—and consider the effects of announcements and actual auction events. "Effectiveness" is generally interpreted as a statistically significant and persistent decline in the cost of funds. Another area of research considers the relationship between the CB swaps and the impact on conditions in the last four markets—Brazil, Mexico, Korea, and Singapore—to be added to dollar swaps with the Federal Reserve.

Initial studies of the liquidity facilities' consequences focused primarily on the TAF, and the CB dollar swaps were treated as a related arm of the liquidity facilities. Mishkin (2008) originally argued that the TAF "may have had significant beneficial effects on financial markets," but this claim was met with skepticism by Taylor and Williams (2009), who focused on the effects of the facilities introduced in the first phase of the crisis, specifically the period from August 9, 2007, through March 20, 2008. Taylor and Williams concluded that the TAF auctions (seven in their sample) had no effect in reducing the three-month Libor-OIS spread.[19]

In a comprehensive study of the early response to the crisis, McAndrews, Sarkar, and Wang (2008) use more of an event-study methodology, as in Taylor and Williams (2009). They explore a broader events panel that includes TAF as well as CB swap announcement dates and auction dates. Also using the three-month Libor-over-OIS spread, with the dependent variable being *changes* and not the (potentially nonstationary) level of the spread, McAndrews, Sarkar, and Wang find that TAF announcements as well as actual TAF operations significantly reduced spreads. Noteworthy for our discussion of the central bank swap facilities is that these researchers distinguish between domestic TAF and international (swap facility) announcements in econometric exercises. The announcements along the international dimension of the liquidity facilities are the dominant drivers of the overall announcement effects, both quantitatively and in terms of statistical significance.[20]

Baba and Packer (2009) and Aizenman and Pasricha (2009) also focus directly on the dollar swap facilities. Baba and Packer provide extensive details on the U.S. dollar auctions by the European Central Bank, the Swiss National Bank, and the Bank of England in the period between September 2007 and October 2008. In addition to examining Libor-OIS spreads, they examine daily data for three FX swap pairs over the periods from August 2007 through September 2008 and from September 2008 through January 2009. The econometric analysis focuses on whether the CB swaps affected counterparty-specific risks and had a common-effects component across all three FX swap bases.

As in McAndrews, Sarkar, and Wang (2008), Baba and Packer distinguish between announcement effects and the actual auctions' effects. The effects of the actual auctions are mixed and contingent on the maturities of funds supplied at the auctions. Announcements about the auctions are permitted to differ, by time period, in their effects on financial variables.

[19] Further, Taylor and Williams (2009) use the *level* of (not the *changes* in) the Libor-OIS spread as the dependent variable in regressions, biasing the results against finding a TAF effect. The period examined covers only the early stages of the TAF (announced December 12, 2007) and dollar swaps with the European Central Bank and the Swiss National Bank (see Table 1). The variable of interest in the econometric work is the spread between the three-month Libor and the Fed's overnight federal funds rate target. Other authors, such as Wu (2008) and McAndrews, Sarkar, and Wang (2008), take issue with the identification strategy of Taylor and Williams, noting, for example, that the study omits the effects on spreads of facility announcements, considers only the actual auction events, and was performed on the level of the spreads—not the changes in spreads. In Wu (2008), the econometric strategy is to examine separately the TAF's effects on relieving financial institutions' liquidity concerns and on reducing the counterparty risk premiums, and then to quantify the overall effects on strains in the interbank money market. Wu's econometric specification assumes that the Libor-OIS spread would be permanently moved by the introduction of the TAF (with a dummy variable introduced equal to 1 for days since December 12, 2007, the first TAF announcement date), concluding that the TAF significantly reduced the Libor-OIS spread.

[20] Meyer and Sack (2008) and Deutsche Bank (2009) likewise find that TAF announcements and auctions reduce the Libor-OIS spread for a number of different specifications of the credit risk and VIX (Chicago Board Options Exchange Volatility Index) measures, although without the distinctions between domestic and international facility announcements.

The CB dollar auction variables reduce both the level and volatility of all the spreads in the period after Lehman's failure, but mainly serve to reduce volatility in the period prior to the bankruptcy.

The analysis by Aizenman and Pasricha (2009) reaches more mixed conclusions about the effects of the announcements of the Federal Reserve's swap arrangements with the central banks of Brazil, Korea, Mexico, and Singapore. The authors treat these countries as being in a special emerging-markets group that had swap arrangements with the United States. They find that the credit default swap (CDS) spreads of these countries fell at the time the CB swap facilities were announced, but so did the CDS spreads of other emerging-market countries. Indeed, the spreads of most emerging markets had started to decline even before the CB swap arrangements were announced. Exchange rates responded significantly for the currencies of the countries with these arrangements, on average appreciating when nonswap countries' currencies depreciated, though these effects were subsequently reversed.

The general tenor of these few empirical studies of CB dollar swaps supports a role for the dollar swap facilities in influencing financial markets. This role was achieved through some combination of announcement effects and the actual operations' effects. However, it is important to point out that definitive statements about the consequences of any specific CB dollar swap operation, announcement, or facility remain difficult to quantify. The measured effects may have been short term and not measurably persistent.

This type of result and critique is common to empirical studies that examine the effects of news on high-frequency data. Thus, tests of long-term consequences are notoriously difficult to conduct in light of the highly volatile conditions and the many changes in facilities and operations over the life of the swap facilities. Indeed, Baba and Packer (2009) acknowledge similar difficulties in evaluation, noting that "these measures were widely welcomed by market participants and credited with alleviating funding pressures in term funding markets. However, the increase in the dollar swap lines to unlimited amounts occurred shortly after the adoption of many other measures by the authorities to stabilize the financial system by reducing counterparty credit and liquidity risks . . . with the combination of the [range of] measures . . . likely important in alleviating funding pressures on non-U.S. banks in particular."

Benchmarks for what might have occurred in the absence of the facility are speculative by definition. Overall, though, the balance of market perceptions and the carefully implemented empirical studies suggest that the central bank reciprocal swap arrangements were a highly welcome and useful response to the dollar funding shortages in international markets.

6. Conclusion

This paper has reviewed the evolution of the reciprocal currency arrangements, or dollar swap facilities, that the Federal Reserve established with various foreign central banks in 2007 and 2008 and exited in February 2010. In brief, the performance of the CB swap facilities is intertwined with the pricing and functioning of TAF auctions, which were another means of providing dollar liquidity to banks. Both the TAF and the dollar swap facilities have been effective in reducing dollar funding costs to domestic and foreign firms and have been viewed as successful backstop facilities for depository institutions.

It is worth noting that while we have focused exclusively on the Federal Reserve dollar swaps with foreign central banks, this type of facility has been implemented by other networks of European and Asian monetary authorities, including the ASEAN group's Chiang Mai initiative.[21] The global network of swap facilities targeted widespread dysfunction across markets, as central banks extended loans against the collateral provided by their constituent financial institutions.

Empirical studies have pointed to the particular role played by the international facilities in influencing financial markets. The large expansion of the Federal Reserve's balance sheet that was associated with the CB dollar swaps in fourth-quarter 2008 occurred as global banks demanded term funding to cover potential year-end shortages. These positions unwound significantly in first-quarter 2009 as outstanding balances matured and were not rolled over, and they continued to decline during 2009. Availability of dollars to foreign banks was associated with credit tiering across these institutions that persisted, even if less severely, well into 2009.

In crisis periods, broad market dysfunction is often accompanied by significant credit tiering across financial firms. Such tiering can persist for some time after the need for broad liquidity provision has receded. As a crisis abates, a key challenge for policymakers is to identify when the use of liquidity support becomes concentrated among "adversely selected" institutions that might continue to rely on the liquidity facilities. The use of penalty rates in pricing these liquidity operations can assist in making such judgments because penalty rates create economic incentives for participants to exit these programs as the cost of market-based sources of funds returns to more normal levels.

Overall, we conclude that currency swap facilities, beyond their more traditional use in foreign exchange policy, have been an important part of the central bank toolbox for managing and resolving financial crises.

[21] Details are provided in McGuire and von Peter (2009b, Figure 7).

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Stijn Claessens

Commentary

The paper by Linda S. Goldberg, Craig Kennedy, and Jason Miu is part of a growing literature investigating the causes and effects of the recent global financial crisis and the appropriateness and effectiveness of various policy responses. The paper specifically analyzes the adoption of swap lines by central banks in fall 2008. The financial crisis reduced the availability of dollar funds in foreign financial markets to varying degrees. Central banks responded by implementing reciprocal currency arrangements (RCAs), or swaps, which quickly increased in size and with some becoming unlimited. As the central banks intended, RCAs affected the levels and differentials of dollar interest rates in various markets.

Besides offering the motivation for the foreign exchange (FX) swaps, the paper provides many facts associated with the timelines of actions and the institutional aspects of the swaps mechanisms. This alone makes the study very valuable as a reference source. Importantly, it explores the consequences of the FX swaps and their effectiveness by presenting comprehensive data on volumes, spreads, interest rates, and arbitrage conditions over time. The specific spreads examined are the spread between the London inter-bank offered rate (Libor) and the overnight indexed swap rate, the foreign-exchange-swap–implied basis spread, and the intraday federal funds rate (morning over afternoon), as well as the variation in interest rates among commercial banks in Europe.

The main question investigated is, did the RCAs reduce interest rates (spreads) and, if so, by how much? Goldberg, Kennedy, and Miu document that the RCAs were established because of sharp differences in the dollar cost of funding in fall 2008. They show that volumes peaked at the end of 2008 and that RCAs started unwinding in 2009; they also explain that the arrangements are planned to be phased out by February 2010. The study provides support for the argument that RCAs operated as designed. Specifically, it demonstrates that the European premium abated by year-end 2008 and largely normalized over 2009. It also shows that spreads in the first half of 2009 reflected pockets of dollar shortages owing to continued credit tiering by lenders and potentially some self-selection by weaker banks. The study highlights the fact that the costs of accessing different official liquidity facilities varied as designs and collateral policies differed. It concludes with a positive view of the FX swaps while questioning simple interpretations based on, say, event studies.

My primary question regarding this issue is whether the root cause of the problem was the "simple" lack of dollar liquidity in some foreign financial markets or whether it reflected concerns about the solvency of major financial institutions at the time. The challenge, in my view, is therefore to separate the effects of liquidity provision through the FX swap lines from the (largely concurrent) provision of guarantees, recapitalizations, and other forms of public support.

Answering this question requires answering the separate question of what causes deviations of dollar interest rates. My general observation is that it is hard to imagine liquidity factors

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alone as causing such a spike in interest rates as we saw in fall 2008. Rather, a shock to solvency that varied around the world was more likely the cause. In this commentary, I therefore suggest more detailed empirical analysis, which could help make this distinction. Needless to say, my suggestions are subject to data limitations, but I would hope that the Federal Reserve Bank of New York would have access to a wider range of data than other researchers do.

Analysis of differences in interest rates requires a conceptual framing. Goldberg, Kennedy, and Miu make it clear that dollar rates can vary for several reasons: differences in liquidity availability, for one, but also differences in credit risk and transaction costs. One can use an event study to "test" whether the availability of liquidity through RCAs affects interest rates or spreads. For example, we can look at spreads before and after the use of RCAs, possibly differentiating markets that had limited arrangements from those with unlimited ones. The general finding reported in the paper is one of lower spreads with RCAs in place. The study also reports a lower foreign exchange premium, which is a lower deviation from covered interest rate parity.

But with these tests come problems of anticipation and identification, as the authors explain. First, RCAs could be anticipated, especially after the first arrangement, which might make it harder to detect any effects and thus create a bias *against* finding significant results. A more important problem is the difficulty of identification. Because many other events were occurring at the same time—changes in monetary policies, implementation of financial policies (guarantees, recapitalizations)—we cannot be sure that the results are attributable solely to the establishment of the RCAs.

This brings me to the second category: credit risk, which may have been a cause of the increase in interest rates before the introduction of the RCAs as well as a trigger for the drop in spreads when public support measures were being established. There are various types of credit risk, each of which differs in its implications. One type is bank credit risk. This type of risk is investigated by the authors using the variation in European bank ratings, with some support found for it affecting spreads. Another type is country risk, which is not specifically tested.

Regardless, tests can correct, but only to some degree. For example, it is not easy to control for perceived bank credit risk because bank ratings (as assigned) may not be that reliable and because they are also influenced by factors such as "too-big-to-fail." Country risk could be proxied by sovereign and credit default swap spreads and ratings, but such risk is affected as well by many similar factors, such as large government recapitalizations and guarantees.

Still, a simple test would be to look at the same bank in different markets. The use of interest rate data for the same bank could show whether differences in liquidity matter, keeping credit risk similar. Of course, this too is not a perfect approach. The same bank does not necessarily pose the same credit risk in every market—for instance, a foreign bank subsidiary may present a different risk than that of the headquarter bank. And, as liquidity affects solvency risk, credit risk can vary over time because of liquidity provisioning.

The third category of the causes of differences is transaction costs. As one might expect, there are many transaction costs that can give rise to differences in interest rates. Differences in transaction costs specifically related to RCAs can include the following: the (fixed) pricing may vary; the pricing rules of central banks may differ (for example, the auction types used by central banks vary); the maturity of the facilities varies; differences exist in collateral requirements and in eligible assets; and banks may face legal and other administrative challenges that limit access to the facilities.

It is possible—but difficult—to correct for each of these factors. Nevertheless, the paper gives some examples showing that the differences can lead to large spreads. I think more could be done here. One thing to bear in mind is that some of these transaction costs are policy induced and vary over time. For example, central banks wanted to increase or reduce the use of RCAs (and other liquidity facilities) and consequently priced them below or above market conditions.

These considerations lead me to suggest possible further work for the paper, or in this area. Let me start with some suggestions for aggregate-spreads analysis. Here I would look more across markets that varied in the use of RCAs. For example, we could compare interest rates in emerging markets without RCAs with those in advanced countries with them. Or we could look at advanced countries to determine whether the levels of RCAs mattered. In this case, I would like to see if one could somehow scale the RCAs according to the size of the problem. Clearly, some markets had much greater liquidity needs, which suggests considering the net funding gaps by market in one's analysis.

Within the same market, it may be worth using interest rates in other currencies since one can control for nondollar, nonliquidity factors, such as policies and risk. For example, one might expect dollar interest rates relative to nondollar rates to decrease more when an RCA is announced, even when credit risk decreases (or increases). Perhaps one could also conduct joint tests of arbitrage across currency pairs vis-à-vis dollars. Within the same currency, it may be useful to consider the interest rate or spreads for banks based in, say, different European countries to analyze the role of country factors. It could also be valuable to use the yield curve or futures to derive expectations and check for arbitrage opportunities (futures, for example, are affected less by credit risk).

Recall that because interbank spreads increased in most markets and most currencies, credit risk is likely important. Here I would suggest exploiting more individual interest rates. A suggestion is to use interest rates on specific (collateral) assets. One could check for arbitrage conditions, which would require making corrections for haircuts. While we would still need to control in some ways for bank credit risk (as there is recourse to the bank), lack of arbitrage could perhaps show more clearly whether RCAs had an impact. For those banks that had access to multiple markets, one could also compare rates across those markets.

Detailed rates of individual banks can be useful as well, because credit risk could then be differentiated more effectively from liquidity demand. One way would be to use banks' offer rates in the auctions, especially when combined with the volumes demanded by the types of banks. This approach presumably would require data from foreign central banks, but the data would be very valuable; they would allow one to study the effect of various bank characteristics, such as too-big-to-fail, foreign versus domestic, subsidiaries versus branches. Changes in the size of individual commercial banks' access over time could be especially interesting to study. Here one could investigate the moral hazard of some facilities. For example, by examining a bank's borrowing interest rate, we could determine whether access over time is evolving toward weaker borrowers.

I raise a few minor issues to consider as well. For instance, I was surprised to find that the paper did not use the bid-ask rate when looking at the FX premium. More generally, it might be interesting to know what happened to bid-ask spreads over this period; presumably, spreads widened more in markets with greater dollar liquidity problems. There were also problems reported during this period with the measurement of Libor. Since Libor is based on the quotes of various banks, it need not be actual lending rates. This could have suggested a bias when transactions were few or not occurring. What role could this measurement issue have played in the data used by the authors?

Clearly, there are many policy questions that have come to the fore with the financial crisis. In this regard, the paper could expand its analysis, even if it does not answer all the questions—which is understandably very hard. Some of the big questions are: should there be regular, standing RCAs? Since RCAs have shown to be of value, yet were not put in place immediately at some cost, the question arises as to whether they should become permanent features of the international financial architecture. If they are to become permanent, however, how large should they be? And what about moral hazard—can it be controlled? Or are there other mechanisms that can facilitate cross-border liquidity as well, but do not present the same moral hazard problems? For example, Continuous Linked Settlement is a private sector solution. Could it suffice? What about other clearing and settlement mechanisms?

Another set of questions relates to macroprudential rules. The financial crisis has presumably taught us that these rules need to be tightened for liquidity—besides rules in general, those for open FX positions in particular. Is it useful, however, to add liquidity and foreign exchange risk to capital adequacy requirements? Could or should there be exceptions to such rules in times of stress? Another set of questions, mostly beyond the scope of the paper, relates to the need to improve cross-border banking resolution, both for branches and subsidiaries. Indeed, differences in these rules across countries have played a role in the spread of liquidity and solvency problems—and, as such, improvements are called for. But which improvements are needed and in what specific ways of implementation are they most useful from this perspective? Are there lessons here from integrated markets, such as the European markets? Quite a few questions, but the authors have demonstrated the ability to address complex issues. So I am confident we can expect more from them.

Tobias Adrian, Karin Kimbrough, and Dina Marchioni

The Federal Reserve's Commercial Paper Funding Facility

1. Introduction

The commercial paper market experienced considerable strain in the weeks following Lehman Brothers' bankruptcy on September 15, 2008. The Reserve Primary Fund—a prime money market mutual fund with $785 million in exposure to Lehman Brothers—"broke the buck" on September 16, triggering an unprecedented flight to quality from high-yielding to Treasury-only money market funds. These broad investor flows within the money market sector severely disrupted the ability of commercial paper issuers to roll over their short-term liabilities.

As redemption demands accelerated, particularly in high-yielding money market mutual funds, investors became increasingly reluctant to purchase commercial paper, especially for longer dated maturities. As a result, an increasingly high percentage of outstanding paper had to be refinanced each day, interest rates on longer term commercial paper increased significantly, and the volume of outstanding paper declined sharply. These market disruptions had the potential to constrain the economic activities of commercial paper issuers. Indeed, a large share of outstanding commercial paper is issued or sponsored by financial intermediaries, and the difficulties they faced placing commercial paper further reduced their ability to meet the credit needs of businesses and households.

In light of these strains, the Federal Reserve announced the creation of the Commercial Paper Funding Facility (CPFF) on October 7, 2008, with the aim of supporting the orderly functioning of the commercial paper market. Registration for the CPFF began October 20, 2008, and the facility became operational on October 27. The CPFF operated as a lender-of-last-resort facility for the commercial paper market. It effectively extended access to the Federal Reserve's discount window to issuers of commercial paper, even if these issuers were not chartered as commercial banks. Unlike the discount window, the CPFF was a temporary liquidity facility that was authorized under section 13(3) of the Federal Reserve Act in the event of "unusual and exigent circumstances." It expired February 1, 2010.[1]

The goal of the CPFF was to address temporary liquidity distortions in the commercial paper market by providing a backstop to U.S. issuers of commercial paper. This liquidity backstop provided assurance to both issuers and investors that firms would be able to roll over their maturing commercial paper. The facility enabled issuers to engage in term lending funded by commercial paper issuance, which in turn enhanced the ability of financial intermediaries to extend crucial credit to U.S. businesses and households.

The CPFF did not address the solvency of issuing firms. Rather, the focus was on shielding the allocation of real economic investment from liquidity distortions created by the run on high-yielding money market instruments that had been

[1] Initially, the CPFF was set to expire on April 30, 2009, but it was extended to October 30 and subsequently to February 1, 2010.

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triggered by the bankruptcy of Lehman Brothers. The facility was explicitly designed to protect the Federal Reserve from potential credit losses. Issuance to the CPFF was either secured by collateral or subject to an additional surcharge, which was calibrated to protect the Federal Reserve from any potential credit losses.

This paper offers an overview of the Commercial Paper Funding Facility. We explain the economic role of the commercial paper market as a source of funding for various financial intermediaries. We briefly review the events surrounding the turmoil that led to the creation of the CPFF. Our study also presents operational details of the CPFF and documents its usage and effectiveness. In addition, we discuss the economics of the facility in the context of the financial system and in relation to the Federal Reserve's role as lender of last resort. Also considered are issues associated with the risk of moral hazard that have been raised following the launch of the CPFF.

2. Background on the Commercial Paper Market

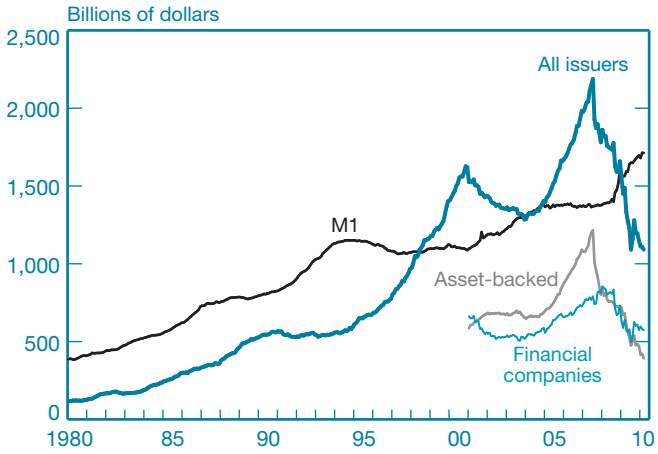
The commercial paper market is used by commercial banks, nonbank financial institutions, and nonfinancial corporations to obtain short-term external funding. There are two main types of commercial paper: unsecured and asset-backed.

Unsecured commercial paper consists of promissory notes issued by financial or nonfinancial institutions with a fixed maturity of 1 to 270 days, unless the paper is issued with the option of an extendable maturity. Unsecured commercial paper is not backed by collateral, which makes the credit rating of the originating institution a key variable in determining the cost of issuance.

Asset-backed commercial paper (ABCP) is collateralized by other financial assets and therefore is a secured form of borrowing. Historically, senior tranches of asset-backed securities (ABS) have served as collateral for ABCP. As such, ABCP is a financial instrument that has frequently provided maturity transformation: While the underlying loans or mortgages in the ABS are of long maturity (typically five to thirty years), ABCP maturities range between 1 and 270 days.

Institutions that issue ABCP first sell their assets to a bankruptcy-remote special-purpose vehicle (SPV).[2] The SPV then issues the ABCP, which is backed by the assets in the vehicle and also by backup credit lines of the sponsoring institution. If the sponsoring institution enters bankruptcy, the assets of the SPV do not become part of the sponsor's pool of assets.

Chart 1
Outstanding Commercial Paper and the Money Stock Measure (M1)



Source: Board of Governors of the Federal Reserve System.

All commercial paper is traded in the over-the-counter market, where money market desks of securities broker-dealers and banks provide underwriting and market-making services. In the United States, commercial paper is cleared and settled by the Depository Trust Company (DTC).[3]

Commercial paper provides institutions with direct access to the money market. In traditional bank-intermediated financial systems, borrowing institutions obtain loans from commercial banks, which in turn are funded primarily by deposits. Since the early 1980s, however, the U.S. financial system has undergone a major transformation, as an ever-increasing fraction of credit intermediation migrated from banks to financial markets.

One way to gauge the degree to which this process of disintermediation affected the commercial paper market is to compare outstanding commercial paper with the money stock. Commercial paper represented only 30 percent of the money stock measure (M1) in 1980. It overtook M1 in mid-1998 and, at its peak, was 60 percent larger than M1 in August 2007 (Chart 1).[4] The sharp contractions of commercial paper in 2007 and 2008 led the ratio of commercial paper to M1 to fall

[2] An SPV is a legal entity created to serve a particular function—in this case, purchasing or financing specific assets. "Bankruptcy remoteness" refers to assets of an SPV being shielded from the bankruptcy of the sponsoring institution.

[3] DTC is a subsidiary of the Depository Trust and Clearing Corporation. See http://www.dtcc.com/.

[4] M1 consists of: 1) currency outside the U.S. Treasury, Federal Reserve Banks, and the vaults of depository institutions; 2) travelers checks of nonbank issuers; 3) demand deposits; and 4) other checkable deposits.

below 72 percent in the second half of 2009, a fraction not seen since the mid-1990s.

The mix of unsecured commercial paper and ABCP in the market has varied considerably over the last few years, as ABCP represented more than 45 percent of the market between 2001 and 2007. The rise of ABCP is intertwined with the growth of securitization. Since 1998, financial intermediaries have increasingly relied on ABCP as a source of funding for assets warehoused for securitization.[5] In the decade prior to the crisis, ABCP increased from $250 billion in 1997 to more than $1 trillion by 2007 (that is, from roughly 20 percent to as much as 50 percent of outstanding commercial paper), fueled by the considerable distribution of residential mortgage exposure through structured finance products.

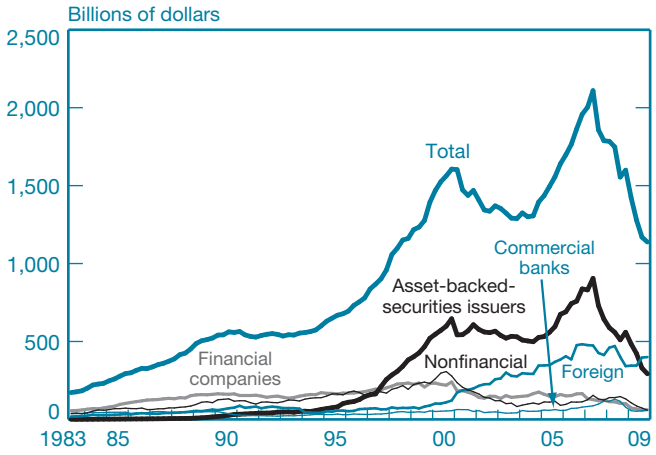
Outstanding commercial paper peaked at a total market value of $2.2 trillion in August 2007. At that time, ABCP accounted for more than 52 percent of the total market, while financial commercial paper accounted for an additional 38 percent and nonfinancial commercial paper approximately 10 percent. Between August 15, 2007, and September 15, 2008, the market experienced a notable decline associated with mounting credit problems of ABCP collateral. The initial decline of outstanding ABCP is often used to date the beginning of the first wave of the 2007-09 financial crisis.[6] As the deterioration of the U.S. housing market accelerated in the summer of 2007, the riskiness of the ABS used as collateral in ABCP transactions increased. As a result, ABCP issuers struggled to issue commercial paper.

Between September 2007 and January 2008, total assets of commercial banks grew unusually fast as many ABS that were previously funded in the ABCP market were moved from the balance sheets of ABCP issuers to those of commercial banks. As a result of a drying up of funding in the ABCP market, commercial banks started to fund the ABS in unsecured money markets, such as the Libor (London interbank offered rate), Eurodollar, and commercial paper markets, all of which would also become compromised at the peak of the crisis as credit risk reached extreme levels.

2.1 Major Commercial Paper Issuers

The Flow of Funds Accounts of the Federal Reserve provide an overview of issuers in the commercial paper market since the early 1980s (Chart 2). In the past decade, ABS issuers were the largest issuers of commercial paper, usually in the form of

Chart 2
Commercial Paper Issuers



Source: Board of Governors of the Federal Reserve System.

ABCP. Commercial paper funding of ABS stopped growing after Enron's bankruptcy in 2001, as changes in accounting and regulatory practices concerning off-balance-sheet entities required that additional capital be held against the entities on the balance sheet.[7] At the end of 2003, capital regulation regarding off-balance-sheet conduits changed, and the growth of ABS-issued commercial paper resumed. Indeed, the growth in ABS issuance goes hand in hand with the growth of outstanding ABCP.

The second-largest issuers of commercial paper in recent years have been foreign issuers of U.S.-dollar-denominated paper, which include foreign banks and other financial institutions. Other issuers of commercial paper include finance companies, nonfinancial corporations, and commercial banks. For commercial banks, commercial paper issuance is relatively expensive; a combination of deposits—checking deposits, term deposits, or certificates of deposit—and borrowing in the federal funds market is usually a less expensive funding alternative than commercial paper (Chart 3), although a bank holding company might issue commercial paper more readily given the limited availability of deposits and financing that can be transferred from its commercial banks.[8] However, commercial paper does provide a marginal source of funding to the commercial banking sector and, at times—and at least for certain issuers—commercial paper rates are actually lower than other money market rates, such as Eurodollar rates.

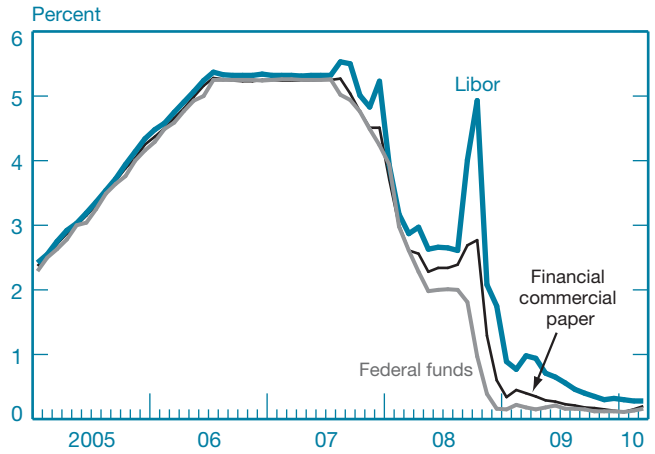
[5] For an overview of asset-backed commercial paper, see Covitz, Liang, and Suarez (2009). Overviews of the securitization markets are provided by Adrian, Ashcraft, and Pozsar (2009) and Acharya and Schnabl (2010).

[6] For a comprehensive timeline of the financial crisis, see http://timeline.stlouisfed.org/.

[7] For an overview of recent accounting changes concerning off-balance-sheet vehicles, see http://www.fasb.org/cs/ContentServer?c=FASBContent_C&pagename=FASB%2FFASBContent_C%2FNewsPage&cid=1176155633483.

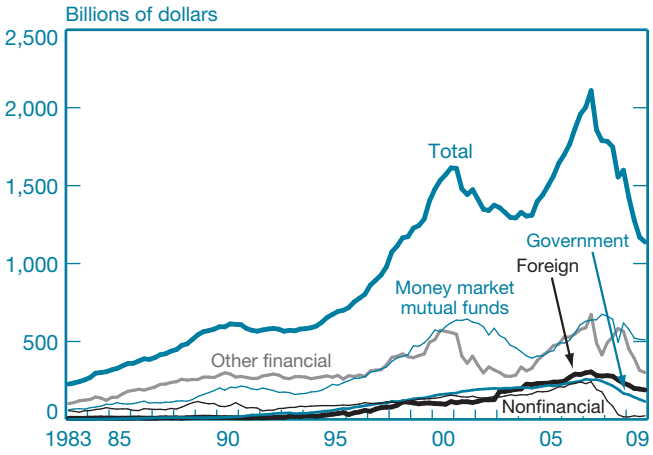
[8] The relationship between commercial banks and affiliated subsidiaries is constrained by section 23A of the Federal Reserve Act; see http://www.federalreserve.gov/aboutthefed/section23a.htm.

Chart 3
Federal Funds, One-Month Libor, and Commercial Paper Rates



Source: Board of Governors of the Federal Reserve System.
Note: Libor is the London interbank offered rate.

Chart 4
Commercial Paper Holdings by Investor Class



Source: Board of Governors of the Federal Reserve System.

As credit conditions deteriorated in the second half of 2007, many commercial banks took back onto their balance sheets obligations that were formerly held in off-balance-sheet vehicles and funded in the ABCP market. As a result, funding for these loans, mortgages, and securities migrated from the ABCP market to the unsecured interbank market, leading to a widening of the spread between Libor and the federal funds rate.

2.2 Lenders in the Commercial Paper Market

Commercial paper is held by many classes of investors (Chart 4). The largest share of ownership is by money market mutual funds, followed by the foreign sector, and then by mutual funds that are not money market mutual funds. Other financial institutions that hold commercial paper include nonfinancial corporations, commercial banks, insurance companies, and pension funds.

The creation of the Commercial Paper Funding Facility is closely tied to the operation of money market mutual funds. Money market funds in the United States are regulated by the Securities and Exchange Commission's (SEC) Investment Company Act of 1940. Rule 2a-7 of the Act restricts investments by quality, maturity, and diversity. Under this rule, money market funds are limited to investing mainly in highly rated debt with maturities of less than thirteen months. A fund's portfolio must maintain a weighted-average maturity of ninety days or less, and money market funds cannot invest more than 5 percent in any one issuer, except for government securities and repurchase agreements (repos). Eligible money market securities include commercial paper, repos, short-term bonds, and other money market funds.

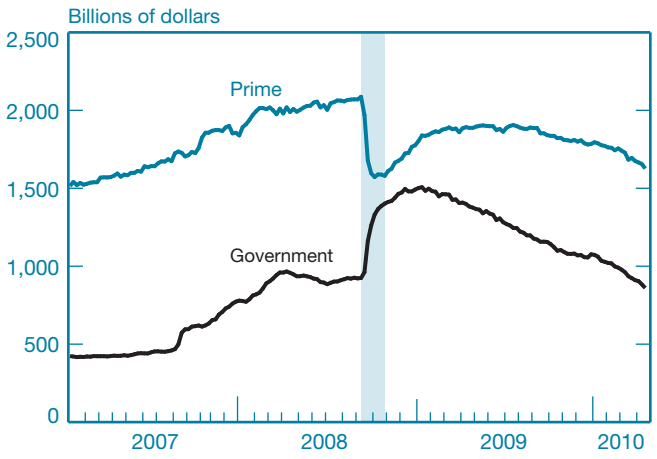
Money market funds seek a stable $1 net asset value (NAV). If a fund's NAV drops below $1, the fund is said to have "broken the buck." Money market funds, to preserve a stable NAV, must have securities that are liquid and have low credit risk. Between 1971—when the first money market fund was created in the United States—and September 2008, only one 2a-7 fund had broken the buck: the Community Bankers U.S. Government Money Market Fund of Denver, in 1994. In light of disruptions to the sector in 2008, the SEC is currently reevaluating 2a-7 guidelines and considering the mandating of floating NAVs and the shortening of weighted-average maturities.[9]

2.3 The Commercial Paper Crisis of September 2008

Considerable strains in the commercial paper market emerged following the bankruptcy of Lehman Brothers Holdings Inc. on September 15, 2008. Exposure to Lehman forced the Reserve Primary Fund to break the buck on September 16. As a result, money market investors reallocated their funds from prime money market funds to those that held only government securities (Chart 5).

[9] For more details on the money market mutual fund universe and the regulation of 2a-7 funds, see http://www.sec.gov/answers/mfmmkt.htm.

Chart 5
U.S. Money Market Fund Assets by Fund Type



Source: iMoney.

Note: The band denotes September 16-October 21.

This reallocation unleashed a tidal wave of redemption demands that overwhelmed the funds' immediate liquid reserves. In the week following the Lehman bankruptcy, prime money market mutual funds received more than $117 billion in redemption requests from investors concerned about losses on presumably safe investments, possible contagion from Lehman's bankruptcy, and financial institutions with large exposures to subprime assets. As a result, 2a-7 money market mutual funds were reluctant, and in some cases unable, to purchase commercial paper (or other money market assets with credit exposure). Any purchases made were concentrated in very short maturities; shortening the duration of their asset holdings made it easier for money market funds to manage uncertainty over further redemptions.

As demand by money market funds shrank, commercial paper issuers were unable to issue term paper and instead issued overnight paper. Thus, with each passing maturity date of commercial paper outstanding, an issuer's rollover risk increased sharply. Banks bore the increasing risk of having their credit lines drawn by issuers unable to place commercial paper in the market precisely when the banks themselves were having difficulty securing funding from the market and were attempting to reduce risk.[10]

More broadly, the deepening dysfunction in the commercial paper market risked greater disruptions across the real economy. The sudden disruption in commercial paper issuance led to higher issuing costs, forced asset sales by entities unable to raise cash, resulted in greater insolvency risk among issuers, and increased pressure on credit lines from commercial banks. Together, these factors resulted in reduced credit availability to individuals and businesses generally.

The commercial paper market was vulnerable to the credit, rollover, and liquidity risks that, although small in a period of stable rates and high liquidity, emerged in the wake of the Lehman crisis. Investors averse to credit risk shunned commercial paper issuers that had previously been considered of high quality but were now thought to be candidates for default. Domestic financial paper issuance plummeted 24 percent in late 2008. Likewise, rollover risk—the likelihood that investors will have to be compensated when the issuer rolls over the maturing paper—is magnified when issuers face lack of demand. A combination of liquidity risk and jump-to-default risk was manifested through sharp increases in the rates on A2/P2-rated nonfinancial paper, whose spreads in excess of the overnight index swap (OIS) rate rose from 296 basis points on the Friday prior to Lehman's bankruptcy to 504 basis points one week later. Over the period from September 15 to December 31, the spread averaged 539 basis points. These inherent risks in commercial paper were heightened as money market mutual funds, the principal investors in commercial paper, retreated from this market.

In the month following the Lehman bankruptcy, commercial paper outstanding shrank by $300 billion. About 70 percent of this sharp decline was led by the financial commercial paper sector, while 20 percent was attributed to a shrinking of the ABCP market. Notably, the nonfinancial sector was responsible for only a 6 percent retrenchment in the size of total commercial paper outstanding. In the period between the Lehman bankruptcy and the start of the CPFF, total outstanding commercial paper fell sharply, to $1.5 trillion from $1.8 trillion. By the end of September 2008, more than 75 percent of commercial paper financing was being rolled over each day, leaving the market unusually exposed to additional liquidity shocks.

As rollover risk escalated, institutions relying on commercial paper were increasingly vulnerable to bankruptcy if money market fund investors pulled away from the commercial paper market. Concerned by this growing risk, the Federal Reserve considered ways to stabilize short-term funding markets by providing additional sources of funding to stave off liquidity-driven defaults and help reduce rollover risk.

2.4 The Federal Reserve's Response

The CPFF was part of a series of extraordinary policy interventions in late 2008 by the Federal Reserve and other U.S. government agencies. Other important interventions included:

[10] Commercial banks provide a liquidity backstop for issuers of commercial paper. Rating agencies require that issuers have in place lines of credit in a stipulated percentage of the maximum dollar amount of commercial paper that may be outstanding under the program. See Bond Market Association and Depository Trust and Clearing Corporation (2003).

1. the expansion of eligible collateral for the Primary Dealer Credit Facility (PDCF) and the Term Securities Lending Facility (TSLF) on September 14;
2. the expansion of foreign exchange swap lines with foreign central banks on September 18;
3. the creation, on September 19, of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), which extended "nonrecourse loans" (secured loans on which lenders can seize pledged collateral to minimize loss upon default) at the primary credit rate to U.S. depository institutions and bank holding companies to finance their purchases of high-quality ABCP from money market mutual funds;
4. the announcement of a temporary guarantee program for money market mutual funds on September 19;
5. the October 14 announcement by the Federal Deposit Insurance Corporation (FDIC) of the creation of the Temporary Liquidity Guarantee Program (TLGP) to guarantee the senior debt of all FDIC-insured institutions and their holding companies as well as deposits in non-interest-bearing deposit transactions;
6. the announcement of the Money Market Investor Funding Facility (MMIFF) on October 21;
7. the creation of the Term Asset-Backed Securities Loan Facility (TALF) on November 25, under which the Federal Reserve Bank of New York was authorized to lend up to $200 billion on a nonrecourse basis to holders of AAA-rated ABS and recently originated consumer and small-business loans; and
8. the November 25 announcement by the Federal Reserve that it would purchase the direct obligations of housing-related government-sponsored enterprises (GSEs) and mortgage-backed securities backed by the GSEs.[11]

3. CPFF Design and Operation

The Commercial Paper Funding Facility was designed to stabilize short-term financing markets by providing an additional source of funding to institutions to help them reduce reinvestment risk and stave off liquidity-driven defaults. To accomplish this, a special-purpose vehicle—the CPFF LLC—was created to purchase ninety-day commercial paper from highly rated U.S. issuers and effectively pledge it to the Federal Reserve Bank of New York in exchange for cash.

In the twenty days between the announcement of the CPFF and its first purchases from registered users, Federal Reserve staff fine-tuned the facility's terms and conditions and its operational design, which included building a new legal, trading, investment, custodial, and administrative infrastructure as well as establishing essential financial and operational risk controls. For the CPFF to be effective as a liquidity backstop, it had to be simple to use, compliant with existing market conventions, open to a large cross section of the commercial paper market while minimizing credit risk to the Reserve Bank, priced to relieve funding market pressures, and implemented quickly to forestall another liquidity event. The facility's terms and conditions ultimately addressed these objectives.[12]

3.1 Operational Design

A market backstop required accessibility by any issuer in the market. However, purchases of commercial paper could not be open to any firm needing access to short-term funding, as this would have deviated from the intent of offering a backstop to issuers whose short-term funding was disrupted by liquidity events rather than the firm's own credit event. To minimize credit risk, the Federal Reserve limited purchases to top-tier paper, rated A1/P1/F1 or higher, consistent with 2a-7 fund conventions in place at the time.[13] In late 2008, top-tier commercial paper accounted for nearly 90 percent of the market, indicating that the criterion would allow the facility to backstop the vast majority of the market while also shielding the Federal Reserve from lower quality credits in the market.

To effectively reduce rollover risk, the CPFF had to offer term financing beyond what the Federal Reserve had extended up to that point.[14] Since term commercial paper is most liquid at one- and three-month tenors and funding concerns for the year-end were mounting, three-month commercial paper became the logical tenor to offer issuers. Furthermore, the facility gave assurance that the purchases of commercial paper would be held to maturity rather than liquidated shortly thereafter.

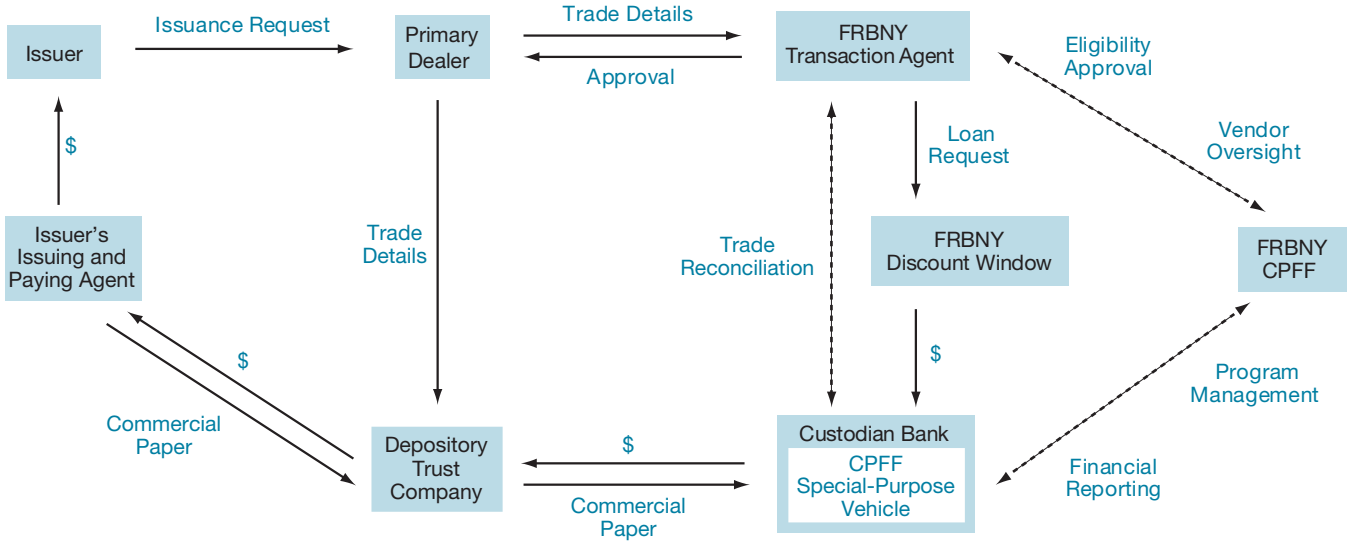
[11] See Adrian, Burke, and McAndrews (2009) for more on the PDCF; Fleming, Hrung, and Keane (2009) for details on the TSLF; Davis, McAndrews, and Franklin (2009) for a review of the MMIFF; Ashcraft, Malz, and Pozsar (2010) for more on the TALF; and Adrian and Shin (2010) for an overview of the liquidity facilities in a broader context. The impact of the CPFF and other credit and liquidity programs on the Federal Reserve's balance sheet and its income statement is described at http://www.federalreserve.gov/monetarypolicy/bst_fedfinancials.htm.

[12] For a comprehensive overview of terms and conditions, frequently asked questions, announcements, and operational details relating to the CPFF, see http://www.ny.frb.org/markets/cpff.html.

[13] A split rating was acceptable if two ratings were top-tier.

[14] The Fed had already started the twenty-eight-day Term Auction Facility (TAF) in December 2007. On July 30, 2008, an extension to an eighty-four-day maturity was announced, with an effective date of August 11, 2008. For an overview of the TAF, see Armantier, Krieger, and McAndrews (2008).

Issuance to the Commercial Paper Funding Facility (CPFF)



Note: Solid lines represent steps in the transaction; dashed lines represent some of the controls.

In establishing the CPFF, the Federal Reserve faced the added complication of engaging in transactions that fell outside of the central bank's traditional operating framework. Prior to the creation of the CPFF, temporary emergency lending facilities created under section 13(3) of the Federal Reserve Act were forms of secured borrowing with traditional counterparties—that is, depository institutions or primary dealers. To address the risks that had emerged in the commercial paper market, the Federal Reserve had to expand its lending to include U.S. corporations as well as financial institutions that would usually not have direct access to its market operations (finance companies, for example).

The Federal Reserve's financial transactions were limited to open market operations with primary dealers and loans to depository institutions through the discount window.[15] The CPFF operation married aspects of both types of Fed operations with the market conventions of the commercial paper market. To execute CPFF transactions, the Federal Reserve Bank of New York used its primary dealers as agents to the transactions between the Fed and commercial paper issuers. Primary dealers actively underwrite, place, and make markets in the commercial paper market, and they had the ability to funnel CPFF issuance from their clientele to the facility each day.

By designating primary dealers as agents to the CPFF transactions, the facility effectively expanded its reach to hundreds of firms looking for backstop financing. Trade execution was conducted electronically, with controls and accuracy checks, and processed "straight through" with limited manual intervention, allowing multitudes of trades to be executed quickly and accurately and settled on the same day. The same-day settlement feature assured firms that the CPFF could meet an unexpected liquidity need.

Building the facility's infrastructure in a compressed timeframe proved a substantial challenge, so the Federal Reserve enlisted the services of experienced market participants, including Pacific Investment Management Company (PIMCO) and State Street Bank and Trust Company. The SPV created by the Federal Reserve—CPFF LLC—was held in custody at State Street, a depository institution. Creating the SPV facilitated discount window lending to the commercial paper market. Each day, CPFF purchases were matched by a loan from the New York Fed's discount window to the custodian bank, which then transferred the loan amount to the SVP to fund the purchases.

At maturity, the transaction unwound this way: The issuer paid the CPFF LLC the loan principal plus interest, which was determined by the interest rate set on the date of issuance, and the SPV paid the Federal Reserve Bank of New York the principal and interest on its loan, set at the federal funds target on the original loan date.[16] Because the custodian bank, the issuing and paying agent (hired by the issuer to administer the issuance of and payments on the commercial paper), and all primary dealers cleared commercial paper through the Depository Trust Company, the CPFF had in place a mechanism that allowed it to purchase commercial paper efficiently through the market's standard clearing institution (see exhibit).

[15] These included loans of cash and securities as well as purchases and sales of U.S. Treasury and government agency debt.

[16] If the target federal funds rate was a range, then the loan was set at the maximum rate within that range.

Commercial Paper Funding Facility Pricing Structure

Rates and Fees	Unsecured Commercial Paper	Asset-Backed Commercial Paper
Lending rate	Three-month OIS + 100 basis points	Three-month OIS + 300 basis points
Credit surcharge	100 basis points	None
All-in cost	Three-month OIS + 200 basis points	Three-month OIS + 300 basis points

Source: Federal Reserve Bank of New York.

Note: OIS is the overnight index swap rate.

To sell commercial paper to the CPFF LLC, an issuer was required to register in advance of the initial issuance.[17] The registration process allowed the Federal Reserve Bank of New York to verify eligibility criteria (including the maximum amount the issuer could sell to the facility), review the issuer's credit quality, and, among other logistics, process the registration fee. While the vast majority of registrants issued to the CPFF shortly after registering, some registered to retain the option of future issuance should the need arise. The CPFF's registration period began on October 20, 2008, one week prior to the first purchase date, to allow time for processing the large number of issuers that wanted the option of issuing to the facility at its inception.

3.2 The CPFF as Liquidity Backstop

Eligibility requirements associated with tenor, credit quality, pricing, and maximum issuance were structured to help limit the use of the facility to backstop financing.[18] Of all these requirements, the facility's pricing structure was the most influential. It was absolutely essential that the rates on CPFF issuance were precisely calibrated to ease financial market stress by offering financing at a rate below the market's extreme levels. At the same time, the Federal Reserve had to ensure that the rates were not too attractive; otherwise, issuers would rely heavily on the CPFF, potentially impairing long-run liquidity and market functioning in the commercial paper market. On October 14, 2008, the Federal Reserve released the pricing structure for the facility (see table).

[17] An "issuer" is the legal entity that issues the commercial paper. If a parent company and a subsidiary issued commercial paper separately, they were considered separate issuers for the purposes of the CPFF. Only U.S. issuers of commercial paper, including U.S. issuers with a foreign parent, were eligible to sell commercial paper to the SPV.

[18] The SPV was allowed to purchase only three-month, U.S.-dollar-denominated unsecured and asset-backed commercial paper (rated at least A1/P1/F1) from U.S. issuers or U.S.-based issuers of a foreign parent company. Although split ratings (such that one rating is Tier 2) were accepted, A2/P2 paper—which represents about 5 percent of issuance in the commercial paper market—was ineligible.

The facility controlled for changes in short-term interest rates by setting the price of commercial paper issuance to the CPFF at a fixed spread above the daily three-month OIS rate. As is common practice in the market, commercial paper issued to the CPFF was sold at a discount from face value, as determined by the lending rate, using the standard interest calculations and the actual over-360-day-count convention. The all-in costs of the OIS plus 200 and 300 basis points per year on unsecured and asset-backed commercial paper, respectively, were determined after performing historical analysis of several factors, including investment-grade financing rates in recent interest rate cycles, average spreads between unsecured and asset-backed paper, and estimation of potential losses on a diversified portfolio of commercial paper.

The higher funding costs for ABCP in the market (and in the CPFF pricing structure), relative to unsecured issuance backed by the full faith and credit of the issuing entity, were an indicator of the riskiness and illiquidity of the underlying collateral in ABCP conduits. In addition to conducting empirical analysis, Federal Reserve staff surveyed a large number of market participants to distinguish between the credit and liquidity components of commercial paper rates at the height of the crisis.

Purchases of commercial paper had to be secured to the satisfaction of the Federal Reserve. Because financial and nonfinancial commercial paper is unsecured, the Fed needed to find alternative means to secure the loans. Although financial institutions could pledge financial assets as collateral against a loan (similar to a discount window transaction), nonfinancial commercial paper issuers would not necessarily have the same privilege. Assessing the value of nonfinancial assets would further complicate lending.

Lenders are generally compensated for taking risk by charging higher interest rates or, in the case of a line of credit, assessing fees on usage. An assessment of a credit surcharge more closely approximated market practice and thus became the default practice for securing a loan. Participation in the FDIC's TLGP qualified as a satisfactory guarantee for unsecured commercial paper, as the U.S. government ensured repayment on the commercial paper at maturity, thus

removing credit risk.[19] TLGP issuers were not required to pay the unsecured credit surcharge. As the TLGP was not fully operational on the CPFF's inception date, TLGP issuers were initially charged an unsecured credit surcharge for paper sold to the facility; however, these fees were subsequently reimbursed once it was established that the entity was covered by the TLGP.

The registration fee for the CPFF was an additional feature that further underlined the nature of the facility as a liquidity backstop. The pricing of the registration fee was not dissimilar to a commitment fee that a bank would charge a borrower for an available line of credit. This fee effectively served as an insurance premium, whereby the issuer bought the option of issuing to the facility at any time over the life of the program. The 10 basis point fee was charged on the maximum amount an issuer could sell to the CPFF, or the greatest amount of U.S.-dollar-denominated commercial paper the issuer had outstanding on any day between January 1 and August 31, 2008. The maximum amount of issuance to the CPFF was reduced by any commercial paper outstanding with investors at the time of issuance, including paper issued to the CPFF.

These criteria supported the backstop nature of the facility by limiting issuance to the amount of paper that the institution maintained prior to the market disruptions in September 2008, rather than providing additional funding to grow or leverage issuers' balance sheets. These terms also disqualified firms that were not previously active participants in the commercial paper market from accessing funding through the CPFF.[20]

The CPFF's pricing structure and other program requirements helped ensure that the facility played a constructive role in restoring stability to the market. At the same time, they also served to: 1) prevent artificial inflation of issuance beyond what may be absorbed by investor demand under normal conditions, 2) ensure that the facility was used as a backstop in times of stress while also providing a disincentive to issue to the facility under more liquid market conditions, and 3) mitigate the credit risk associated with adverse selection to minimize the Federal Reserve's exposure to loss relative to its accumulated capital from program fees.

[19] For each unsecured commercial paper transaction to the CPFF, the issuer was charged 100 basis points per year, calculated from the face value of the commercial paper at the time of settlement. When distributing the proceeds of the new commercial paper issuance, the SPV reduced the funds due the issuer by an amount equal to the unsecured credit surcharge.

[20] An ABCP issuer was also deemed inactive if it did not issue ABCP to institutions other than the sponsoring institution for any consecutive period of three months or longer between January 1 and August 31, 2008. A few months after the facility's inception, the Federal Reserve clarified these terms for ABCP issuers, announcing that the CPFF would not purchase ABCP from issuers that were inactive prior to the creation of the facility.

3.3 The Fed's Counterparty Credit Risk Management

From the Federal Reserve's perspective, CPFF lending rates were analogous to setting haircuts on a nonrecourse loan. In setting penalty rates for eligible commercial paper, the Federal Reserve faced a trade-off: Higher penalty rates protect the central bank from credit risk; however, they limit the amount of liquidity available to the financial system.

For a given CPFF interest rate, a rate lower than those available in the market could provide market participants with arbitrage opportunities. In essence, the Federal Reserve lent against specific collateral types—in this case, highly rated commercial paper—at a penalty rate and held a margin of excess collateral, including cash collateral that should protect it against any loss under normal market conditions.

The anticipated credit risk of the facility's aggregate exposure was an important factor guiding the selection of registration and credit enhancement fees as well as rates for unsecured and asset-backed paper. An initial analysis of the facility's credit risk was conducted to determine ranges of expected and unexpected losses under normal and stressed market conditions. Hypothetical stress losses of 1.03 percent to 1.38 percent were found to reflect historical loss probabilities based on downgrade probabilities of short- and long-term ratings. Any estimated potential credit losses by the CPFF SPV were offset by the facility's invested income from fees and interest received on maturing paper.

In this regard, the cumulative invested income represented the capital available to absorb potential credit losses. The large flow of interest income from the first wave of maturities increased the facility's total capital to more than $2 billion, yielding a leverage ratio of nearly 3.4 percent (the leverage ratio is the book value of equity—accumulated through the fee income—divided by the book value of total commercial paper held in the facility). This capital cushion provided a sufficient buffer to absorb the portfolio's stress losses at a 99 percent confidence level, as calculated by a team of New York Fed economists and PIMCO credit analysts. Nevertheless, the facility's credit exposures were more concentrated than a highly granular loan portfolio at a commercial bank, so its ex post loss results could vary significantly from historical loss trends. On February 1, 2010, the date the CPFF expired, the facility had accumulated income in excess of the commercial paper held in the SPV; as a result, no losses were incurred.

3.4 Moral Hazard

The mere existence of a liquidity backstop raises concerns about moral hazard. In the case of the CPFF, expectations that the Fed would act as a lender of last resort and purchase commercial paper could have led issuers to engage in riskier behavior than they otherwise would have. Through its eligibility restrictions, the CPFF was structured to address this possibility of moral hazard.

For example, several months into the program, the eligibility rules were altered to deter the unintended consequence of reviving ABCP conduits that had exited the market. On January 23, 2009, the Federal Reserve announced that the CPFF would not purchase ABCP from issuers that were inactive prior to the facility's creation. In this way, policymakers sought to limit moral hazard through issuance that no longer had a natural investor base. In addition, the CPFF accepted only paper rated A1/P1. Presumably, issuers that engaged in riskier behavior would risk their top-tier credit rating and, consequently, jeopardize their eligibility for the facility.

Despite these eligibility restrictions, as long as a liquidity backstop exists for an asset market, there will always be some risk that issuers expect liquidity gaps to be filled for higher rated financial and asset-backed commercial paper. One way around this implicit moral hazard would be to publish information on participation with a lag. The attendant cost of such publication, however, is the associated stigma. This creates a risk that the facility will not be used when it is needed most, even in cases where the liquidity risk is broad-based rather than firm-specific.

3.5 The CPFF's Relation to Other Federal Reserve Liquidity Facilities

To address the strains in dollar funding markets that emerged immediately after the Primary Reserve Fund "broke the buck," the Federal Reserve introduced, in addition to the CPFF, two other facilities under section 13(3): the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility and the Money Market Investor Funding Facility. All three facilities supported short-term funding markets and thereby increased the availability of credit through various mechanisms, although the CPFF was used more heavily than the other facilities.

Two factors help explain the CPFF's considerable use. First, the CPFF addressed problems in short-term debt markets at their root—through direct lending to issuers—at a time when issuers faced potential liquidity shortfalls as a result of market dislocations. Indeed, the main factor distinguishing the CPFF from the other two facilities is the CPFF's role as a backstop to issuers, whereas the other facilities provide emergency lending to institutional money market investors. Second, the CPFF backstopped issuance of both unsecured and secured commercial paper, while the AMLF funded only ABCP and the MMIFF special-purpose vehicles purchased only certificates of deposit, bank notes, and commercial paper from specific financial institutions.[21]

While the MMIFF was a liquidity facility for money market mutual funds in the case of abrupt withdrawals by investors, the CPFF effectively bypassed the money market universe by allowing issuers to issue directly into it. Thus, the two facilities addressed slightly different needs.

The AMLF was launched by the Federal Reserve on September 19, 2008. The Federal Reserve Bank of Boston was authorized to make loans to U.S. depository institutions and bank holding companies for the purpose of financing purchases of ABCP from money market mutual funds. The program specifically sought to help the money market mutual funds facing elevated redemption requests to meet their funding needs. The AMLF operated via a custodian bank, and lending occurred directly through the discount window. Money market mutual funds sold ABCP to their custodian bank, which would subsequently pledge the ABCP to the discount window against a cash loan. The AMLF was made operational in a very short timeframe, because it was much less complex than the CPFF. However, the AMLF accepted only highly rated ABCP, not unsecured commercial paper. AMLF usage peaked on October 8, 2008.

The CPFF, PDCF, TSLF, TALF, and AMLF shared the common features of being liquidity facilities aimed at stabilizing funding in the money markets and being created to counteract the financial market turbulence that threatened the stability of the system as a whole. [22] Effectively, these facilities extended the Federal Reserve's lender-of-last-resort role to include nondepository institutions (the PDCF, TSLF, and AMLF) and specific securities markets (the CPFF and TALF). The facilities were based on the Federal Reserve's ability to extend credit to "any individual, partnership, or corporation" under "unusual and exigent circumstances," as per section 13(3) of the Federal Reserve Act.[23]

[21] The economic rationale for the MMIFF is described in detail by Davis, McAndrews, and Franklin (2009).

[22] See also the November 18, 2008, testimony of Federal Reserve Chairman Ben Bernanke before the U.S. House of Representatives' Committee on Financial Services on the subject of the Troubled Asset Relief Program and the Federal Reserve's liquidity facilities: http://www.federalreserve.gov/newsevents/testimony/bernanke20081118a.htm.

[23] For details on the powers of Federal Reserve Banks, see http://www.federalreserve.gov/aboutthefed/section13.htm.

4. CPFF Usage and Its Impact on the Commercial Paper Market

An issuer's decision to use the CPFF was predicated in part on the cost of issuance to the facility relative to the cost of issuance in the market or other alternative funding sources. As we discussed, the facility's pricing was designed to be cost-effective during times of market stress, but prohibitively expensive during times of normal market function. Accordingly, as conditions in financing markets normalized in 2009, CPFF usage progressively declined.

4.1 Usage and Market Impact

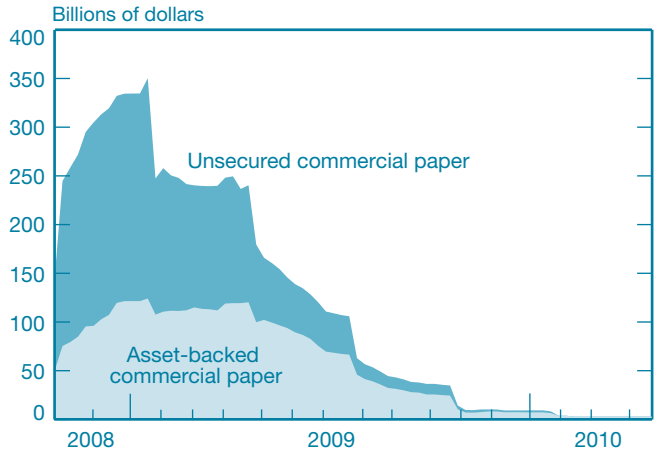
The facility's assets grew rapidly at inception, reaching $144 billion in the first week of operation. Assets more than doubled, to $293 billion, after one month and totaled $333 billion by the end of December 2008 (Chart 6). CPFF peak usage occurred in the third week of January 2009, exactly three months after the first issuance date, with approximately $350 billion in commercial paper held in the SPV. Throughout 2009, CPFF use steadily declined, reaching a level of around $10 billion in December.

At its peak level, the portfolio was primarily composed of financial commercial paper. The portfolio became more and more tilted toward ABCP after the first vintage of the CPFF matured at the end of January 2009. The large share of ABCP in the facility, which continued to increase during 2009, illustrated the continuing difficulties obtaining funding in collateralized money markets.

Issuers to the CPFF included a variety of ABCP conduits—single-seller, hybrid, multi-seller, and securities arbitrage conduits—and other financial institutions that conducted banking, insurance, and credit finance in the United States. Issuance trends varied widely across registrants, reflecting the ability of issuers to finance in the market, reduced leverage in the financial system, a consolidation of issuers in the marketplace, and access to other government programs, among other factors.[24]

[24] Single-seller conduits are established to fund the assets originated by one seller, or one seller and its subsidiaries and related entities, while multi-seller conduits are structured to fund assets originated by a variety of sellers, typically all clients of the sponsoring commercial bank. Securities arbitrage issuers primarily fund highly rated securities, and investors in the conduits are exposed to the risk of default, or credit risk, of those securities. Hybrid conduits incorporate the structural features of two or more conduit types. Most hybrid conduits have multi-seller and securities arbitrage characteristics. Bate, Bushweller, and Rutan (2003) explain conduits in more detail.

Chart 6
Commercial Paper Funding Facility Issuance Outstanding



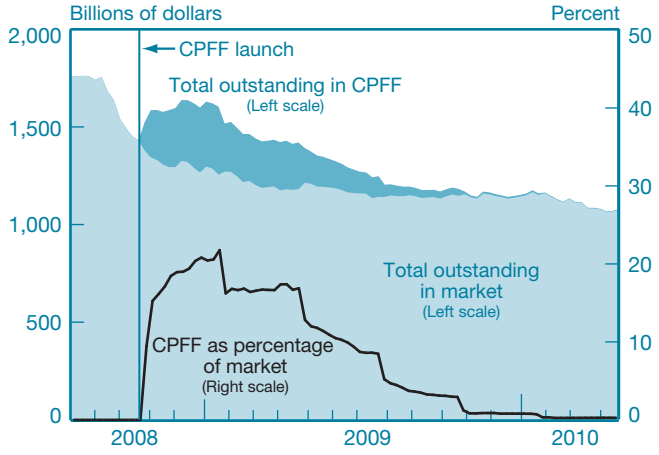
Source: Federal Reserve Bank of New York.

As of December 31, 2009, two-thirds of CPFF holdings were unsecured and the remaining third constituted ABCP. The unsecured paper was issued predominantly by banks and nonbank financials (diversified financials), some of which included TLGP-guaranteed paper. Insurance companies also issued unsecured paper, although to a lesser degree. By the end of 2009, many insurance companies faced losses in light of their exposure to mortgage financing; insurance represented just one of many sectors adversely affected by the financial crisis and economic downturn. Rating agencies subsequently downgraded the commercial paper of several insurance companies, effectively compromising their eligibility for the CPFF.

ABCP issuance accounted for a growing proportion of assets in the CPFF, suggesting that conduits were having greater difficulty reentering the market and posing some risk of adverse selection in the facility. ABCP conduits were widely used as a means to fund "hard-to-finance" assets. Consequently, it was not surprising to observe a more gradual retrenchment from the facility by this sector. However, ABCP issuance in the market and in the CPFF declined naturally as assets amortized, securitization slowed, and assets were consolidated to parents' balance sheets. In addition, ABCP programs shrank with changes to regulatory capital requirements and accounting rules.

The CPFF indeed had a stabilizing effect on the commercial paper market, as shown in Chart 7. At its peak in January 2009, the CPFF held more than 20 percent of all outstanding commercial paper. By the time it expired on February 1, 2010,

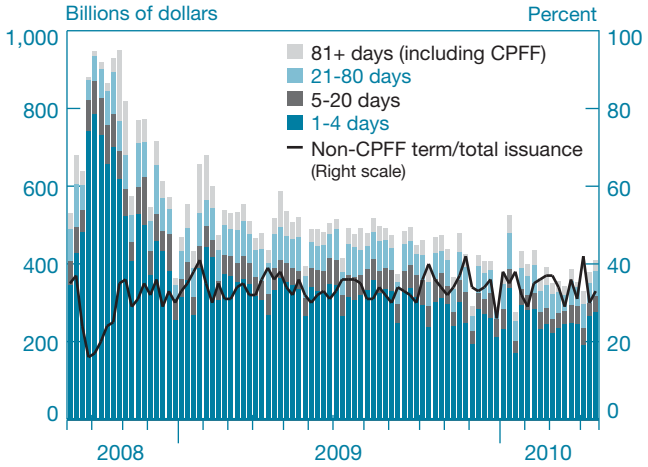
Chart 7
Total Commercial Paper Outstanding



Source: Board of Governors of the Federal Reserve System.

Note: CPFF is the Commercial Paper Funding Facility.

Chart 8
Weekly Commercial Paper Issuance



Source: Board of Governors of the Federal Reserve System.

Note: CPFF is the Commercial Paper Funding Facility.

the facility represented only 1 percent of market issuance. The self-liquidating feature of the CPFF is illustrated by the steady decline in the amount of outstanding commercial paper throughout 2009.

During the crisis period after Lehman's bankruptcy and prior to the CPFF's start-up, the fraction of term commercial paper issuance collapsed as money market funds shortened the duration of their assets to ensure against further redemption pressures (see Chart 8). In fact, more than 75 percent of commercial paper issued in the second half of September and in early October consisted of maturities of only one to four days. As a result of the shortened maturities, total weekly commercial paper issuance rose rapidly during the crisis. Once the CPFF started operation on October 27, term commercial paper issuance began rising and quickly reverted to a tight range of between 30 and 40 percent of total commercial paper.

The expansion of the CPFF was accompanied by a narrowing of the spread between commercial paper rates and comparable OIS rates (Chart 9). The degree to which the narrower spread was attributable to the CPFF's expansion requires further research, but the coincidence suggests that the program had a meaningful effect.

The one-month AA-rated financials spread declined from 188 basis points in October 2008 to 38 basis points in December 2009 (the latter being the average of daily business day rates during December). Over the same period, the ABCP spread declined from 256 basis points to 86 basis points.[25]

[25] The decline in the less liquid market of three-month commercial paper rates was also substantial. We report the one-month rates because of greater data availability.

Meanwhile, the spread for A2/P2 commercial paper—which was not eligible for the CPFF—*rose* from 483 basis points to a December average of 503 basis points. The one-month A2/P2 spreads to OIS continued to rise through the end of 2008, as creditors demanded increasing compensation from lower rated issuers for use of their balance sheets over year-end, a period when firms typically reduce leverage for the purpose of financial reporting and minimize risk amid a period of reduced market liquidity. Only after the passage of year-end did the spread between eligible A1/P1 and ineligible A2/P2 paper narrow.

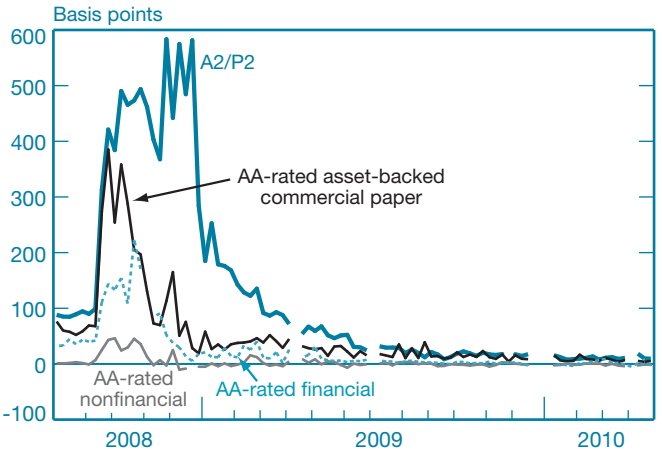
The CPFF's holdings rose rapidly in the first three months following the facility's creation, likely because the rates it charged were considerably below the average market rates. As average commercial paper rates began to decline throughout 2009, CPFF usage declined as well.

Average spreads on commercial paper issued in the market (Chart 9) mask the actual cross-sectional dispersion of rates across issuers within each credit rating bucket. The underlying dispersion in rates owes partly to the fact that investors, particularly money market funds, have policies that limit their concentrations to counterparties in order to manage their credit exposure and maintain diversification. As money market funds effectively became more risk averse and attuned to credit differentiation, some funds responded to the financial crisis by either charging higher rates to issuers perceived as potentially more risky or barring certain names altogether from their portfolios.

Continued issuance to the CPFF amid declining commercial paper rates highlighted the wide range of rates transacted in the

Chart 9

One-Month Commercial Paper Rates Less One-Month Overnight Index Swap Rate



Sources: Board of Governors of the Federal Reserve System; Bloomberg.

market. Although the one-month commercial paper interest rate charged for AA-rated ABCP averaged 32 basis points in the second half of 2009 and never exceeded 62 basis points, ABCP issuance into the CPFF at the penalty rate of 300 basis points (for the three-month maturity) occurred throughout the year, suggesting that some issuers continued to find CPFF rates attractive relative to market rates.

Another possible explanation is that demand for issuance fell short of some issuers' required funding needs. At the onset of the crisis, investors were less willing to hold large positions in commercial paper; thus, issuers may have been left with no option other than to satisfy remaining liquidity needs by issuing to the CPFF.

4.2. "Roll"

"Roll" refers to times when issuers retire existing commercial paper at its maturity, but still require funding and therefore issue new paper. In other words, it represents the number of times when commercial paper is reissued, or "rolled over." Because the maturity of CPFF commercial paper was ninety days, rolls occurred once a quarter.

From the beginning of the CPFF to its end, there were five rolls of ninety-day commercial paper. The first roll was the most significant, given that CPFF holdings represented 20 percent of the total commercial paper market. Market analysts had speculated that the still-fragile commercial paper market might come under additional strain if the maturing paper were reissued over a highly concentrated period into the private market. However, the first roll went smoothly, as issuance into the private market remained small and whatever financing returned to the commercial paper or other private markets was relatively dispersed (some issuers prefunded their CPFF maturities and used the proceeds to pay the maturing issuance in the CPFF).

Throughout the second and third rolls, an increasing percentage of smaller dollar amounts came due and was paid down. By the fourth roll, in October 2009, approximately 80 percent ($28 billion) of the commercial paper in the CPFF matured, of which roughly $20 billion was paid down. As a result, commercial paper holdings in the CPFF amounted to just 1 percent of the total commercial paper market following the penultimate roll.

The most dramatic effect of the rolls was seen in the composition of CPFF holdings. With each roll, ABCP became an even greater share of CPFF holdings as money funds continued to shun secured paper, particularly if it was perceived to be of poor credit quality. Most of the remaining ABCP may have been of lower credit quality and had no natural buyer. This transformation in CPFF holdings raised policymakers' concerns about adverse selection into the program and about complications that would arise if certain issuers could not have repaid upon the program's conclusion.

4.3. Impact on the Federal Reserve's Balance Sheet

Compared with the other new liquidity facilities or with outright purchases, the CPFF had a large effect on the Fed's balance-sheet growth. Only foreign exchange swaps and the TAF made larger contributions. During this period of relatively rapid expansion in assets, the Fed's liabilities expanded primarily through excess reserve balances, although some of the balance-sheet expansion was sterilized by increased issuance of Treasury SFP bills.[26] While the CPFF contributed to growth in reserves, the contraction in the facility's holdings also outpaced that of other Federal Reserve programs, given its punitive rate structure. This contraction significantly offset the reserves creation of later programs, such as the Large-Scale Asset Purchase Program.[27]

[26] On September 17, 2008, the U.S. Treasury announced the Supplementary Financing Program (SFP), through which the Treasury issues a series of Treasury bills, separate from its current borrowing program, and deposits the proceeds from these issuances into an account at the Federal Reserve Bank of New York. Funds in this account drain reserves from the banking system and therefore offset the reserve impact of Federal Reserve lending and liquidity initiatives. Interest on reserves is discussed in Keister and McAndrews (2009).

[27] The impact of the CPFF and other credit and liquidity programs on the Federal Reserve's balance sheet and income statement can be found at http://www.federalreserve.gov/monetarypolicy/bst_fedfinancials.htm.

The CPFF's penalty fee represented income for the Federal Reserve. The facility generated roughly $5 billion in net income from its inception to its close in April 2010. This amount represented a relatively large share of total profits from the liquidity facilities, estimated to be $12.9 billion as of December 2009 (Fleming and Klagge 2009). These profits, which were transferred by the Federal Reserve to the Treasury, ultimately helped reduce the financial burden on taxpayers.

The economic interpretation for the income generated by the CPFF is as follows. During fall 2008, the private market for commercial paper was severely disrupted by the reallocation of short-term savings from prime money market funds to Treasury-only funds. As a result, the Federal Reserve established the CPFF as a lender-of-last-resort facility to address the temporary liquidity distortions created by the money market reallocations. However, by law, the Federal Reserve had to protect itself against potential credit losses. It therefore loaned to commercial paper issuers at a penalty rate, which in turn generated income from the facility.

While market rates for commercial paper were unusually high, commercial paper issuers were willing to pay the penalty rate, thereby transferring money to the taxpayer. As such, U.S. households gained in the aggregate. In addition to the fee income generated by the CPFF, taxpayers also benefited from the facility's role in potentially preventing commercial paper issuers from being forced into bankruptcy, an event that could have distorted real investment decisions.

5. Conclusion

The Commercial Paper Funding Facility serves as a noteworthy model for the Federal Reserve's role as lender of last resort—a role that, in this case, reached beyond depository institutions. In contrast to traditional discount window lending, the CPFF supported liquidity in a particular market as opposed to supporting the liquidity of a particular set of institutions. Like the discount window, the CPFF was constructed as a backstop, not as a permanent source of funding. While the discount window accepts a very broad range of collateral—including loans, mortgages, and securities—the CPFF focused on a particular asset class, but had less stringent requirements for the types of institutions that can borrow. The CPFF can be considered a model of liquidity provision in a market-based financial system, where maturity transformation occurs outside of the commercial banking sector in a quantitatively and economically important magnitude.

The legal basis for the CPFF stemmed from section 13(3) of the Federal Reserve Act, requiring the use of such a facility in "unusual and exigent circumstances." As such, the Federal Reserve does not have the authority to make the CPFF a permanent liquidity backstop. This in turn has implications for the ongoing debate on regulatory reform. The financial market crisis of 2007-09 demonstrated the current financial architecture's vulnerabilities to liquidity crises emanating from nondepository institutions. As such, an important component of regulatory reform focuses on improving the resiliency of money markets to financial and economic shocks. Many ongoing reform efforts aim to reduce the vulnerability of money markets to liquidity crises. These efforts focus particularly on reforming money market funds, the commercial paper market, and the repo markets.

It has long been understood that the public sector plays a crucial role in the provision of liquidity. In times of aggregate liquidity shortages, only the monetary authority can act as lender of last resort, owing to its ability to create money.[28] Traditionally, the lender of last resort has been available only to depository institutions because the vast majority of maturity and liquidity transformation took place in those institutions. Since the mid-1980s, however, the rapid growth of a market-based system of credit formation has allowed for maturity transformation by a wide range of institutions, including money market funds, finance companies, and securities broker-dealers, and through a range of market instruments, such as asset-backed commercial paper and tri-party repo.

Despite the recent crisis, it seems likely that large amounts of maturity and liquidity transformation will continue to be conducted outside of depository institutions—and therefore without access to the traditional lender of last resort—in what is known as "the shadow banking system."[29] The public sector's role in providing backstop liquidity to the shadow banking system will continue to be debated. Although the duration of the CPFF was necessarily limited, the facility provides a model for a market-based lender-of-last-resort liquidity backstop, which could serve as a guide for future policy discussion.

[28] See Holmström and Tirole (1998) for a theory of public liquidity provision, Diamond and Dybvig (1983) for a classic justification of discount window lending, and Acharya, Gale, and Yorulmazer (2008) for a setting with rollover risk.

[29] Adrian, Ashcraft, and Pozsar (2009) provide a detailed overview of the shadow banking system.

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Joseph Gagnon, Matthew Raskin, Julie Remache, and Brian Sack

Large-Scale Asset Purchases by the Federal Reserve: Did They Work?

1. Introduction

In December 2008, the Federal Open Market Committee (FOMC) lowered the target for the federal funds rate to a range of 0 to 25 basis points. With its traditional policy instrument set as low as possible, the Federal Reserve faced the challenge of how to further ease the stance of monetary policy as the economic outlook deteriorated. The Federal Reserve responded in part by purchasing substantial quantities of assets with medium and long maturities in an effort to drive down private borrowing rates, particularly at longer maturities. These large-scale asset purchases (LSAPs) have greatly increased the size of the Federal Reserve's balance sheet, and the additional assets may remain in place for years to come.

To be sure, the Federal Reserve undertook other important initiatives to combat the financial crisis. It launched a number of facilities to relieve financial strains at specific types of institutions and in specific markets. In addition, in an attempt to provide even more stimulus, it used public communications about its policy intentions to lower market expectations of the federal funds rate in the future. All of these strategies were designed to ease financial conditions and to support a sustained economic recovery. Over time, though, the credit extended by the liquidity facilities has declined, and the dominant component of the Federal Reserve's balance sheet has become the assets accumulated through the LSAP programs.

The decision to purchase large volumes of assets through March 2010 came in two steps. In November 2008, the Federal Reserve announced purchases of housing agency debt and agency mortgage-backed securities (MBS) of up to $600 billion. In March 2009, the FOMC decided to substantially expand its purchases of agency-related securities and to purchase longer term Treasury securities as well, with total asset purchases of up to $1.75 trillion, an amount twice the magnitude of total Federal Reserve assets prior to 2008.[1] The FOMC stated that the increased purchases of agency-related securities should "provide greater support to mortgage lending and housing markets" and that purchases of longer term Treasury securities should "help improve conditions in private credit markets."

In this paper, we review the Federal Reserve's experience with implementing the LSAPs through March 2010 and describe some of the challenges raised by such large purchases in a relatively short time. In addition, we discuss the economic

[1] The Treasury Department also established a program to purchase agency MBS beginning in September 2008. By the program's termination at year-end 2009, it had purchased $220 billion of such securities. This program was much smaller than the Federal Reserve's LSAPs and no specific purchase amount targets were announced, so it is not included in our analysis.

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mechanisms through which LSAPs may be expected to stimulate the economy and present some empirical evidence on those effects. In particular, LSAPs reduce the supply to the private sector of assets with long duration (and, in the case of mortgage securities, highly negative convexity) and increase the supply of assets (bank reserves) with zero duration and convexity.[2] To the extent that private investors do not view these assets as perfect substitutes, the reduction in supply of the riskier longer term assets reduces the risk premiums required to hold them and thus reduces their yields. We assess the extent to which LSAPs had the desired effects on market interest rates using two different approaches and find that the purchases resulted in economically meaningful and long-lasting reductions in longer term interest rates on a range of securities, including securities that were not included in the purchase programs. We show that these reductions in interest rates primarily reflect lower risk premiums rather than lower expectations of future short-term interest rates.[3] We conclude with a discussion of issues raised by these policies and potential lessons for implementing monetary policy at the zero bound in the future.

2. How LSAPs Affect the Economy

The primary channel through which LSAPs appear to work is by affecting the risk premium on the asset being purchased. By purchasing a particular asset, a central bank reduces the amount of the security that the private sector holds, displacing some investors and reducing the holdings of others, while simultaneously increasing the amount of short-term, risk-free bank reserves held by the private sector. In order for investors to be willing to make those adjustments, the expected return on the purchased security has to fall. Put differently, the purchases bid up the price of the asset and hence lower its yield. This pattern was described by Tobin (1958, 1969) and is commonly known as the "portfolio-balance" effect.[4]

Note that the portfolio-balance effect has nothing to do with the expected path of short-term interest rates. Longer term yields can be parsed into two components: the average level of short-term risk-free interest rates expected over the term to maturity of the asset and the risk premium. The former represents the expected return that investors could earn by rolling over short-term risk-free investments, and the latter is the expected additional return that investors demand for holding the risk associated with the longer term asset. In theory, the effects of the LSAPs on longer term interest rates could arise by influencing either of these two components. However, the Federal Reserve did not use LSAPs as an explicit signal that the future path of short-term risk-free interest rates would remain low.[5] In fact, at the same time that the Federal Reserve was expanding its balance sheet through the LSAPs, it was going to great lengths to inform investors that it would still be able to raise short-term interest rates at the appropriate time. Thus, any reduction in longer term yields instead has likely come through a narrowing in risk premiums.

For Treasury securities, the most important component of the risk premium is referred to as the "term premium," and it reflects the reluctance of investors to bear the interest rate risk associated with holding an asset that has a long duration. The term premium is the additional return investors require, over and above the average of expected future short-term interest rates, for accepting a fixed, long-term yield. The LSAPs have removed a considerable amount of assets with high duration from the markets. With less duration risk to hold in the aggregate, the market should require a lower premium to hold that risk. This effect may arise because those investors most willing to bear the risk are the ones left holding it.[6] Or, even if investors do not differ greatly in their attitudes toward duration risk, they may require lower compensation for holding duration risk when they have smaller amounts of it in their portfolios.

In addition to the effect of removing duration and hence shrinking the term premium across all asset classes, Federal Reserve purchases of agency debt and agency MBS might be expected to have an effect on the yields on those assets through other elements of their risk premiums. For example, these

[2] Negative convexity arises from the ability of mortgage borrowers to prepay their loans. As interest rates fall, the incentive to prepay increases, generally resulting in an increase in prepayments to MBS holders. This effect causes the duration of MBS to fall as interest rates decline and vice versa. Convexity is explained in more detail in the next section.

[3] As we discuss below, these risk premiums, or excess expected returns, arise due to interest rate, credit, or liquidity risk, or other characteristics that make the assets' returns uncertain.

[4] There is a large body of literature on consumer-optimizing models of portfolio selection, which are variants of the portfolio-balance model that impose restrictions arising from the assumed (risk-averse) utility functions of investors. See Markowitz (1952), Sharpe (1964), and Campbell and Viceira (2001, 2005). More recently, Vayanos and Vila (2009) have developed a theoretical model of the term structure based on preferred habitats of investors, which also relies on risk aversion. Andres, Lopez-Salido, and Nelson (2004) provide an example of a dynamic stochastic general equilibrium model with imperfect asset substitutability based on frictions in financial markets.

[5] Indeed, the FOMC instead directly used language in its statements to signal that it anticipates that short-term interest rates will remain exceptionally low for an extended period. However, as discussed below, neither the language about future policy rates in the FOMC statements nor the LSAP announcements appear to have had a substantial effect on the expected future federal funds rate.

[6] Indeed, in the preferred-habitat model of Modigliani and Sutch (1966), it is possible that some agents seek to hold long-duration assets, such as for retirement, so that the term premium can, in principle, be negative.

assets may be seen as having greater credit or liquidity risk than Treasury securities.[7] In addition, the purchases of MBS reduce the amount of prepayment risk that investors have to hold in the aggregate. Prepayment risk on MBS causes the duration of the securities to shrink when interest rates decline and rise when interest rates increase. These changes in duration imply that MBS have negative convexity: compared with the price of a noncallable bond with the same coupon and maturity, MBS prices rise less when rates fall and decline more when rates rise. Given this undesirable profile and the cost of hedging against it, investors typically demand an extra return to bear the negative convexity risk, keeping MBS rates higher than they would otherwise be. The LSAPs removed a considerable amount of assets with high convexity risk, which would be expected to reduce MBS yields.

These portfolio-balance effects should not only reduce longer term yields on the assets being purchased, but also spill over into the yields on other assets. The reason is that investors view different assets as substitutes and, in response to changes in the relative rates of return, will attempt to buy more of the assets with higher relative returns. In this case, lower prospective returns on agency debt, agency MBS, and Treasury securities should cause investors to seek to shift some of their portfolios into other assets, such as corporate bonds and equities, and thus should bid up their prices. It is through the broad array of all asset prices that the LSAPs would be expected to provide stimulus to economic activity. Many private borrowers would find their longer term borrowing costs lower than they would otherwise be, and the value of long-term assets held by households and firms—and thus aggregate wealth—would be higher.

The effects described so far would be caused by LSAP-induced changes in the stock of assets held by the public. Moreover, to the extent that investors care about expected future returns on their assets, today's asset prices should reflect expectations about the future stock of assets. Thus, a credible announcement that the Federal Reserve will purchase longer term assets at a future date should reduce longer term interest rates immediately. Otherwise, investors could make excess profits by buying the assets today to sell to the Federal Reserve in the future.

There may also be effects on the prices of longer term assets if the presence of the Federal Reserve as a consistent and significant buyer in the market enhances market functioning and liquidity. The LSAP programs began at a point of significant market strains, and the poor liquidity of some assets weighed on their prices. By providing an ongoing source of demand for longer term assets, the LSAPs may have allowed dealers and other investors to take larger positions in these securities or to make markets in them more actively, knowing that they could sell the assets, if needed, to the Federal Reserve. Such improved trading opportunities could reduce the liquidity risk premiums embedded in asset prices, thereby lowering their yields.[8]

This liquidity (or market-functioning) channel, which is distinct from the portfolio-balance channel, appears to have been important in the early stages of the LSAP programs for certain types of assets. For example, the LSAP programs began at a point when the spreads between yields on agency-related securities and yields on Treasury securities were well above historical norms, even after adjusting for the convexity risk in MBS associated with the high interest rate volatility at that time.[9] These spreads in part reflected poor liquidity and elevated liquidity risk premiums on these securities.[10] The flow of Federal Reserve purchases may have helped to restore liquidity in these markets and reduced the liquidity risk of holding those securities, thereby narrowing the spreads of yields on agency debt and MBS to yields on Treasury securities and reducing the cost of financing agency-related securities.

Another asset for which the market-functioning channel was important in the early stages of the LSAP programs is older Treasury securities, which had become unusually cheap relative to more recently issued Treasury securities with comparable maturities.[11] Such differences would normally be arbitraged away, but investors and dealers were reluctant to buy the older securities because their poor liquidity meant that they might be difficult to sell. However, after the Federal Reserve began buying such bonds, the yield spreads narrowed to normal levels.

Overall, LSAPs may affect market interest rates through a combination of portfolio-balance and market-functioning effects. Although the effects on market functioning appear to

[7] Prior to December 2009, the Treasury had committed to sizable but limited capital injections in the housing agencies, and thus had not issued a blanket guarantee of agency obligations. On December 24, 2009, the Treasury removed the limit on capital injections over the next three years, stating that it wished to "leave no uncertainty about the Treasury's commitment to support these firms." Agency debt and agency MBS are not as liquid as Treasury securities. The direct effect of LSAPs on liquidity of these securities is considered in more detail below.

[8] It is possible that the flow of purchases may affect longer term interest rates for reasons other than the effects on market functioning and liquidity, if the market faces other frictions.

[9] According to Bloomberg L.P., the option-adjusted spread between the current-coupon Fannie Mae thirty-year MBS and Treasuries averaged 146 basis points in the four weeks ending November 21, 2008. Over the period 1996 to 2007, this spread averaged 89 basis points and exceeded 146 basis points on less than 4 percent of days.

[10] Another contributing factor to the high yield spreads is that many financial firms at that time faced constraints on their balance sheets, given the large capital losses on other assets and limited access to new funds. Capital constraints put agency-related debt at a disadvantage relative to Treasury securities, as agency-related holdings have a 20 percent risk weighting compared with 0 percent for Treasury securities.

[11] See Gürkaynak and Wright (2010, p. 56).

have been important at the start of the LSAPs when financial markets were unusually strained, the primary long-run effects are likely associated with the portfolio-balance effect. The lack of significant movements in interest rates around the time that each component of the LSAP programs was wound down suggests that market functioning was no longer impaired and that the Federal Reserve presence in the market had little additional effect beyond that through its portfolio holdings.

3. Implementation of LSAPs

The Federal Reserve holds assets that it has purchased in the open market in its System Open Market Account (SOMA). Historically, SOMA holdings have been nearly all Treasury securities, although small amounts of agency debt were held at times.[12] Purchases and sales of SOMA assets are called outright open market operations (OMOs). Outright OMOs, in conjunction with repurchase agreements and reverse repurchase agreements, traditionally were used to alter the supply of bank reserves in order to influence conditions in the federal funds market.[13] Most of the higher frequency adjustments to reserve supply were accomplished through repurchase and reverse repurchase agreements, with outright OMOs conducted periodically to accommodate trend growth in currency demand.

OMOs generally were designed to have a minimal effect on the prices of the securities included in the operations. To that end, they tended to be small in relation to the markets for Treasury bills and Treasury coupon securities. LSAPs, however, aimed to have a noticeable impact on the interest rates of the assets being purchased as well as on other assets with similar characteristics. In order to achieve this goal, the Federal Reserve designed LSAPs to be large relative to the markets for these assets. Between December 2008 and March 2010, the Federal Reserve purchased more than $1.7 trillion in assets. This represents 22 percent of the $7.7 trillion stock of longer term agency debt, fixed-rate agency MBS, and Treasury securities outstanding at the beginning of the LSAPs.[14] Another way to scale the purchases is to measure the amount of duration they removed from the market using the concept of "ten-year equivalents," or the amount of ten-year-par Treasury securities that would have the same duration as the portfolio of assets purchased. Between December 2008 and March 2010, the Federal Reserve purchased about $850 billion in ten-year equivalents. That represents more than 20 percent of the $3.7 trillion outstanding stock of ten-year equivalents across these three asset classes at the beginning of the programs.[15, 16] We believe that no investor—public or private—has ever accumulated such a large amount of securities in such a short period of time.

As with all OMOs, the implementation of LSAP programs was carried out by the Federal Reserve Bank of New York under delegated authority from the FOMC to the SOMA manager at the New York Fed. Under this authority, the SOMA manager is responsible for the design and execution of OMOs to achieve the policy mandate set forth by the FOMC. Among the challenges in implementing OMOs for the LSAP programs was the need to communicate clearly to market participants the Federal Reserve's goals and strategy for LSAPs and to execute such large purchases while maintaining healthy market functioning.

Purchases of MBS posed the greatest operational challenge, owing to the more complex nature and heterogeneity of these securities and to the size of the MBS purchase program. Although the New York Fed had routinely accepted agency MBS as collateral in repurchase agreement transactions, these securities previously had not been purchased on an outright basis. In order to quickly and efficiently implement the MBS purchases and to mitigate financial and operational risk, the New York Fed hired external investment managers to execute these purchases.[17] Working closely with staff at the New York Fed on a day-to-day basis, the investment managers executed a certain quantity of purchases on behalf of the Federal Reserve

[12] Agency purchases were introduced in 1971 in order to "widen the base for System open market operations and to add breadth to the market for agency securities." New purchases were stopped in 1981, although some maturing funds from agency holdings were reinvested in newly issued agency securities. Beginning in 1997, all holdings of agency securities were allowed to mature without replacement. The last agency holding acquired under these programs matured in December 2003.

[13] A repurchase agreement is similar to a collateralized loan. The borrower sells a security to the lender and simultaneously promises to buy back the security at a fixed price. The Federal Reserve lends funds to the market through repurchase agreements in order to increase reserves. To withdraw funds, the Federal Reserve engages in repurchase agreements in the opposite direction, also known as "reverse repurchase agreements."

[14] The outstanding stock is computed from Barclay's Capital Indices, based on data for November 24, 2008 (the day before the initial announcement of LSAPs). The amount includes only fixed-rate issues with at least one year to final maturity, and at least $250 million par amount outstanding. The measure of agency debt outstanding includes debt issued by U.S. government agencies, quasi-federal corporations, and corporate or foreign debt guaranteed by the U.S. government (such as USAID securities), but the largest issues are from Fannie Mae, Freddie Mac, and the Federal Home Loan Bank System.

[15] The outstanding stock of ten-year equivalents is also computed from Barclay's Capital Indices, based on data for November 24, 2008. Note that this measure of duration is affected by changes in the shape of the Treasury yield curve, and by the level of interest rates through their effect on prepayment of MBS.

[16] Note that in these calculations, we combine the purchases of all three asset types, as they all remove duration from the market and hence should affect risk premiums on all assets with duration exposure. In the regression analysis in section 4, we focus on the net public sector supply of long-term assets held because this measure plausibly may be assumed to be exogenous with respect to risk premiums. We thus ignore privately issued long-term assets that are held by private investors.

across a range of actively traded securities in the market each day. Those transactions were carried out with the Federal Reserve's primary dealers as the counterparties.[18]

Purchases of agency debt and Treasury securities posed less of a challenge, as these securities were already handled by the New York Fed in traditional OMOs. Unlike MBS purchases, the agency and Treasury purchases were arranged as multi-price reverse auctions conducted over the Federal Reserve's proprietary trading system, FedTrade.[19] The auctions provided a mechanism through which primary dealer counterparties could indicate the prices and quantities that they were willing to sell, facilitating competition between auction participants and enabling a market-based determination of purchases. Overall, the New York Fed conducted sixty operations for purchasing Treasury securities, or an average of nearly two per week over the course of the program; for agency securities, the number of operations through January 2010 totaled sixty-two, or about one per week.[20] Each operation focused on a particular maturity segment of securities and, to the extent possible, was scheduled to avoid conflicting with other operations or market events, such as Treasury debt auctions, agency offerings, and significant planned economic news releases. A summary of purchases was published on the New York Fed's website following each operation.[21]

For each of the three types of assets included in the LSAPs, the SOMA manager, in consultation with the FOMC, designed a strategy for the pace and composition of purchases. The approach for each program was similar, but not identical, as due consideration needed to be given to the unique features of each asset class. In general, the composition of purchases was tilted toward longer maturity or longer duration securities in order to enhance the portfolio-balance effect and reduce longer term interest rates. But purchases included a range of maturities in order to minimize any distortions in the yield curves for these assets. Within each sector, the New York Fed focused purchases on assets that appeared to be underpriced relative to other assets within that sector, in some cases reflecting reduced market liquidity, as discussed above. These assessments were made using modeled yield curves and fair market values for securities to be purchased.[22] The overall pace of purchases had to be high enough to achieve the FOMC's targets within the stated time frame, but allow for some variation from day to day based on market liquidity conditions.

Recall that purchases of agency debt and MBS began at a time when liquidity in these markets was poor and spreads to Treasury yields were unusually wide. In these circumstances, LSAPs helped to improve market liquidity by providing a large buyer for these securities on a consistent basis. Spreads of MBS and agency yields narrowed relative to Treasury yields and spreads between on-the-run and off-the-run Treasury securities narrowed. Trading flows increased and market participants reported narrower bid-ask spreads in these markets, reflecting improved liquidity. However, as financial conditions improved over the course of the programs, the LSAPs became more of an impediment to market liquidity by removing such a large amount of the available supply. Some market analysts argued that the relatively rich pricing of agency debt and MBS was also having a negative impact on market liquidity because it was driving some major investors out of these markets. However, displacing agency debt and MBS investors to a significant extent was an unavoidable element of the programs that was necessary for achieving their goals. Despite periodic strains, these markets generally continued to function with adequate liquidity, in that investors could trade relatively large amounts of securities with little effect on market prices.

Because the MBS purchases were arranged with primary dealer counterparties directly, there was no auction mechanism to provide a measure of market supply. Instead, the New York Fed aimed to adjust the pace of purchases of each class of MBS in response to measures of whether that class appeared relatively cheap or expensive, driven in part by changes in liquidity. To avoid buying at excessively high prices and to support market functioning, the New York Fed increased purchases when market liquidity appeared to be good and reduced them when liquidity appeared to be poor. Different measures of liquidity were used to make these adjustments,

[17] Four investment firms were hired to provide trading and advisory services at the start of the program: BlackRock, Goldman Sachs Asset Management, PIMCO, and Wellington Management Company. On August 17, 2009, the New York Fed announced that Wellington Management Company would become the sole investment manager and that BlackRock would be retained for analytical support services. JPMorgan was hired as the program administrative agent and custodian.

[18] Weekly summaries of MBS purchases can be found at http://www.newyorkfed.org/markets/mbs/.

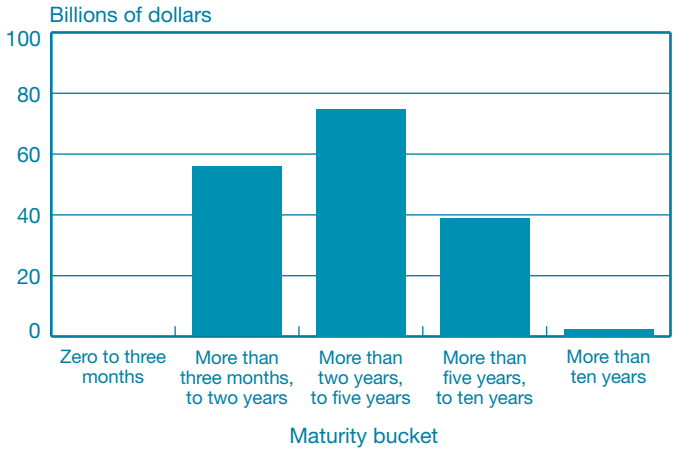
[19] In these multi-price reverse auctions, participants enter prices at which they are willing to sell selected amounts of specific securities to the New York Fed. The offers are ranked according to their attractiveness and accepted until the desired purchase amount is reached, much like in the case of a single-price auction. However, in the case of these multi-price auctions, sellers whose offers are accepted receive the price they submitted, whereas in a single-price auction all successful offers would receive the clearing price for that security.

[20] A tentative two-week schedule of Treasury operations was announced on a biweekly basis, while agency operations were announced one day ahead. Providing advance notice of auctions helped to boost participation by allowing dealers time to assess and adjust their inventories.

[21] Summaries of Treasury purchases are available at http://www.newyorkfed.org/markets/pomo/display/index.cfm. Summaries of agency purchases are available at http://www.newyorkfed.org/markets/pomo/display/index.cfm?opertype=agny.

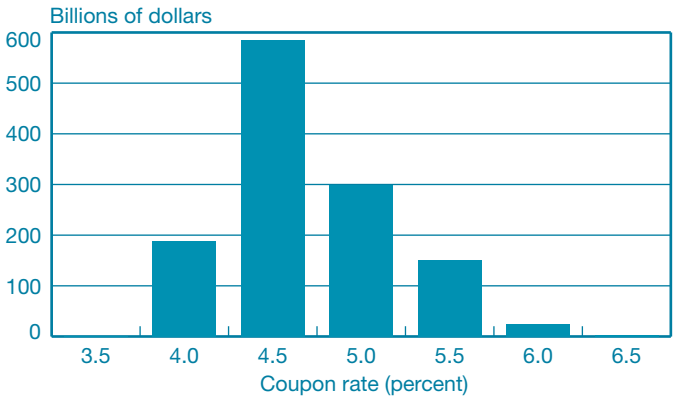
[22] For Treasury and agency debt purchases, underlying discount curves were estimated from prices of a current cross-section of comparable securities from the same issuer to generate a fair valuation for securities being purchased. In the case of MBS, valuations between different securities were compared with historical norms.

Chart 1
Distribution of Agency Debt Purchases by Maturity



Source: Federal Reserve Bank of New York.

Chart 2
Distribution of Mortgage-Backed Securities Purchases by Coupon



Source: Federal Reserve Bank of New York.

including measures of trading volumes, relative price valuations, bid-ask spreads, and indications of supply imbalances. Throughout the program, the pace of daily purchases ranged from $2 billion to $9 billion.[23] In terms of composition, the Federal Reserve purchased MBS in all coupon classes, but purchases were concentrated in the "production," or newly issued, thirty-year securities, which were in abundant supply in the first few months of the program and generally had lower coupons than existing MBS because of the prevailing low interest rates.[24] It was felt that concentrating purchases on production MBS would help to reinforce the decline in primary mortgage rates by providing mortgage originators with a deep and ready market for new loans.

In the case of agency debt, the New York Fed adjusted the amount of securities purchased in each operation in response to the total amount of propositions submitted, provided that these propositions were at competitive prices. This strategy was used in order to target different segments of the maturity spectrum optimally from the perspective of market functioning and liquidity. The program initially focused on off-the-run securities; but as liquidity improved and yield spreads for these securities narrowed, the New York Fed added on-the-run securities to the eligible set of securities in September 2009 in order to mitigate market dislocations that had developed during the program.

[23] The program also made purchases and sales in the MBS dollar roll market to help support financing of dealer MBS portfolios and to smooth out temporary fluctuations in the supply of particular coupon categories of MBS. In a dollar roll transaction, the buyer purchases MBS for the current delivery month and simultaneously sells substantially similar MBS for a future delivery month.

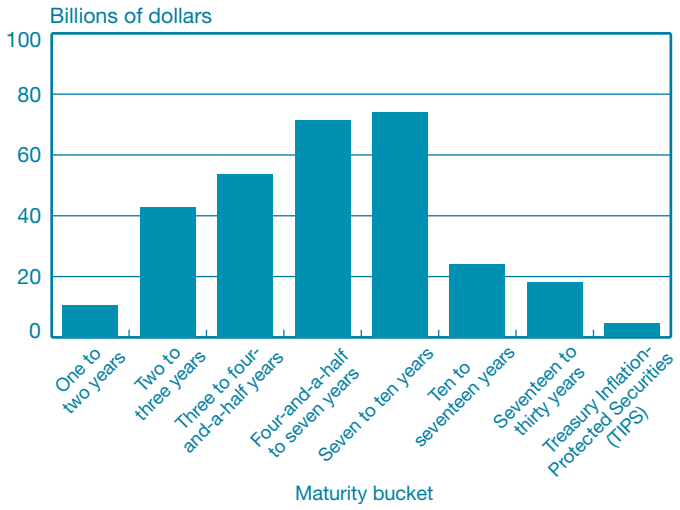
[24] MBS with low coupons have a longer duration than high-coupon securities, in part because they tend to have a lower prepayment rate.

Concerns about market functioning and liquidity were generally lower in the Treasury LSAP program, as that program was much smaller in relation to the size of the market and to the level of typical trading flows. As such, neither the pace nor the composition of purchases was adjusted significantly throughout the program. The amount of propositions in each operation routinely exceeded the targeted quantity by three times or more.

Purchases of agency debt were concentrated in medium-term securities because of the small outstanding supply at longer maturities (Chart 1). Purchases of agency MBS were concentrated in newly issued, low-coupon, thirty-year securities of Fannie Mae and Freddie Mac (Chart 2), which were relatively more liquid and had longer durations than other MBS. Purchases of Treasury securities were concentrated in the two- to ten-year maturity sectors (Chart 3). Nevertheless, there were significant amounts purchased outside of these targeted sectors, including a range of maturities of Treasury debt and higher coupon, seasoned agency MBS, in order to avoid substantial distortions in the yield curves and spreads on these assets. In these circumstances, LSAPs appeared to improve market liquidity. Spreads of agency debt and MBS yields narrowed relative to Treasury yields, and spreads between on-the-run and off-the-run Treasury securities also narrowed.

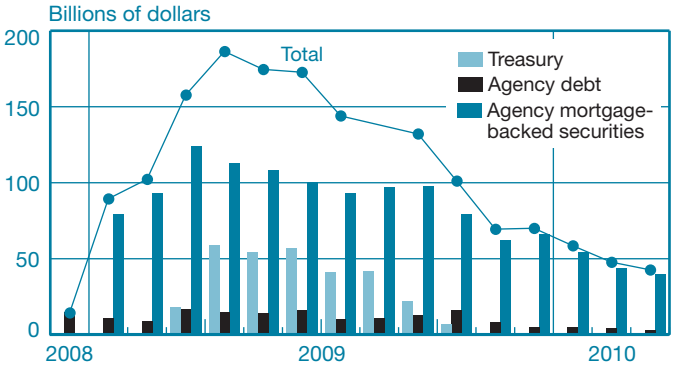
The pace of purchases evolved fairly smoothly over the course of the program. Total purchases ranged between $50 billion and $200 billion on a monthly basis (Chart 4). Purchases were somewhat heavier from March 2009 through June 2009, reflecting the expansion of the LSAP programs at that time and the large amount of MBS purchases made to

Chart 3
Distribution of Treasury Purchases by Maturity



Source: Federal Reserve Bank of New York.

Chart 4
Pace of Purchases by Asset Class



Source: Federal Reserve Bank of New York.

offset significant origination activity. The decision to taper purchases led to a slowing pace after mid-2009.[25]

The Federal Reserve issued a press release shortly after the initial announcement of each program providing further details on the timing and overall structure of the programs. Documents providing answers to frequently asked questions were released at the start of each program. These documents provided details as to the types of securities eligible for purchase and the investment strategy that would be employed, and they were updated to reflect changes in the programs, such as the increase in the targeted size of the agency debt and MBS programs or the inclusion of on-the-run securities for purchase in the agency debt program. The timely release of information was provided in order to reduce uncertainty and speculation about operational details. This information may also have helped to prevent erratic trading based on differential access to information or on rumors and misconceptions.

[25] The decision to gradually slow the pace of Treasury purchases was announced in the August 2009 FOMC statement. The decision to gradually slow the pace of agency purchases was announced in the September 2009 FOMC statement.

4. Estimates of LSAP Effects

4.1 Other Studies

According to the expectations theory of the term structure, altering the maturity of the net supply of assets from the government to private investors should have only minimal effects on the term structure of interest rates. This view was supported by the literature studying Operation Twist in the early 1960s, which did not find robustly significant effects of a swap between short-term and long-term Treasury securities in the SOMA portfolio.[26] However, as noted by Solow and Tobin (1987), Federal Reserve purchases during Operation Twist were small and were soon more than offset by increased Treasury issuance of long-term debt. Overall, there was little movement in the average maturity of Treasury debt held by the public and thus little hope of estimating a statistically significant and robust effect.

Subsequent time-series studies, using longer spans of data, generally have found a noticeable effect on the term structure of shifts in the maturity structure of Treasury debt.[27] The estimated size of this effect depends on the degree of theoretical restrictions imposed on the estimating equation. Tighter restrictions implied by simple models of household behavior generally lead to smaller estimates, but these restrictions typically are rejected statistically in favor of less restrictive specifications. Other time-series studies, while not focusing on the maturity structure of public debt, have found that increases in the total supply of public debt tend to raise longer term

[26] See, for example, Modigliani and Sutch (1967). The current program differs from Operation Twist in that the reduction in long-term bonds is financed by reserve creation rather than sales of short-term Treasury bills. However, with interest rates on bank reserves and short-term bills roughly equal in the current environment, the two assets should be viewed as close substitutes, and thus the effect on the term spread should be similar.

[27] All of the studies focused on the United States. See Friedman (1981), Frankel (1985), Agell and Persson (1992), Kuttner (2006), and Greenwood and Vayanos (2010). Since the original draft of this paper was written, Hamilton and Wu (2010) have estimated the model of Vayanos and Vila (2009) and obtained results broadly similar to ours.

interest rates.[28] Kozicki, Santor, and Suchanek (2010) analyze time-series data on the size of central bank balance sheets and find that increases in the balance sheets are associated with declines in long-term forward interest rates. Stroebel and Taylor (2009) find little effect of daily Federal Reserve purchases on the spread between MBS yields and swap yields and a moderate effect on the spread between MBS yields and Treasury yields.

Bernanke, Reinhart, and Sack (2004) adopt an alternative approach to time-series analysis. They examine specific news events concerning future Treasury issuance or purchases of longer term securities and find that longer term yields dropped significantly on days when the market learned of future declines in the net supply of longer term Treasury securities.

Since the original draft of this paper was written, several studies have examined the issue of whether LSAPs can affect longer term interest rates. D'Amico and King (2010), Hamilton and Wu (2010), Krishnamurthy and Vissing-Jorgensen (forthcoming), Neely (2010), and Swanson (2011) all find evidence that LSAPs do indeed reduce longer term interest rates.

In this paper, we employ both time-series and event-study methodologies to gauge the overall effects of the LSAP programs.

4.2 An Event Study of Recent LSAP Communications

In this section, we use an event-study analysis of Federal Reserve communications to derive estimates of the effects of LSAPs implemented between December 2008 and March 2010. In particular, we examine changes in interest rates around official communications regarding asset purchases, taking the cumulative changes as a measure of the overall effects. In doing so, we implicitly assume that: 1) our event set includes all announcements that have affected expectations about the total future volume of LSAPs, 2) LSAP expectations have not been affected by anything other than these announcements, 3) we can measure responses in windows wide enough to capture long-run effects but not so wide that information affecting yields through other channels is likely to have arrived, and 4) markets are efficient in the sense that all the effects on yields occur when market participants update their expectations and not when actual purchases take place.[29]

The financial variables we examine are the two-year and ten-year Treasury yields, the ten-year agency debt yield, the current-coupon thirty-year agency MBS yield, the ten-year Treasury term premium (based on Kim and Wright [2005]), the ten-year swap rate, and the Baa corporate bond index yield.[30] Swap rates and corporate bond yields help us gauge the extent to which news about LSAPs affected yields on assets that were not purchased by the Federal Reserve.

We focus on a narrow set of official communications, each of which contained new information concerning the potential or actual expansion of the size, composition, and/or timing of LSAPs. The eight announcements included in this "baseline" event set are:

- the initial LSAP announcement on November 25, 2008, in which the Federal Reserve announced it would purchase up to $100 billion in agency debt, and up to $500 billion in agency MBS;
- Chairman Bernanke's December 1, 2008, speech, in which he stated that in order to influence financial conditions, the Fed "could purchase longer term Treasury securities . . . in substantial quantities";
- the December 2008 and January 2009 FOMC statements, which indicated that the FOMC was considering expanding purchases of agency securities and initiating purchases of longer term Treasury securities;
- the March 2009 FOMC statement, in which the FOMC announced the decision to purchase "up to" $300 billion of longer term Treasury securities and to increase the size of agency debt and agency MBS purchases to "up to" $200 billion and $1.25 trillion, respectively;
- the August 2009 FOMC statement, which dropped the "up to" language qualifying the maximum amount of Treasury purchases and announced a gradual slowing in the pace of these purchases;

[28] See Engen and Hubbard (2005), Gale and Orszag (2004), and Laubach (2009). Warnock and Warnock (2009) also find that purchases of U.S. debt by foreign governments tend to lower U.S. long-term interest rates.

[29] These are strong assumptions. The need for them arises in part because we do not have a direct measure of expectations about the size of future LSAPs. With such a measure, we could use announcements to identify exogenous shocks to LSAP expectations. The corresponding yield responses could then be used to derive statistical estimates of the effects of changes in expectations and, from these, the total effects of LSAPs could be extrapolated. Such an approach is typical of studies of the effects of surprise changes to the target federal funds rate, using interest rate futures contracts to measure market expectations. A particular challenge in isolating the effects of LSAPs is that the announcements we identify are likely to have contained non-LSAP information relevant to yields, including policy measures and updates to the FOMC's economic outlook. As a result, it is impossible to draw a response window narrow enough to include only the effects of LSAPs.

[30] We measure agency debt yields using Freddie Mac's on-the-run fixed-rate senior benchmark noncallable note; as of February 1, 2010, Fannie Mae had not issued a ten-year note since 2007. On-the-run agency debt was not included in LSAPs until September 2009, but the cumulative changes in the first off-the-run yield are almost identical to the changes in the on-the-run yield. The MBS yield is the average of the Freddie Mac and Fannie Mae current-coupon thirty-year agency MBS yields. The interest rates are from Bloomberg L.P., except for the Baa yield, which is from Barclay's Capital. The Kim-Wright term premium data are made available by the Federal Reserve Board at http://www.federalreserve.gov/econresdata/researchdata.htm. The Kim-Wright term premium is based on implied zero-coupon yields on off-the-run securities, whereas the Treasury yield series are for on-the-run coupon securities.

- the September 2009 FOMC statement, which dropped the "up to" language qualifying the maximum amount of agency MBS purchases and announced a gradual slowing in the pace of agency debt and MBS purchases; and
- the November 2009 FOMC statement, which stated that the FOMC would purchase "around $175 billion of agency debt."

Table 1

Interest Rate Changes around Baseline and Extended Event Set Announcements

Date	Event	Two-Year U.S. Treasury	Ten-Year U.S. Treasury	Ten-Year Agency	Agency Mortgage-Backed Securities[b]	Ten-Year Term Premium	Ten-Year Swap	Baa Index
11/25/2008[a]	Initial large-scale-asset-purchase announcement	-2	-22	-58	-44	-17	-29	-18
12/1/2008[a]	Chairman speech	-8	-19	-39	-15	-17	-17	-12
12/16/2008[a]	Federal Open Market Committee (FOMC) Statement	-9	-26	-29	-37	-12	-32	-11
1/28/2009[a]	FOMC statement	10	14	14	11	9	14	2
3/18/2009[a]	FOMC statement	-22	-47	-52	-31	-40	-39	-29
4/29/2009	FOMC statement	1	10	-1	6	6	8	-3
6/24/2009	FOMC statement	10	6	3	2	4	4	5
8/12/2009[a]	FOMC statement	-2	5	4	2	3	1	2
9/23/2009[a]	FOMC statement	1	-3	-3	-1	-1	-5	-4
11/4/2009[a]	FOMC statement	-2	6	8	1	5	5	3
12/16/2009	FOMC statement	-2	1	0	-1	1	1	-1
1/27/2010	FOMC statement	11	3	4	4	1	3	1
3/16/2010	FOMC statement	-3	-5	-4	-4	-4	-4	-5
1/6/2009	Minutes release	0	-4	3	-17	-1	-9	-14
2/18/2009	Minutes release	9	11	4	6	8	9	16
4/8/2009	Minutes release	2	-4	-7	-9	-4	-6	-6
5/20/2009	Minutes release	-5	-5	-5	-7	-4	-4	-10
7/15/2009	Minutes release	7	13	16	16	10	16	7
9/2/2009	Minutes release	-1	-6	-6	-4	-7	-8	-5
10/14/2009	Minutes release	1	7	10	3	7	7	8
11/24/2009	Minutes release	0	-5	-5	-9	-5	-6	-3
1/6/2010	Minutes release	-2	6	5	4	6	7	-1
2/17/2010	Minutes release	4	7	7	8	6	8	5
Baseline event set		-34	-91	-156	-113	-71	-101	-67
Baseline set + all FOMC		-1	-55	-134	-114	-47	-75	-72
Cumulative change: 11/24/08 to 3/31/2010		-19	50	-75	-95	30	28	-489
Standard deviation of daily changes: 11/24/08 to 3/31/10		5	8	9	10	6	9	7

Sources: Bloomberg L.P.; Barclay's Capital; Board of Governors of the Federal Reserve System.

[a]Included in the baseline event set.

[b]Two-day change for agency mortgage-backed securities on March 18, 2009, because of a Bloomberg L.P. data error.

We consider the response of interest rates using one-day windows around the announcements, measured from the closing level the day prior to the announcement to the closing level the day of the announcement.[31] Selecting the window length involves a trade-off between allowing sufficient time for revised expectations to become fully incorporated in asset prices and keeping the window narrow enough to make it unlikely to contain the release of other important information. Although event studies often examine *intraday* price changes in order to avoid the pollution of measured responses by extraneous information, we believe a wider window is suitable in this context. Specifically, given the novelty of the LSAPs and the diversity of beliefs about the mechanisms by which they operate, changes may have been absorbed more slowly than for typical monetary policy shocks (such as those to the federal funds target rate).

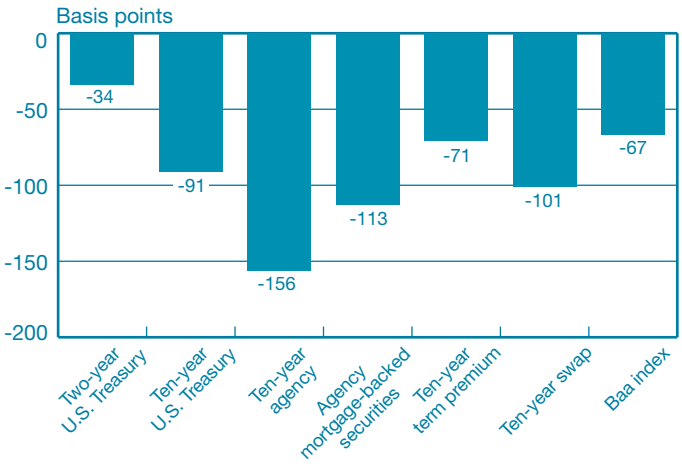
Table 1 displays the changes in interest rates on each day in the baseline event set described above as well as on days in which the FOMC issued communications concerning the LSAPs that provided little new information. With one minor exception, interest rates moved in the expected direction on each of the baseline event days. On November 25, December 1, December 16, and March 18, FOMC communications pointed to greater-than-expected LSAP purchases, and long-term rates fell. On January 28, August 12, and November 4, FOMC communications pointed to lower-than-expected LSAP purchases, and long-term rates rose. The magnitude of the surprise was likely rather low on these last two dates, which is consistent with the relatively small movements in long-term interest rates. On September 23, long-term rates fell despite FOMC language that might have reduced expected future LSAPs, but the decline was very small (only 1 basis point for the term premium).

Chart 5 displays the cumulative changes in interest rates across the eight announcements in the baseline event set. All interest rates declined notably, with the ten-year Treasury yield, ten-year agency debt yield, and current-coupon agency MBS yield declining 91, 156, and 113 basis points, respectively. The large change in the ten-year Treasury yield relative to the two-year Treasury yield suggests that the announcements reduced longer term rates principally by reducing the term premium, as opposed to signaling a commitment to keep policy rates low for an extended period of time. This inference is confirmed by the large cumulative drop in the Kim-Wright ten-year term premium measure. The relatively large changes in agency debt and agency MBS yields demonstrate that the LSAPs also helped to lower spreads of the yields on these assets relative to those on Treasury securities. The substantial declines

[31] We use the two-day change for the MBS yield around the March 2009 FOMC meeting because of an error in the Bloomberg MBS yield series on March 18. As discussed below, we also tried using two-day windows for all event days and interest rates.

Chart 5

Cumulative Interest Changes on Baseline Event Set Days



Sources: Bloomberg L.P.; Barclay's Capital; Board of Governors of the Federal Reserve System.

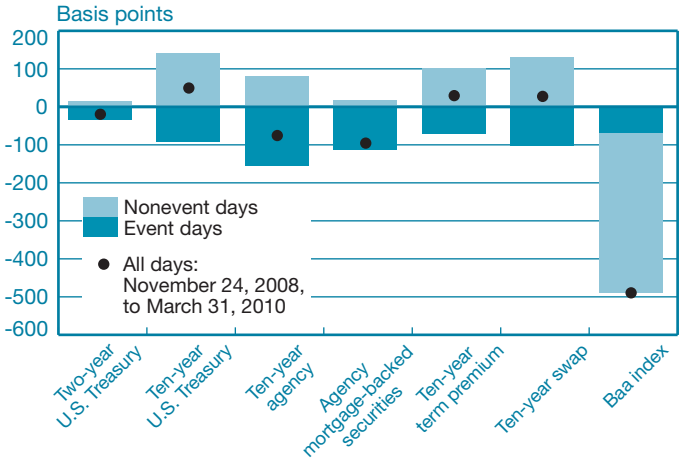
in the swap rate and the Baa corporate bond yield show that LSAPs had widespread effects, beyond those on the securities targeted for purchase.

Some observers, noting that the ten-year Treasury yield did not decline on net over the course of the LSAP programs, have argued that the LSAPs did not have a lasting effect. Chart 6 compares the net changes in interest rates on the baseline event days with the net changes on all other days from November 24, 2008, through March 31, 2010. The ten-year Treasury yield and swap rate increased more than 100 basis points on nonevent days, and hence were up moderately over the entire period. However, there were many factors at play that would have been expected to lift Treasury yields over that period, including a very large increase in the expected future fiscal deficit, a significant rebound in the economic outlook, and a sharp reversal of the flight-to-quality flows that had occurred in the fall of 2008.[32] It is likely those factors, and not a reversal of the effects of the LSAP announcements, that drove Treasury yields higher on other days. Supporting that view, other interest rates showed very different patterns than that of the ten-year Treasury yield on nonevent days. The agency debt yield rose less than the Treasury yield, the MBS yield was little changed, and the Baa corporate bond yield dropped about 400 basis points. This combination of a rising Treasury yield and a falling corporate bond yield is consistent with the relaxation of the extreme financial strains and flight-to-quality

[32] On December 10, 2008, the *Blue Chip Economic Indicators* survey's average projection of the fiscal year 2009 federal deficit was $672 billion. In January 2010, the Congressional Budget Office estimated the 2009 deficit at $1,587 billion and projected the 2010 deficit at $1,381 billion. The Conference Board's Index of Leading Economic Indicators rose from 99.2 in November 2008 to 109.4 in March 2010.

Chart 6

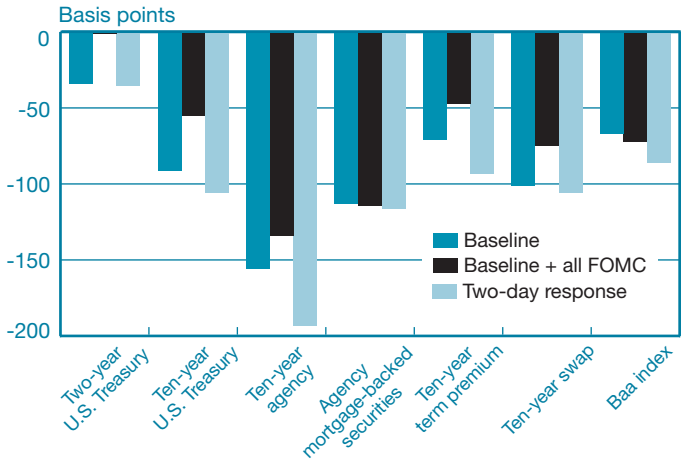
Cumulative Changes since November 2008, Event versus Nonevent Days



Sources: Bloomberg L.P.; Barclay's Capital; Board of Governors of the Federal Reserve System.

Chart 7

Cumulative Interest Rate Changes around Announcement Events, Alternative Event Study Parameters



Sources: Bloomberg L.P.; Barclay's Capital; Board of Governors of the Federal Reserve System.

that characterized the early part of 2009, and it highlights the importance of focusing on event days to measure the effects of LSAPs separately from the effects of other developments.

Finally, Chart 7 plots cumulative interest rate changes using two modifications to our event study. In the first, we continue to use one-day response windows, but expand the event set to include all FOMC statements and minutes between November 2008 and January 2010 to allow for the possibility that markets gleaned information about the future of LSAPs from these communications. In the second, we use the same baseline event set as above, but extend the response window to two days to allow for lagged reactions to the news by some market participants. Most of the measured effects of the LSAPs change only modestly using these alternative parameterizations of the event study. Using the expanded event set, we show that the cumulative declines are between 10 basis points larger and 30 basis points smaller than when we use the baseline set. The smaller declines may reflect that markets had attributed some probability to further increases in the LSAPs and that these expectations were adjusted downward when the FOMC did not move in that direction on the nonbaseline event days. However, using two-day response windows, we see that the cumulative declines are 0 to 40 basis points larger than they are when the one-day windows are used, suggesting that it may have taken more than one day for the market to fully adjust to these communications.[33]

To more carefully evaluate whether the effects found above arose through the term premium, as would be expected from the theoretical discussion in section 2, we focus on yield movements around the two FOMC announcements that also contained new language on the prospects for future short-term interest rates. In particular, on December 16, 2008, the FOMC stated its view that the federal funds rate was likely to remain at "exceptionally low levels for some time." On March 18, 2009, the FOMC modified this language to "exceptionally low levels for an extended period." We want to make sure that the yield movements around those dates do not reflect a decline in expected future short-term interest rates associated with those statements.

One way to approach this issue is to rely on the Kim-Wright (2005) estimated term premium used above to examine the market interest rates with maturities that are most likely to be affected by the FOMC statements concerning the future federal funds rate. Any movement in the expected federal funds rate at these horizons is likely to be much greater than the average movement in the expected federal funds rate over the next ten years. We focus on the movement in the estimated one-year-ahead instantaneous interest rate around the release of the FOMC statements.[34] According to the Kim-Wright estimates, the one-year-ahead expected instantaneous interest rate dropped only 4 basis points on December 16, 2008, and rose 16 basis points the following day.[35] An alternative gauge of

[33] MBS yields in particular may have taken longer to respond fully to these communications. Adding a third day to the windows increases the cumulative decline of MBS yields by more than 30 basis points, whereas it has little effect on the cumulative declines in the other yields.

[34] The instantaneous interest rate is a construct of the Kim-Wright model that is essentially equivalent to the federal funds rate.

[35] The two-year-ahead expected instantaneous interest rate dropped 6 basis points on December 16 and rose 4 basis points on December 17.

market expectations is the one-year-ahead forward instantaneous interest rate, as the term premium would presumably be limited in size at this horizon.[36] This rate dropped 11 basis points on December 16, but rose 17 basis points the following day.

On March 18, 2009, the Kim-Wright one-year-ahead expected instantaneous interest rate dropped 4 basis points and rose by the same amount on the following day.[37] The one-year-ahead forward instantaneous rate dropped 28 basis points on March 18, but about half of this decline was unwound over the next few days. Overall, these observations on expected future and forward interest rates suggest that the December 2008 and March 2009 FOMC statements did not have large effects on market expectations of the future path of the federal funds rate—certainly not enough to explain the substantial decline in longer term interest rates on those days.[38]

In principle, the LSAP programs could have raised the expected future path of the federal funds rate by accelerating the expected pace of economic recovery. In this case, the LSAP effect on the term premium would be greater than the effect on the long-term Treasury yield. According to Table 1, however, the LSAP effects on the ten-year Treasury yield are slightly larger than those on the ten-year term premium, suggesting that LSAPs did not raise the expected future federal funds rate.

Altogether then, we find that longer term interest rates declined by up to 150 basis points around key LSAP announcements. Moreover, the majority of the decline in the ten-year Treasury yield around these announcements can be attributed to declines in the term premium. Chart 7 shows that, depending on the event set and response window used, LSAP announcements reduced the ten-year term premium by between 50 and 100 basis points. Little of the observed declines in longer term yields appears to reflect declining expectations of future short-term interest rates associated with FOMC communications about the likely future path of the federal funds rate.

[36] The forward rate is the sum of the expected future instantaneous rate and the forward term premium. It can be derived directly from the yield curve without requiring any modeling of, or assumptions about, its components beyond those required to fit a yield curve to observed bond yields.

[37] The two-year-ahead expected instantaneous interest rate dropped 14 basis points on March 18 and rose 3 basis points on March 19.

[38] It is possible that these FOMC statements affected the term premium directly by reducing uncertainty about the path of future interest rates. Estimating this effect is beyond the scope of this paper, but we believe such effects are likely to have been small.

4.3 Time-Series Analysis of Longer Term Treasury Supply

In this section, we use a different method and different data to measure the impact of asset purchases (or sales) on the ten-year term premium.[39] Specifically, we estimate statistical models that explain the historical variation (prior to the announcement of the LSAP programs) in the term premium using factors related to: 1) the business cycle, 2) uncertainty about economic fundamentals, and 3) the net public sector supply of longer term dollar-denominated debt securities. Using a variety of model specifications, we estimate the effects on the term premium of changes in the stock of longer term debt held by private investors. We then use these results to estimate the (out-of-sample) impact of the Federal Reserve's asset purchases through March 2010, which represent a reduction in the supply of longer term debt securities to private investors.

Following Backus and Wright (2007), we explain historical time-variation in the term premium using an ordinary-least-squares regression model of the form:

$$tp_t^{10} = X_t\beta + \varepsilon_t,$$

where tp_t^{10} is the nominal ten-year yield term premium, and X_t is a set of observable factors.[40] However, we expand on the set of explanatory variables used by Backus and Wright, focusing on the three types of variables noted above.[41]

In particular, the following variables are included to capture term premium variation related to the business cycle and fundamental uncertainty:

- *Unemployment gap*: measured as the difference between the unemployment rate and the Congressional Budget Office's estimate of the natural rate of unemployment.
- *Core CPI inflation*: a second measure of the macroeconomic state, the twelve-month change in core CPI, may also proxy for inflation uncertainty.[42]

[39] The term premium likely captures the largest component of the LSAPs' effects on private borrowing rates. However, as we highlighted in section 2, LSAPs also affected other components of risk premiums. The statistical models here do not attempt to estimate these other effects or the effects on term premiums at different horizons.

[40] Whereas Backus and Wright modeled the instantaneous *forward term premium* ten years ahead, we focus on the ten-year *yield term premium* because of our interest in the purchases' effects on longer term interest rates.

[41] In early analysis, we also included a measure of the on-the-run Treasury liquidity premium as a proxy for the flight-to-quality demand for Treasuries. However, the coefficient on this term was never significant, and excluding it did not affect the magnitude or significance of the other coefficients. For ease of exposition, we omit it here.

[42] Mankiw, Reis, and Wolfers (2004) show that inflation disagreement, the level of inflation, the absolute value of the change in inflation, and relative price variability positively covary.

- *Long-run inflation disagreement*: measured as the interquartile range of five- to ten-year-ahead inflation expectations, as reported by the Michigan Survey of Consumers.[43]
- *Six-month realized daily volatility of the on-the-run ten-year Treasury yield*: a proxy for interest rate uncertainty. We use this instead of option-implied volatility because it is available over a longer period.[44]

To capture the effects of changes in the net public sector supply of longer term debt securities, we use the following time series, each of which is expressed as a percentage of nominal GDP:

- publicly held Treasury securities with at least one year to maturity, including securities held by private investors as well as those held by the Federal Reserve and by foreign official institutions;
- Treasury securities held in the Federal Reserve's SOMA portfolio with at least one year to maturity;[45]
- U.S. debt securities held by foreign official agencies, with at least one year to maturity; this measure includes Treasury securities, agency-related securities, and corporate bonds, and is interpolated from annual stock surveys, using monthly Treasury International Capital (TIC) flows, by the Board of Governors of the Federal Reserve System.[46]

An important assumption of our statistical analysis is that these longer term debt stock variables are exogenous with respect to the term premium. For example, this assumption implies that the Treasury does not issue more long-term debt when the term premium declines. To the extent that these public sector agencies do respond to term premiums in a manner similar to private investors, that is, by buying more long-term debt (or selling less long-term debt) when the term premium is high, our estimates of the effect of public sector longer term debt supply on the term premium will be biased downward. Overall, we believe it is reasonable to assume that these public agencies respond very little to term premiums. However, our estimates may be viewed as somewhat conservative owing to this potential downward bias.

The response of private investors to the net public sector supply of assets should not be affected by the specific public sector agency doing the purchases or sales. Thus, when the Treasury buys back a longer term security, it should have the same effect on longer term yields as when the Federal Reserve buys that security or when a foreign official agency buys that security (assuming that each is expected to hold the security on a persistent basis and controlling for any policy signals the purchases convey). Moreover, the term premium should be roughly equally affected by public sector purchases of either Treasury securities or agency-related securities with similar durations. Accordingly, the appropriate measure of the net supply of longer term debt securities by the public sector would include longer term Treasury securities less the total amount of longer term debt held by the SOMA and by foreign official institutions.[47] We estimate models with this measure of the net supply of longer term debt expressed in both unadjusted terms and as ten-year Treasury equivalents.[48] The duration adjustment captures relevant variation in the *composition* of the outstanding stock of debt securities.[49]

We estimate the model on monthly data over the period January 1985 to June 2008. This period was selected because it is the full sample over which data on each of the variables are available, and because it ends shortly before the initial announcement of asset purchases in the fall of 2008. The first two columns of Table 2 present results from a regression of the ten-year term premium on the explanatory variables, using the unadjusted net debt stock measure. The third and fourth columns present results using the duration-adjusted net debt stock. For comparison, in this and subsequent tables we include estimates from the model without any debt supply variable in the final columns.

[43] We use the Michigan survey because of its long history and relatively high frequency (monthly), but our results are not significantly affected if we use long-run inflation disagreement taken from the *Blue Chip Economic Indicators* survey instead. The Michigan survey did not include the long-run inflation question during some months in the 1980s. We linearly interpolate the series when data are missing.

[44] Realized and implied volatility are highly correlated at the monthly frequency, and our modeling choice does not appear to substantively alter the results.

[45] As noted above, the SOMA held agency securities between 1971 and 2003. However, these were a very small portion of total SOMA holdings (less than 5 percent), and information on the maturity and duration of these holdings is not available.

[46] See Bertaut and Tryon (2007). The data are available at http://www.federalreserve.gov/pubs/ifdp/2007/910/default.htm.

[47] We do not include privately issued debt securities held by private investors because these securities have a net zero supply from the point of view of the private sector, and because demand and supply for them are likely not exogenous with respect to the term premium.

[48] The unadjusted stock of Treasury securities with remaining maturity greater than one year is obtained from Table FD-5 of the Treasury *Bulletin*. This table excludes SOMA holdings but includes foreign official holdings, which we subtracted using the TIC data described above. The duration-adjusted stock of non-SOMA Treasuries comes from Barclay's Capital and, unlike the unadjusted measure, excludes Treasury Inflation-Protected Securities (TIPS). In the duration-adjusted regressions, we use foreign holdings of long-term Treasury securities only (that is, we do not use agency-related securities or corporate bonds) and assume that these have the same duration as non-SOMA Treasuries held by the public. Because we cannot isolate foreign holdings of TIPS, the adjusted stock variable may understate holdings (by subtracting TIPS holdings from a total stock measure that already excludes it). The effect should be minor.

[49] As described in section 2, the adjustment converts the amount, S, into an amount of ten-year Treasury securities with the same portfolio duration: ten-year equivalents = $S^*duration(S)/duration(10y)$.

Table 2
Ordinary-Least-Squares Regression of Ten-Year Term Premium, January 1985 to June 2008

	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	-2.182***	0.348	-2.324***	0.349	-1.852***	0.334
Cyclical factors						
Unemployment gap	0.180**	0.064	0.185**	0.063	0.252***	0.070
Core CPI	0.307***	0.056	0.298***	0.057	0.480***	0.062
Uncertainty						
Inflation disagreement	0.377**	0.131	0.394**	0.133	0.286*	0.123
Realized volatility	0.943***	0.207	0.994***	0.206	0.944***	0.271
Supply						
Unadjusted	0.044***	0.009	—	—	—	—
Duration-adjusted	—	—	0.064***	0.014	—	—
Adjusted R^2	0.84		0.84		0.78	
Standard error of regression	0.36		0.37		0.43	
Number of observations	282		282		282	

Source: Authors' calculations.

Note: Newey-West standard errors with twelve lags.

***Statistically significant at the 1 percent level.
**Statistically significant at the 5 percent level.
*Statistically significant at the 10 percent level.

The results are similar with either measure of the debt stock. The explanatory variables are almost all significant at the 1 percent level and always have the expected sign. Specifically, one percentage point increases in the unemployment gap, core CPI inflation, inflation disagreement, and realized volatility increase the term premium about 20, 30, 40, and 100 basis points, respectively. As for the supply variables, a 1-percent-of-GDP increase in longer term debt supply increases the ten-year term premium by 4.4 basis points on an unadjusted basis and by 6.4 basis points when expressed in terms of ten-year Treasury equivalents.[50] Both coefficients are statistically significant at the 1 percent level.[51]

The $1.725 trillion in purchases by the Federal Reserve between December 2008 and March 2010 is roughly 12 percent of 2009 nominal GDP, which, according to the estimates in the first column of Table 2, implies that total Federal Reserve asset purchases reduced the term premium by 52 basis points. In terms of ten-year equivalents, the Federal Reserve purchased a total of approximately $850 billion—roughly 6 percent of 2009 nominal GDP—which, according to estimates in the third column, would imply that asset purchases reduced the term premium by 38 basis points.

None of the variables included in the model can grow or decline without bound, and thus there is a strong presumption that they are stationary. However, some of them may have a sufficiently large autocorrelation to appear nonstationary within our twenty-three-year estimation sample. Thus, we also use dynamic ordinary least squares (DOLS) based on Stock and Watson (1993) to estimate the long-run relationship (also known as the cointegrating vector) between the term premium and the explanatory variables. In addition to the levels of our explanatory variables, the contemporaneous, lead, and lagged first differences of each are included as regressors.[52] The level coefficients from the DOLS regression estimate the long-run relationship between the variables, and the deviation of the

[50] We cannot reject the possibility that the debt stock coefficients are constant between the first and second halves of the sample.

[51] If the debt stock components—Treasury, SOMA, and TIC—are entered separately into the regression, the coefficients on SOMA and TIC are a bit larger and the coefficient on Treasury is considerably smaller than the coefficient on the combined variable. We suspect that the smaller separate Treasury estimate arises because shifts in the supply of long-term Treasury securities are anticipated far in advance. In the regressions reported here, we nevertheless impose the assumption that the effects are the same.

[52] The following procedure was used to select the leads and lags included within the DOLS regression. We started with a single lead and lag of the first difference of each explanatory variable. If the lead or lag for a variable was statistically significant at the 5 percent level (using Newey-West standard errors with twelve lags), we added one more and removed all leads and lags that were not significant. If the added lead or lag was still significant, we added four more. For each specification, this was enough to make the leads and lags of the longest length statistically insignificant. For robustness, we also estimated the model using six leads and lags of the first differences. The coefficient estimates on supply in the cointegrating vectors were virtually unchanged from those derived according to the selection procedure just described.

Table 3

Dynamic Ordinary-Least-Squares Regression of Ten-Year Term Premium, January 1985 to June 2008

	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	-2.288***	0.388	-2.351***	0.425	-1.879***	0.355
Cyclical factors						
Unemployment gap	0.222***	0.062	0.219***	0.063	0.283***	0.071
Core CPI	0.302***	0.065	0.281***	0.063	0.502***	0.067
Uncertainty						
Inflation disagreement	0.458**	0.173	0.454*	0.180	0.292	0.152
Realized volatility	0.822***	0.221	0.901***	0.229	0.867**	0.296
Supply						
Unadjusted	0.042***	0.008	—	—	—	—
Duration-adjusted	—	—	0.062***	0.014	—	—
Long-run properties						
Adjustment parameter[a]	-0.154***	0.03	-0.151***	0.024	-0.116***	0.021
ADF test on cointegration error[b]	-6.051***		-5.957***		-3.441**	
Number of observations	282		280		282	

Source: Authors' calculations.

Note: Newey-West standard errors with twelve lags.

[a]Estimated by regressing the change in the term premium on the contemporaneous change in each explanatory variable and on the lagged level of the cointegration error.

[b]Null hypothesis: no cointegrating relationship. Critical values are from Ericsson and MacKinnon (1999).

***Statistically significant at the 1 percent level.

**Statistically significant at the 5 percent level.

*Statistically significant at the 10 percent level.

term premium from this long-run relationship is referred to as the cointegration error. Regressing the change in the term premium on the contemporaneous change in the explanatory variables and on the lagged level of the cointegration error allows us to estimate the long-run adjustment speed of the cointegrating relationship and to test the significance of the cointegrating relationship.

The first two columns of Table 3 present results from the DOLS model, again estimated over the period January 1985 to June 2008. The long-run effects of changes in the longer term debt stock are almost identical to those obtained in Table 2. Specifically, an increase in longer term debt equal to 1 percent of GDP increases the term premium by slightly more than 4 basis points in the unadjusted specification and by slightly more than 6 basis points in the duration-adjusted specification. The adjustment speed parameters of -0.15 imply that deviations in the term premium from long-run equilibrium have a half-life of roughly five months. The *t*-statistics on the adjustment speeds are -5.7 and -6.3, which are sufficiently large to reject the hypothesis that these variables do not have a stable long-run relationship (that is, they are not cointegrated) at the 1 percent significance level. Note that the adjustment speed drops substantially when the debt stock variables are excluded (the final columns), suggesting that the longer term debt stock is an important part of the long-run relationship.

The preceding regressions are based on the Kim-Wright model of the ten-year term premium, which was estimated over a sample that does not include a major financial crisis or monetary policy constrained by the zero bound on nominal interest rates. As a robustness check, we also estimate a specification that uses the ten-year Treasury yield as the dependent variable and that includes the target federal funds rate and the slope of the near-term Eurodollar futures curve to proxy for the expected path of policy rates.[53] If we assume that the two additional variables adequately control for expected future policy interest rates, the estimated coefficients on the other variables should continue to reveal their impact on the ten-year term premium. Note that another reason for focusing directly on the behavior of the ten-year yield is that the ultimate goal of LSAPs is to lower

[53] Specifically, we use the difference between the implied rates on Eurodollar futures contracts settling approximately two years and one year ahead.

longer term private borrowing rates, many of which are highly correlated with ten-year Treasury yields. As the first and third columns of Table 4 show, the estimated longer term debt supply effects are somewhat higher in this specification than in the term premium regressions. The estimated coefficients of 0.07 and 0.10 on the unadjusted and duration-adjusted debt stocks imply that LSAPs have reduced the ten-year term premium by 82 basis points (unadjusted model) or 58 basis points (duration-adjusted model).[54]

Table 5 summarizes the estimated coefficients on longer term debt stock across our specifications while Table 6 lists the implied effects of the Federal Reserve's asset purchases

Table 4
Ordinary-Least-Squares Regression of Ten-Year Treasury Yield, December 1986 to June 2008

	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	0.297	0.432	0.103	0.443	-0.013	0.513
Rate expectations						
Target fed funds	0.403***	0.114	0.424***	0.118	0.742***	0.114
Eurodollar slope	0.477*	0.214	0.478*	0.225	0.602*	0.273
Cyclical factors						
Unemployment gap	0.127	0.208	0.172	0.210	0.784***	0.198
Core CPI	0.378**	0.125	0.342**	0.131	0.163	0.157
Uncertainty						
Inflation disagreement	0.210	0.165	0.215	0.170	0.111	0.187
Realized volatility	1.057***	0.25	1.145***	0.27	1.340***	0.31
Supply						
Unadjusted	0.069***	0.014	—	—	—	—
Duration-adjusted	—	—	0.098***	0.023	—	—
Adjusted R^2	0.92		0.91		0.88	
Standard error of regression	0.45		0.46		0.53	
Number of observations	259		259		259	

Source: Authors' calculations.

Note: Newey-West standard errors with twelve lags.

***Statistically significant at the 1 percent level.
**Statistically significant at the 5 percent level.
*Statistically significant at the 10 percent level.

Table 5
Effect of 1-Percent-of-GDP Increase in Long-Term Debt on Ten-Year Term Premium
Basis points

	Ordinary-Least-Squares Term Premium Model	Dynamic Ordinary-Least-Squares Term Premium Model[a]	Yield-Level Model
Unadjusted	4.4	4.2	6.9
Duration-adjusted	6.4	6.2	9.8

Source: Authors' calculations.

[a]Long-run effect.

Table 6
Total Effect of Large-Scale Asset Purchases on Ten-Year Term Premium
Basis points

	Ordinary-Least-Squares Term Premium Model	Dynamic Ordinary-Least-Squares Term Premium Model[a]	Yield-Level Model
Unadjusted	52	50	82
95 percent CI	31-74	31-69	50-115
Duration-adjusted	38	36	58
95 percent CI	22-54	20-53	31-84

Source: Authors' calculations.

[a]Long-run effect.

on the ten-year term premium. Our results suggest that the $1.725 trillion in announced purchases reduced the ten-year term premium by between 38 and 82 basis points. This range of point forecasts overlaps considerably with that obtained in our event study, which is impressive given that entirely separate data and methodologies were used to obtain the results.[55]

5. Conclusion

With policy interest rates in many countries constrained by the zero bound, and with short-term interest rates in Japan having been near zero for more than a decade, expansion of the monetary policy toolkit is an important objective. In this paper, we examine lessons from the experience of the Federal Reserve since late 2008 with one of the key policy tools available at the zero bound—large-scale purchases of longer term assets.

By reducing the net supply of assets with long duration, the Federal Reserve's LSAP programs appear to have succeeded in reducing the term premium. The overall size of the reduction in the ten-year term premium associated with LSAPs through March 2010 appears to be somewhere between 30 and 100 basis points, with most estimates in the lower and middle thirds of this range. In addition to reducing the term premium, the LSAP programs had an even more powerful effect on longer term interest rates on agency debt and agency MBS by improving market liquidity and removing assets with high prepayment risk from private portfolios.

Based on this evidence, we conclude that the Federal Reserve's LSAP programs did lower longer term private borrowing rates, which should stimulate economic activity. While the effects are especially noticeable in the mortgage market, they appear to be widespread, extending, for example, to the markets for Treasury securities, corporate bonds, and interest rate swaps. That conclusion is promising, as it means that monetary policy remains potent even after the zero bound is reached. To be sure, achieving this further stimulus was not without its challenges, as it required a sizable expansion of the Federal Reserve's balance sheet, and the purchase of such a large volume of securities in a relatively short time frame required the surmounting of operational hurdles. However, by restoring functioning to the mortgage market and lowering the term premium, the programs provided considerable benefits.

Even though the LSAPs appear to have been successful, it is worth reflecting on their structure and considering whether the approach taken was optimal. The LSAPs, as implemented, were discrete in nature, in that the broad characteristics of the programs were set in two decisions upfront (in November 2008 and March 2009). The remainder of the programs involved carrying out those decisions, with little responsiveness to changes in the economic or financial outlook.

By stating a specific amount and a timetable for LSAPs upfront, the FOMC appeared to commit itself to a future course of action. This commitment was softened somewhat by the use of the phrase "up to" before the specified purchase amounts. However, market participants generally indicated that they expected the full amounts to be purchased, and in the later stages of the programs the FOMC made it clear that close to the full amounts would be purchased. Policymakers often prefer not to make strong commitments on future policies because there is always a chance that future economic conditions will call for a different policy stance than expected. Policymakers may want to assess the benefits of this element of commitment relative to an approach that instead allows greater responsiveness to economic and financial conditions. Bullard (2009) lays out the theoretical case for a policy rule for LSAPs analogous to conventional policy rules for interest rates, but he shows that the practical issues in designing such a rule are substantial, particularly in light of the limited historical experience of economies operating near the zero bound on nominal interest rates.[56] Indeed, further study of both the theoretical and empirical issues raised by LSAPs would be helpful in order to assess whether they can be employed even more effectively in the future.

[54] Using a longer sample and somewhat different specification, Greenwood and Vayanos (2010) also find a statistically significant effect of bond supply on the bond yields. They regress the spread of the five-year Treasury yield to the one-year Treasury yield and the spread of the twenty-year yield to the one-year yield on the ratio of Treasury securities with maturities greater than ten years to total Treasury securities. They do not subtract SOMA or TIC holdings. Over the period 1952-2005, they find that a one percentage point increase in the share of Treasury securities with maturities above ten years increases the five-year yield spread 4 basis points and the twenty-year yield spread 8 basis points.

[55] The event-study range is somewhat higher than the time-series range. This difference may reflect the possibility that LSAP effects are larger when financial conditions are strained. Alternatively, it is possible that the effect of maturity supply on bond yields is nonlinear, so that large reductions in net supply have a proportionally larger (or smaller) effect on yields. The LSAP programs constituted a large shift in maturity supply by historical standards.

[56] An alternative strategy, proposed by Bernanke (2002), is to use unlimited purchases to target near-zero yields on Treasury securities with successively longer maturities, starting with one-year securities. This strategy entails a completely elastic response of LSAPs to interest rates on the targeted securities, but leaves open the question of how to relate the choice of targeted maturities to economic conditions.

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