Recent Developments in Federal Reserve System Liquidity and Reserve Operations

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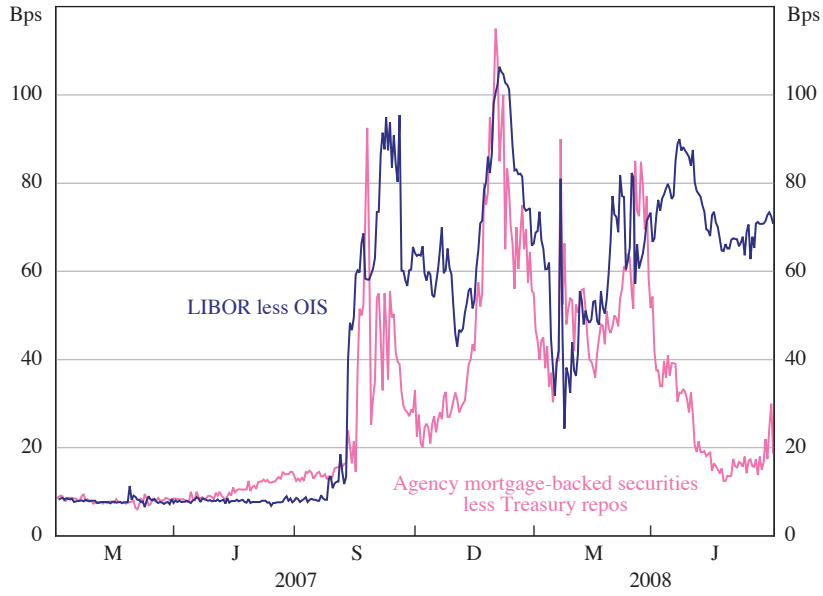
1. Introduction

In August 2007, a deteriorating US housing sector and increasing uncertainty about the value of sub-prime mortgages and other securitised assets triggered a sudden and dramatic increase in funding pressures on commercial banks. These pressures were clearly evident in elevated rates in bank term unsecured borrowing markets that emerged at that time (Figure 1). Dislocations in these bank term funding markets spilled over into the overnight interbank funding market as well. Financial strains persisted and spread, and in mid March 2008 growing concerns about the financial condition of a large US investment bank threatened to undermine the ability of financial institutions to finance a wide range of even some high-quality assets in markets for repurchase agreements (repos).

Figure 1: 3-month Rate Spreads



Sources: Bloomberg; Federal Reserve Bank of New York

1. Reserve Bank of New York, 33 Liberty Street, New York, NY 10045. The views expressed in this paper are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

The Federal Reserve System undertook a series of monetary policy actions to help address macroeconomic risks to the economy, including those linked to financial market strains. From September 2007 to April 2008, the Federal Open Market Committee (FOMC) reduced the target for the nominal overnight federal funds rate by 325 basis points. Alongside these monetary policy actions, the Federal Reserve undertook a series of initiatives aimed at improving market liquidity and overall market function. These arrangements allowed financial intermediaries to finance with the Federal Reserve, assets they could no longer finance as easily in the markets.

This paper reviews the impact that these new liquidity facilities and associated financial market strains had on the balance sheet of the Federal Reserve and on reserve operations over the period August 2007 through June 2008. It presents a comprehensive view of the implementation of monetary policy and the management of the balance sheet during this period, one that focuses on operational considerations and challenges. The paper is organised as follows. Section 2 outlines the features of the operating framework used to implement monetary policy that are most critical for understanding the responses and the challenges faced in managing liquidity since August 2007. Section 3 reviews the structure of new liquidity activities introduced since that time through June 2008, and examines their impact on reserve operations. Section 4 discusses the challenges faced in meeting the operating objective for the implementation of monetary policy – the overnight federal funds rate. Section 5 concludes with a discussion of some of the issues the Federal Reserve System will confront regarding liquidity and reserve operations going forward.

2. Monetary Policy Implementation Framework and Procedures

The current institutional framework and the operating practices used by the Federal Reserve System to implement monetary policy are outlined in this section.[2] Components of the overall framework most critical for understanding the design of recent liquidity facilities and the operational challenges that the Federal Reserve has faced since August 2007 are highlighted.

2.1 Key elements of the current operating framework

2.1.1 Operating objective

The stance of US monetary policy is set by the FOMC in the form of an operating objective for open market operations. After each of its meetings, the FOMC issues

2. Detailed descriptions of the components of this operating framework are available from numerous sources, including various official Federal Reserve publications available on the websites of the Board of Governors (<http://www.federalreserve.gov/>) and the Federal Reserve Bank of New York (<http://www.newyorkfed.org/>). However, few integrated descriptions of the framework and operating procedures are available. One of the most comprehensive presentations can be found in Board of Governors of the Federal Reserve System (2005).

a directive stating the operating objective to the Trading Desk (Desk) at the Federal Reserve Bank of New York (FRBNY), which the FOMC authorises to conduct open market operations for the System Open Market Account (SOMA).[3] For many years the operating objective has been a target for the federal funds rate, the overnight interest rate paid by commercial banks and other depository institutions operating in the United States on their unsecured borrowings from other banks and select entities.[4] The minutes from the FOMC meeting of April 2008 read in part:

> To further its long-run objectives, the Committee in the immediate future seeks conditions in reserve markets consistent with reducing the federal funds rate to an average of around 2 percent. (FOMC 2008)

To keep the federal funds rate around its target, the Desk uses open market operations to align the supply of balances held by depository institutions at Federal Reserve Banks (reserves) with estimates of demand.[5] The Desk's regular operating procedures are described below in Section 2.3, and how these procedures help to maintain the funds rate around the target is discussed in Section 4. Data on overnight transactions in this market are collected by the Desk from brokers who arrange most of the trades between larger banks, and these data are used to track how effectively this operating objective is met.

2.1.2 Reserve requirements and contractual clearing balance obligations

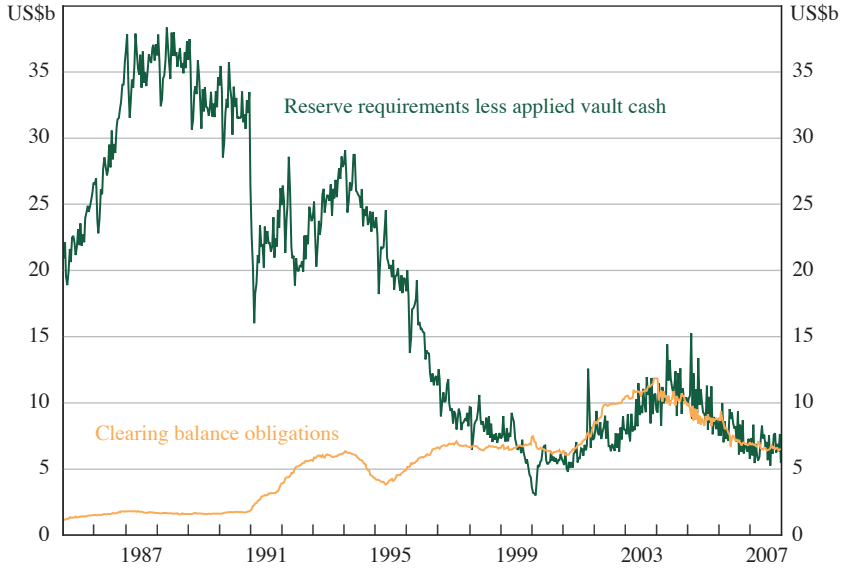
Depository institutions are subject to reserve requirements assessed against their deposit liabilities. Only a narrow set of transaction deposits within the M1 monetary aggregate currently has a positive requirement. Reserve requirements must be satisfied every two-week reserve maintenance period in one of two ways: with cash held on a bank's premises or with balances held on deposit in an account at a district Federal Reserve Bank.[6] Federal Reserve Banks are not currently authorised to pay interest

3. The FRBNY manages SOMA on behalf of the Federal Reserve System. SOMA assets are allocated among, and reported on, the financial statements of the Federal Reserve Banks. Discount window loans are Federal Reserve Bank assets and not part of SOMA. Some decisions involve one or more entities within the Federal Reserve System: the Board of Governors, the individual Federal Reserve Banks, the FRBNY (transacting on behalf of SOMA) and/or the FOMC. These distinctions are important for understanding the structure of, and roles of, various entities comprising the Federal Reserve System. For the purposes of this paper and to facilitate readability, this discussion dispenses with these distinctions for the most part, and simply refers to the Federal Reserve or Federal Reserve System.
4. These borrowings are differentiated from the deposit liabilities of banks by being exempt from reserve requirements.
5. The term 'reserves' is used in a colloquial sense in this paper to refer to all balances held by depository institutions in their accounts at Federal Reserve Banks, whether used to satisfy reserve requirements, clearing balance obligations or held as excess reserves. As used in this paper, the term does not include banks' holdings of vault cash used to satisfy reserve requirements.
6. Some smaller depository institutions have a weekly maintenance period. Reserve requirements and the portion that is satisfied with cash holdings (vault cash) are calculated before the start of each reserve maintenance period.

on the balances held to satisfy reserve requirements. A bank may also contract with its district Federal Reserve Bank to have a clearing balance obligation, whereby the bank agrees to hold a specified level of balances in its Federal Reserve Bank account (Fed account), on average over a reserve maintenance period. A bank earns income credits on balances held to satisfy these obligations, at a rate linked to short-term market rates. But such income credits may only be used to offset charges for certain services offered by Federal Reserve Banks, thereby limiting their value.[7] Penalties apply if a bank has not accumulated enough balances over a two-week maintenance period to meet its reserve requirements and clearing balance obligations, or if it ends any day overdrawn in its Fed account.[8]

Binding requirements in the monetary policy implementation framework provide a basis for estimating reserve demand, and the ability of a bank to meet its requirements over a maintenance period on an average basis makes daily demand for reserves more elastic. However, aggregate total requirements to hold balances in a Fed account – reserve requirements less the portion satisfied with vault cash (called required reserve balances) plus clearing balance obligations – are relatively low by past historical measures (Figure 2). Required reserve balances fell dramatically in the 1990s as banks developed 'retail sweep programs' in order to evade these

Figure 2: Requirements to Hold Reserve Balances
Bi-weekly maintenance period values



Source: Federal Reserve Bank of New York

7. These charges include, for example, fees charged to banks by the Federal Reserve for use of its cheque-clearing services.

8. Banks have limited 'carryover privileges' from one maintenance period to the next for purposes of meeting their reserve requirements, and a clearing balance obligation may be satisfied within a narrow band.

requirements because they earn no interest.[9] Moreover, many large banks operating in the United States have a low level of reserve requirements because they have a relatively small base of transaction deposit liabilities, and few incur enough Federal Reserve service charges to warrant having a significant clearing balance obligation. As a result, aggregate total requirements provide limited protection against potential aggregate daily shocks to reserve supply, and many individual banks active in the interbank market have indicated that their total requirements are low when measured against the uncertainties they face every day about their payments flows.

2.1.3 Standing facilities[10]

Banks that are in sound financial condition can borrow directly from their local Federal Reserve Bank through the primary credit facility (PCF) which is one of the regular discount window programs of the Federal Reserve Banks. From its inception to August 2007, loans were extended only for short terms, typically overnight, and the rate was set 100 basis points above the federal funds target.[11] As a general rule, a bank will utilise the PCF rather than incur the penalties associated with ending a day overdrawn in its Fed account or falling short of meeting its requirements at the conclusion of a maintenance period. However, individual banks have been observed paying rates in the market above the PCF rate, which is evidence of the stigma associated with PCF borrowing. Even so, the availability of PCF credit at a fixed rate helps limit the upward pressure that can develop on the overnight federal funds rate. Federal Reserve Banks do not pay interest on excess reserves, so no corresponding facility is available to help set a floor on market rates.

2.1.4 Eligible assets and counterparties for monetary policy operations

The *Federal Reserve Act* (FRA) limits the types of assets that the Federal Reserve may acquire through open market operations. In practice, these operations have been limited to transactions in US Government securities: Treasury debt and debt issued or fully guaranteed by US federal agencies, which includes agency mortgage-backed securities (agency MBS). Other types of securities eligible under the FRA would not support particularly large or variable open market operations. Counterparties to open market operations are the 'primary dealers' designated by the Desk. These institutions are active dealers in the government securities market, and they routinely finance large inventories of government securities through repo agreements in the market each day. In recent years, few primary dealers have been banks, although many have been part of a larger holding company that has included a banking organisation.

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9. Also, reserve requirement ratios were cut in 1990 and 1992.
10. Use of the term 'standing facility' simply means that the facility is always available on pre-set terms, and it should not be read as suggesting that the Federal Reserve Bank extending credit does not have the discretion to decline to extend credit to the requesting institution.
11. The PCF was established in 2003 to replace the adjustment credit facility, which was administered differently although it served a similar general function.

Individual Federal Reserve Banks may extend loans on a collateralised basis to depository institutions through discount window facilities under terms and conditions set by the Board of Governors. The PCF is such a facility. Under the FRA, a wide variety of assets may be pledged as collateral against discount window loans, including government and private-sector securities, mortgages and consumer and commercial loans.[12] In addition, under the FRA, in unusual and exigent circumstances, the Board of Governors may authorise Federal Reserve Banks to lend to non-depository institutions.[13] Such loans must be secured to the satisfaction of the lending Reserve Bank.

2.2 Historical composition of the domestic portfolio

The composition of the Federal Reserve System balance sheet on the eve of the onset of the financial market turmoil in August 2007 is representative of its structure for much of recent history to that point (Table 1). The total size of the portfolio of domestic financial assets held by the Federal Reserve mirrors the net value of autonomous factors on the balance sheet (liabilities less assets) and reserve balances. By far the single largest of these autonomous factors is Federal Reserve banknote liabilities. By comparison, the net value of all the other factors is very small.[14]

Assets acquired over the years through open market operations are divided between repos against government securities and outright holdings of US Treasury debt.[15] The split between these two asset categories has been a function of historical volatility and uncertainty in autonomous factor movements, such as seasonal swings

Table 1: Balance Sheet of the Federal Reserve System
8 August 2007, US$ billion[(a)]

Assets		Liabilities and capital	
Treasury securities	791	Reserve balances of banks	12
of which – bills	*277*	Federal Reserve banknotes	777
Conventional repos	19	Treasury deposits	5
PCF loans	0	Other liabilities and capital	75
Other assets	59		
Total assets	**869**	**Total liabilities and capital**	**869**

(a) All values are averages for the week ended 8 August 2007 except the following: total assets, total liabilities and capital, and Federal Reserve banknotes, which are values as of 8 August 2007; and other assets and other liabilities and capital, which are calculated as a residual item for assets and liabilities and capital, respectively.

Source: Board of Governors of the Federal Reserve System, Federal Reserve Statistical Release: H.4.1

12. Asset types currently accepted at the discount window are listed in Table 2.
13. This authority is found in Section 13(3) of the FRA.
14. Autonomous factors on the Federal Reserve's balance sheet that are the most difficult to predict on a daily basis include deposits of the US Treasury, the Federal Reserve Bank float, and overnight reverse repos offered as a short-term US dollar investment facility to foreign central banks with an account relationship with the FRBNY.
15. The repos arranged by the Desk are reserve-adding operations.

in demand for Federal Reserve notes around major holidays, and reserve demand. In determining the appropriate size of total outright holdings, an objective has been to avoid a need for frequent temporary downward adjustments to outright holdings. This goal has been met largely by maintaining a layer of repos in the portfolio which acts as a shock absorber, adjusted up or down as needed in response to temporary movements in autonomous factors or reserve demands. Otherwise, outright holdings of Treasury securities generally have been preferred on the basis of their comparative safety, various operational considerations and a preference for limiting direct extensions of central bank credit to private market participants where not necessary.

Over time, most of the steady expansion of the portfolio of assets has been in outright holdings of Treasury securities and has been driven by a need to match growth in Federal Reserve banknote liabilities. An expansion of outright holdings is typically achieved by making direct purchases in the secondary market; the level of outright holdings can then be maintained by exchanging maturing holdings for newly issued Treasury debt at primary auctions.[16] Reverse repos can be arranged in the market as needed to reduce reserve supply for temporary periods, but historically these operations have been infrequent.

The repos outstanding typically contain a mix of shorter-term maturities, which in recent years have ranged from overnight to 14 days, but occasionally longer. Historically, outright holdings of Treasury securities as a share of total available market supply have been disproportionately weighted towards bills – discount instruments with maturities of under one year.[17] This structure was designed to provide liquidity in the event that a large-scale reduction in the portfolio was needed. Holdings of coupon securities have historically tended to be spread across the yield curve in proportions roughly corresponding to total outstanding Treasury issuance.

2.3 Traditional operating practices

The Desk's approach for achieving its operating objective is predicated on the view that a 'neutral' supply of reserves – that is, a cumulative level provided over an entire maintenance period that allows all banks to meet their reserve requirements and clearing balance obligations with minimal levels of excess reserves – ordinarily is needed to maintain the overnight federal funds rate around its target.[18] How this

16. Historically the Desk has also purchased Treasury securities directly from foreign central banks that have an account with the FRBNY. The Federal Reserve cannot increase its holdings of Treasury debt at primary auctions.

17. As at the end of 2006, the Federal Reserve held 18 per cent of all marketable Treasury debt outstanding, but this included 36 per cent of all Treasury bills outstanding.

18. Historically, smaller-sized depository institutions that do not have access to funding markets have demanded some level of excess reserves each day, as a source of liquidity to guard against reserve-draining shocks. As a group, these smaller institutions have typically held between US$1½ billion and US$2 billion of reserves in excess of their requirements. This 'frictional' demand of smaller banks has largely proven to be insensitive to both daily trading conditions in the funds market and to the level of the funds target. The Desk must take account of this source of reserve demand in its daily calculations of reserve supply needed to maintain the funds rate around the target.

approach helps foster this outcome is explored in more detail in Section 4. Because requirements and maintenance period rules provide banks scope to hold varying daily levels of reserves within a maintenance period, so long as requirements are met by the end of the period, the daily distribution of this neutral cumulative level of reserve supply can be of secondary importance. But in the US case, the overnight funds rate has proven to be sensitive to daily reserve supply patterns, because total requirements are low relative to the volatility and uncertainty surrounding even daily movements in factors affecting reserve supply. For this reason, the Desk must evaluate reserve supply and demand conditions closely every morning.[19] Marginal daily changes to reserve levels are most commonly made by adjusting up or down the level of short-term repos outstanding, mostly using overnight operations, and the Desk typically intervenes in the morning when the repo market is most active.[20]

Rates on all the Desk's open market operations with primary dealers are determined by auction and are not directly tied to any official policy rate.[21] In practice, when it arranges its repos, the Desk collects bids from dealers in three distinct collateral buckets (called collateral 'tranches') for Treasury securities, agency debt and agency MBS.[22] The rates on bids in different collateral tranches are normalised by subtracting from each bid rate a reference repo rate for the corresponding collateral type that is based on a survey of market rates performed by the Desk each morning. Each of the primary dealers designates one of two clearing banks, JPMorgan Chase or Bank of New York Mellon, as its correspondent bank for the purposes of cash and collateral management for the Desk's repos. Collateral held by the Federal Reserve against outstanding repos is maintained in securities accounts at the clearing banks operating under tri-party service agreements.[23]

The Desk also makes available to the primary dealers a portion of the Treasury securities that it holds in its portfolio by extending overnight loans of individual issues. The Desk offers to the dealers the opportunity to participate in securities lending auctions every day for specific Treasury issues, and dealers may participate at their discretion. These securities loans can help increase the market supply of individual issues that may be temporarily in high demand, thereby supporting the functioning of the Treasury market. Dealers must pledge other Treasury securities of their choosing as collateral on these loans, so these operations have no reserve impact.

19. Unlike many other central banks, the Federal Reserve does not publish its daily forecasts of reserves or autonomous factors.

20. The Desk rarely intervenes later in the day because of the absence of any additional definitive information about reserve factors and due to reduced liquidity in the repo market.

21. These operations are arranged over a proprietary electronic auction platform that links the Desk to the primary dealers.

22. For accepted propositions in the agency tranche, dealers also have the option to deliver Treasury collateral; and for the agency MBS tranche, dealers have the option to deliver either Treasury or agency debt.

23. The Desk first adopted tri-party collateral arrangements for its repos in 1999.

3. New Federal Reserve Liquidity-providing Facilities

In response to widespread financial market strains that emerged in August 2007, the Federal Reserve established several entirely new facilities to provide liquidity and made several important modifications to existing facilities and operations. This section begins with a listing of these new and revised facilities and activities, noting their critical and distinctive features. It ends with a review of how these new facilities have altered the balance sheet of the Federal Reserve and were coordinated with other reserve management operations.

3.1 Development of new liquidity arrangements

Key liquidity innovations are listed below according to when they were first announced to the public. In some instances, new initiatives were coordinated with measures taken by other central banks to address related financial pressures in their jurisdictions.

- **On 17 August 2007**, the Board of Governors announced temporary changes to the PCF. It cut in half the spread between the PCF rate and the target federal funds rate, from its previous 100 basis points to 50 basis points. It also allowed for term loans of up to 30 days, renewable by the borrower. The rate spread was reduced further to 25 basis points and term loans extended to up to 90 days on 16 March 2008.
- **On 12 December 2007**, the Board of Governors approved the establishment of the term auction facility (TAF), providing for auctions of term loans to depository institutions. The first such auction was scheduled for 17 December, and in general, auctions of 28-day term loans through this discount window facility were to be arranged on a bi-weekly basis. Initial auction sizes were US$20 billion, but these were gradually increased in subsequent months.

  Also on 12 December, the FOMC announced the establishment of temporary reciprocal currency arrangements (swap lines) with the European Central Bank (ECB) and the Swiss National Bank (SNB), to provide US dollars in amounts of up to US$20 billion and US$4 billion to the ECB and SNB, respectively, for a period of up to six months, for lending to depository institutions in their jurisdictions. On 11 March 2008, the FOMC increased these swap lines and extended their term. In general, the lending of these funds by the ECB and SNB was linked to TAF auctions held by the Federal Reserve.
- **On 7 March 2008**, the Federal Reserve announced it would initiate a series of 28-day term repo transactions, expected to cumulate eventually to as much as US$100 billion. On all accepted propositions, dealers could freely submit any type of collateral eligible for the Desk's conventional repos – Treasury, agency debt, or agency MBS. It was expected that most collateral actually delivered on these single-tranche repos would be agency MBS, because financing rates in the market for this collateral are normally higher than rates for the other eligible collateral types.

- **On 11 March 2008**, the Federal Reserve announced an expansion of its securities lending program with the creation of the term securities lending facility (TSLF). Under the TSLF the Fed would lend up to US$200 billion (par values) of Treasury securities in its portfolio to the primary dealers, secured for a term of 28 days by a pledge of other securities, including collateral eligible on open market operations (OMO) and top-rated private-label MBS. Weekly auctions began on 27 March. Subsequent adjustments were made to the pool of eligible collateral.
- **On 16 March 2008**, the Board of Governors announced it had authorised the Federal Reserve Bank of New York to create the primary dealer credit facility (PDCF), for a period of at least six months, to provide overnight loans to the primary dealers against a broad range of investment-grade securities. The PDCF rate was set equal to the PCF rate, with additional back-end fees tied to the frequency of use.

  The establishment of the PDCF was preceded by a decision on 14 March to extend an overnight loan to JPMorgan Chase, so that JPMorgan Chase could in turn lend that money to Bear Stearns. Also on 16 March, the FRBNY, with the Board's approval, agreed in principle to provide up to US$30 billion in financing to facilitate JPMorgan's purchase of Bear Stearns, with terms and the structure of the financing to be finalised later.

These initiatives were aimed at improving market liquidity and functioning in ways that the Federal Reserve's normal liquidity operations could not, by allowing financial intermediaries, some of whom lacked discount window access on a routine basis, to finance assets with the Federal Reserve which they could no longer finance as easily in the markets. In this way these liquidity facilities could reduce the need for those institutions to take the types of actions which could amplify market pressures, such as selling other assets into distressed markets or withdrawing credit lines extended to other financial institutions.

Although all these various innovations were aimed at addressing turmoil in financial markets, they were structured differently from one another in terms of counterparties, eligible collateral for lending, whether they operated as discretionary or standing facilities, in their collateral management and other operational mechanisms, and in their statutory basis. Some key structural differences between four of these facilities are highlighted in Table 2.[24] In establishing these new lending facilities, key features of the infrastructure for existing operations and lending activities were used, to facilitate their rapid and effective deployment. The TAF was established under existing discount window authority for lending to depository institutions, and it adopted the same collateral conventions and administrative arrangements in place for PCF and other discount window programs. But entirely new auction procedures involving a potentially large number of banking institutions and all 12 district Federal Reserve Banks had to be developed. The single-tranche term repos involved a very minor tweaking of conventional repo operations. The TSLF built on the existing securities lending arrangements that have been available to

24. More detailed descriptions of these programs and their functioning can be found at 'Understanding the Recent Changes to Federal Reserve Liquidity Provision' (<http://www.newyorkfed.org/markets/Understanding_Fed_Lending.html>) and on related links on the public website of the FRBNY.

Table 2: Summary Features of Select Liquidity Facilities[(a)]

	PCF	TAF	TSLF	PDCF
Counterparties	Depository institutions	Depository institutions	Primary dealers	Primary dealers
Credit allocation	Standing facility for overnight and term loans	Discretionary auctions of 28-day term loans	Discretionary auctions of 28-day term loans of Treasury securities	Standing facility for overnight loans
Eligible collateral	Discount window collateral, including: broad range of AAA-rated debt securities; OMO-eligible collateral; money market instruments; foreign government securities; foreign-denominated corporate and municipal securities; and residential real estate, commercial, and consumer loans.		Initially, AAA/Aaa-rated private-label residential MBS and OMO-eligible collateral. Later expanded to include more AAA/Aaa-rated ABS.	Broad range of investment-grade debt securities
Collateral management	Loans are extended against pools of collateral maintained by Federal Reserve Banks		Collateral is held in accounts at tri-party service agents	
Comments	Rate reduced to 50 bps over target funds rate then to 25 bps over target funds rate. Loan terms extended to 30 days then to 90 days	ECB and SNB lent US dollars acquired through currency swaps on similar terms	Reserve neutral	Same rate as PCF, with back-end fees tied to frequency of use

(a) Summary features are intended to be general descriptions; exceptions may apply.
Source: Federal Reserve Bank of New York

the primary dealers for many years, including use of the same electronic auction platform used by the Desk to arrange conventional open market operations with the dealers and existing securities lending legal agreements between the FRBNY and the primary dealers, which have had some slight modifications. But it required developing new tri-party settlement arrangements between the Desk, the primary dealers and the two clearing banks to manage the collateral exchange and to include new collateral types not accepted under the Desk's tri-party repos.[25] For the PDCF, new tri-party settlement arrangements were also established for securing loans, and

25. Securities loaned and received as collateral under the ordinary securities lending program do not utilise tri-party collateral arrangements.

new procedures were developed for dealers to communicate loan requests through their clearing bank to the FRBNY discount window.[26]

3.2 Reserve management and portfolio implications of new liquidity arrangements

3.2.1 Reserve neutrality and asset maturity

The large scale on which these new liquidity facilities were deployed had equally sizable implications for the structure of the portfolio of financial assets on the balance sheet of the Federal Reserve and for open market operations. Throughout this period, with one notable exception discussed in Section 4, the Desk adhered to its standard operating practice of providing a level of reserves consistent with requirements in each maintenance period. There is little evidence that maintenance period demand for excess reserves changed in any significant way as a result of developments in broader financial markets, nor does the level of total requirements seem to have been substantially impacted. Furthermore, underlying levels of autonomous factors, such as banknotes in circulation, were largely unaffected. Consequently, the cumulative build-up in TAF loans outstanding, swap lines drawn down by the ECB and SNB, the expansion of single-tranche repos, and greater use of standing facilities (PDCF and the PCF) were offset largely via a reduction in the stock of Treasury securities held outright in the portfolio. Conventional three-tranche repos were adjusted as needed to facilitate daily reserve management and to bridge gaps between periods of growing use of new liquidity facilities and reductions in outright holdings of Treasury securities. Temporary reserve-draining reverse repos were seldom used. Thus, all these new liquidity arrangements involved a comparable increase in the supply of Treasury securities broadly held by investors, at least implicitly, even if these increases were achieved through separate operations. The TSLF, by design, was reserve neutral and required no offsetting operations to sterilise any reserve effects. But this facility did place a claim on Treasury securities in the portfolio and increased the available supply of these securities in the market as a direct result of its operation.[27]

The maturity structures chosen for the new liquidity operations reflected a balance of considerations, foremost being a desire to influence conditions in term funding

26. Credit extended through the PDCF takes the form of repos, but in this paper these extensions will be described as loans.

27. The means by which the increased supply of Treasury securities was distributed across investors in the market varied depending on the type of operation used to reduce Treasury holdings in the portfolio. For outright sales, primary dealers would have been the initial holders of increased Treasury securities. For redemptions that the Treasury offset by issuing more securities to the public, again most of the increased supply would initially have been held by the primary dealers who are the largest bidders at primary auctions. However, in both these cases the dealers would then have been free to distribute these securities to their customers. In contrast, with the TSLF the Treasury securities lent to the primary dealers had to remain within the dealer's tri-party clearing bank, and so they remained on the balance sheet of the borrowing dealer who could then use them as collateral to borrow in the tri-party repo market.

markets where stress was most apparent. But collateral and risk management implications for the Federal Reserve also influenced the maturity choice. It was believed that a program's effectiveness as a backup source of liquidity in term markets would be derived not just from the maturity of the operations themselves, but also from the commitment to maintain a facility for as long as needed. As the offset to most new liquidity operations was a reduction in outright holdings of Treasury securities that carried various maturities, a change in the maturity structure of the assets in the portfolio was not itself the principal objective. Instead, these liquidity innovations relied for their effectiveness primarily on a shift in collateral and counterparties for Federal Reserve extensions of credit.

3.2.2 Open market operations and reserve uncertainty

From their historical peak of US$791 billion, between August 2007 and June 2008 outright holdings by the Federal Reserve of Treasury securities fell by nearly US$300 billion, with much of that decline concentrated after mid March.[28] Most of this reduction, US$159 billion, was achieved by redeeming holdings of Treasury bills when they matured rather than replacing them with newly issued debt at primary auctions.[29] But the size and timing of maturing holdings did not always align with portfolio needs.[30] For this reason, and given other objectives for the composition of outright holdings, the Desk also sold US$89 billion of Treasury bills and US$55 billion of Treasury coupon securities outright in the market. These constituted the first outright sales of Treasury securities from the portfolio since the years 1989–1991, when the Federal Reserve was intervening in foreign exchange markets to purchase foreign-denominated assets, and the first sales ever of coupon securities in the market. At the same time, an additional US$200 billion of Treasury holdings was earmarked for possible lending through the TSLF, making these securities unavailable for other purposes.[31] Altogether, the level of unencumbered outright holdings of Treasury securities fell some US$500 billion from August 2007 to June 2008, to a level of roughly US$300 billion, and holdings of bills were nearly exhausted (Table 3 and Figure 3).[32]

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28. All references to Treasury holdings in this paper are for par values unless otherwise indicated.

29. In August 2007, US$3 billion of maturing Treasury coupon securities in the portfolio were redeemed, for reasons having to do with portfolio limits on holdings of individual securities and unrelated to financial market turmoil.

30. And logistically, the lag between when a portfolio decision is made and when the reserve effect is felt is longer in the case of redemptions than for outright sales of Treasury securities.

31. At their peak during this period, the par value of Treasury securities lent under the TSLF was US$159 billion. For its tri-party collateral arrangements, the Desk has the flexibility to substitute daily the specific Treasury securities it lends through the TSLF on outstanding term agreements.

32. The level of unencumbered outright holdings was actually somewhat smaller than this. About US$40 billion of Treasury securities must be set aside every day to collateralise overnight reverse repos arranged between the FRBNY and foreign central banks that maintain US dollar holdings at the FRBNY. Moreover, the Desk preserves some holdings of more recently auctioned Treasury coupon securities so that they will be available to loan through its regular securities lending program to meet potentially high demand.

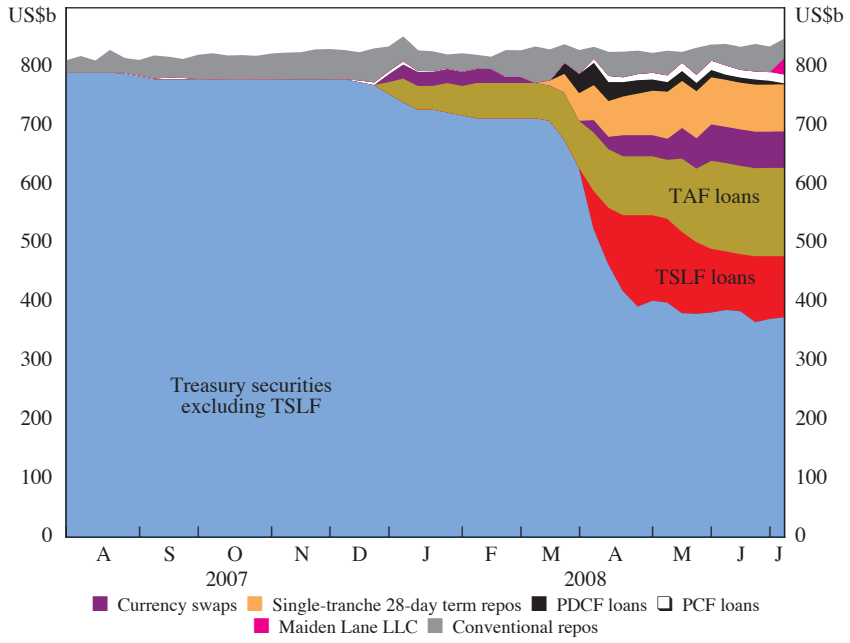
Table 3: Balance Sheet of the Federal Reserve System
2 July 2008, US$ billion[(a)]

Assets		Liabilities and capital	
Treasury securities	479	Reserve balances of banks	21
of which – bills	*22*	Federal Reserve banknotes	795
– sent through the TSLF	*104*	Treasury deposits	5
Conventional repos	30	Other liabilities & capital	85
Single-tranche 28-day term repos	80		
TAF loans	150		
Currency swaps	62		
PDCF loans	2		
PCF loans	15		
Maiden Lane LLC	29		
Other assets	59		
Total assets	**906**	**Total liabilities & capital**	**906**

(a) All values are averages for the week ended 2 July 2008 except the following: total assets, total liabilities and capital, and Federal Reserve banknotes, which are values as of 2 July 2008; and other assets and other liabilities and capital, which are calculated as a residual item for assets and liabilities and capital, respectively.

Source: Board of Governors of the Federal Reserve System, Federal Reserve Statistical Release: H.4.1

Figure 3: Federal Reserve Domestic Financial Assets
Weekly averages



Sources: Board of Governors of the Federal Reserve System, Federal Reserve Statistical Release: H.4.1; Federal Reserve Bank of New York

Although the need to reduce outright holdings was large and concentrated in a relatively short timeframe, planning for the necessary open market operations was facilitated by the fact that many of the new lending operations – TAF auctions, currency swaps, single-tranche repos – were discretionary activities with pre-set amounts. Each operation was planned some time in advance and each had some delay between its auction and settlement dates, and the TSLF was reserve neutral by design. As a result, on no day was the Desk unable to arrange the level of open market operations necessary to provide the level of reserves it estimated was required to achieve the operating objective for the overnight federal funds rate. But the PDCF and revamped PCF are standing facilities that require no advance notification and have no settlement lag, and term PCF loans may also be extinguished early at the borrower's initiative without penalty. This feature of these facilities did make daily estimates of reserve supply more uncertain and presented a challenge to daily reserve management, which is described in Section 4. At their peak, PDCF loans and term loans extended through the PCF were well below amounts that were extended through the other new liquidity facilities, but the PDCF and PCF carry a contingent reserve exposure that would be difficult to anticipate and potentially large.[33]

4. Challenges Meeting the Operating Objective

This section describes how the operating framework and the Desk's daily procedures help to maintain the overnight federal funds rate around its target as well as the normal daily rate dynamics in this market. Challenges meeting the operating objective and in daily reserve management since August 2007 are also presented.

4.1 Federal funds rate control and rate behaviours under normal conditions

The daily operating procedures described in Section 2.3 are aimed at maintaining the overnight federal funds rate around its target. Under this framework, if reserve balances for the maintenance period are too far above requirements, then lenders will push rates down as far as the rate paid on excess reserves (0 per cent). Similarly, if balances are not sufficient to allow banks to meet their total requirements for the maintenance period or to avoid overdrafts at the end of any day, then borrowers will bid up market rates to the level of the PCF rate (or higher where there is a stigma associated with PCF borrowing). However, maintaining the overnight rate around a level in between those two extremes rests primarily on the ability to shape the interest rate expectations of participants operating in this market.

33. The maximum weekly average level of PDCF borrowing during this period was US$38 billion. The maximum weekly average level of all PCF credit outstanding since August 2007 was US$16 billion.

For an individual bank that has not yet accumulated enough reserves to meet all its requirements in the maintenance period that is underway, a decision whether to borrow or lend in the federal funds market on the current day, rather than wait until a day later in the same period to adjust its reserve position, will depend importantly on its expectations for rates on later days in the period relative to current market rates.[34] Through this mechanism, expectations for rates later in the maintenance period can strongly influence current rates, so long as banks retain sufficient scope for deferring or accelerating their accumulation of reserves in the period for meeting their requirements. While empirical studies have found that historically there have been persistent unexplained patterns to daily average federal funds rates by day in the maintenance period cycle – which suggest that a pure 'martingale' process for determining current market rates does not hold in the US case – future rate expectations undoubtedly are an important determinant of current rates.[35]

To maintain market rates around the policy objective, central banks with frameworks similar to the current Federal Reserve structure – featuring reserve requirements, multi-day maintenance periods, and standing facilities at which banks can borrow or lend with the central bank – ensure as best they can that expectations for rates on future days in the maintenance period are around the target rate. Often this involves setting the rates on standing facilities in a symmetric fashion around the policy objective and using discretionary operations to provide an expected level of reserves consistent with the maintenance period requirements. With the probabilities that banks will experience either a reserve deficiency or surplus over the maintenance period being roughly equal, and the costs associated with these outcomes symmetric around the policy rate, in a competitive market expected future rates should align with the policy objective.

The Desk's standard approach has been to aim to provide a level of reserves that at the end of each maintenance period is close to requirements (allowing for those frictional sources of excess demand). But given that banks have no opportunity to earn interest on any excess reserves they might hold, the cost of holding excess reserves is generally greater than that associated with being deficient, which according to the preceding description of rate determination should impart some

34. In the US case, banks have limited or no scope for either altering the level of reserve balances they must hold to meet their requirements (remunerated or not) or for adjusting their reserve positions via participation in open market operations with the central bank at established rates. Adjusting their reserve position in the market at a future date is the only alternative to doing so in the market on the current day. These alternative options are features of operating frameworks of other central banks; the rates associated with their use can also influence current market rates.

35. A fact demonstrated by the many instances when widely-held expectations that the funds rate target would be changed mid-period strongly influenced rates in days ahead of the expected policy switch.

downward bias in rates relative to the operating target.[36] A factor that may help maintain rate expectations more closely around the target is the Desk's daily fine-tuning of reserve supply, and its demonstrated willingness to respond to deviations in the rate from the target by adjusting daily reserve supply in a way that ultimately induces rate movements in the other direction.[37] This behaviour helps ensure that the balance of risks for future rates is centred around the target level, which can in turn influence current rates.

Historically there have been distinct intraday rate patterns in the US market.[38] The funds rate normally exhibits very low volatility from the time trading begins in the morning until late-afternoon. Most intraday volatility in the rate is observed late in the trading session, especially in the last hour or so, after payment flows involving transactions of banks' customers are completed and banks are making final adjustments to their reserve balances. At this point in the day, very abrupt and erratic rate movements can occur when individual banks are faced with the possibility of ending overdrawn or accumulating unwanted excess levels for the period. But even on days when aggregate reserve supply ultimately has proven to be sufficiently low or high relative to requirements so as to induce sharp rate movements, rate volatility has generally been confined to trading very late in the session.

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36. A more formal representation for the market rate expected for the maintenance period settlement date is:

    $E(r_{settlement\ day}) = E(D)*r^d + E(X)*r^x$, where:

    $E(r_{settlement\ day})$ is the level of the funds rate expected to prevail on the maintenance period settlement day;

    r^d is the primary credit discount rate;

    r^x is the rate paid on excess reserves;

    $E(D)$ represents the expected likelihood that final reserve levels will be below the point at which all requirements are just met (the 'neutral' level of reserves); and

    $E(X)$ represents the expected likelihood that final reserve levels will be above requirements.

    In operating systems with a symmetric interest rate corridor around the desired market rate, and in which the central bank aims to provide enough reserves for all banks to meet requirements with minimal excess reserves, and where reserve shocks are symmetric (that is, $E(D) = E(X) = 50$ per cent), the expected market rate on the settlement day should be the policy rate. But with this formulation, in the US case, where r^x is 0 and r^d is above but generally closer to the target, the expected rate would be below the target rate.

37. However, it is not generally possible to control with any precision the extent of the eventual rate response to these daily adjustments to reserve supply, and so the potential for substantial overshooting of rates is high.

38. A discussion of intraday rate behaviours and volatility in the overnight federal funds market is found in Bartolini *et al* (2005).

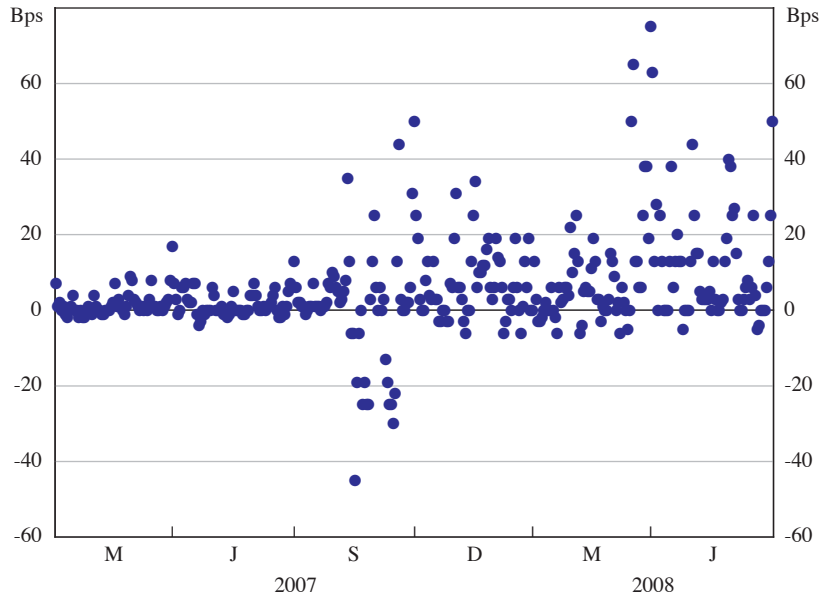
4.2 Challenges since August 2007

4.2.1 Sources of pressure on overnight rates

The period since August 2007 has been marked by a dramatic increase in the volatility of the overnight federal funds rate. While most of this volatility has remained confined to trading late in the session, there has been a significant rise in volatility earlier in the day as well.

As trading activity in unsecured term funding markets contracted, both borrowing and lending banks turned to overnight markets to meet more of their funding and investments needs, but the effects were not equally felt. The daily funding uncertainties that banks with structural deficiencies faced dominated, and the overnight funds rate frequently traded with a strong premium, particularly in early trading hours (Figure 4). Several factors contributed to this pattern. As a group, European-based institutions operating through US affiliates or directly in European markets are structurally short US dollars. Their demand for funding early in the trading session can be inelastic both because they wish to meet a significant portion of their daily needs while home markets remain open and because they may lack deep trading lines with some US regional banking institutions that are important providers of market liquidity later in the trading session. Moreover, because many of these US affiliates have low requirements, their reserve management flexibility is further limited. The resulting upward pressure on funding rates was even more dramatic

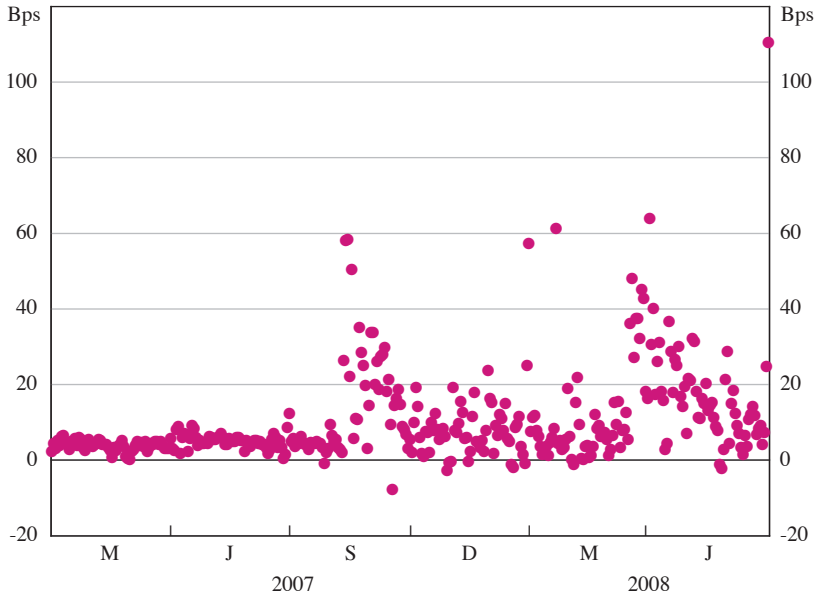
Figure 4: Overnight Federal Funds Rate Spread
Indicative morning rate less FOMC target rate



Source: Federal Reserve Bank of New York

in the closely-linked overnight market for eurodollars in Europe ahead of trading in the federal funds market (Figure 5).

Figure 5: Overnight LIBOR less Morning Federal Funds Rate



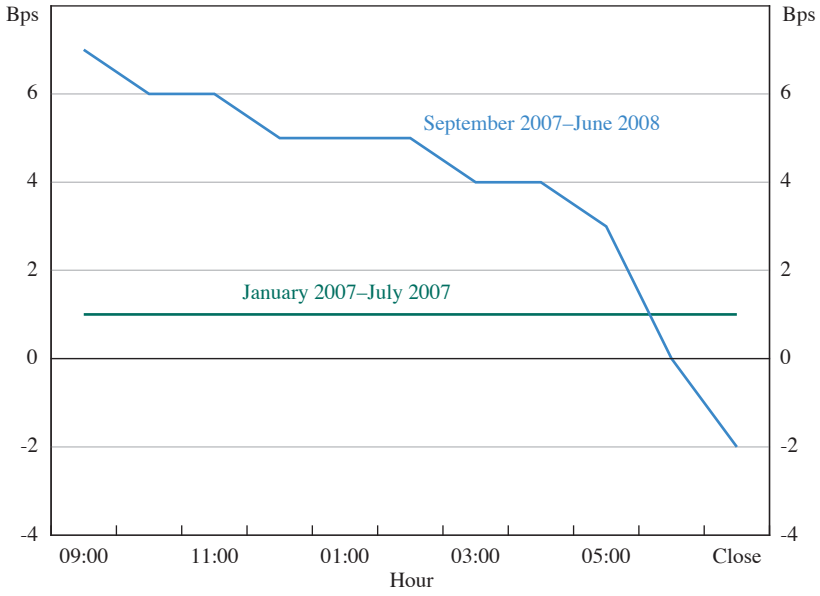
Sources: Bloomberg; Federal Reserve Bank of New York

At the same time, institutions with surplus funds were not willing to lend these funds despite these upward rate pressures, even when reasonably certain that lower rates would dominate later in the day. Many were constrained in their ability to expand their balance sheet to take advantage of favourable rates, and they faced heightened uncertainties about their own funding requirements and payment flows. Available evidence also suggests that the stigma associated with use of the discount window (PCF) increased amidst the financial market turmoil, which made borrowers and lenders alike more cautious in preserving liquidity intraday. Concerns about the credit risk of borrowers appeared to be a lesser cause of the new rate patterns seen in the overnight federal funds market, and there is little evidence that banks sought to hold higher levels of reserve balances at the end of each day in any systematic way.

4.2.2 Desk responses

The factors just described contributed to a recurring intraday pattern with rates close to the target in the morning and then drifting down later in the trading session (Figure 6). This pattern was most pronounced on days when trading flows were seasonally high and uncertain, for example around the end of the month. However, Desk efforts to ensure that rates remained around the target 'on average', over time if not each day, added to intraday rate volatility.

Figure 6: Intraday Cumulative Federal Funds Rates

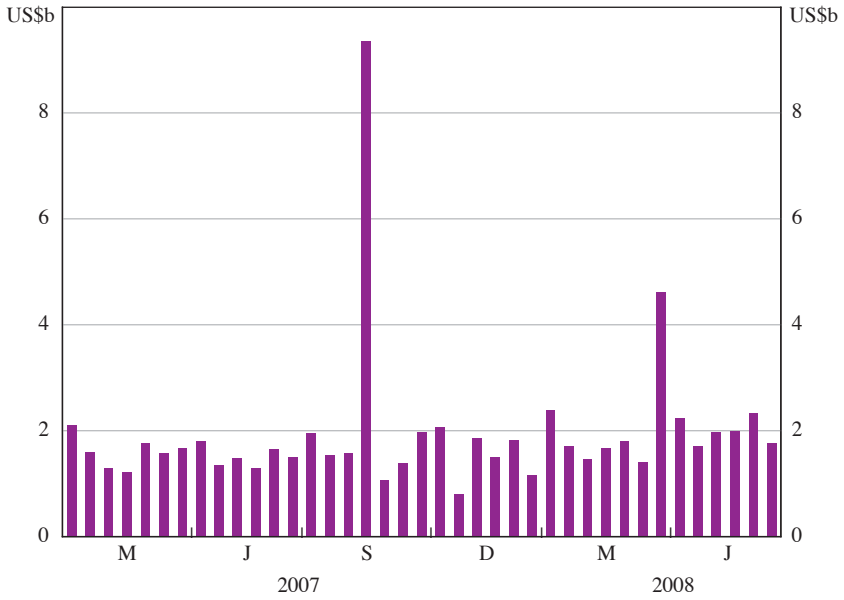


Notes: Hourly cumulative average overnight federal funds rate less target rate of transactions brokered by ICAP. Data from September 2007 to June 2008 begin on 19 September 2007 and end on 1 June 2008 and exclude 31 December 2007.
Source: ICAP

In the two-week reserve maintenance period ending 15 August, underway when financial market stresses first appeared in the US overnight funding market on 9 August, the Desk responded extremely aggressively, so that by the next day the accumulated level of reserves far exceeded the amount needed for all banks to meet their remaining period requirements, and it operated outside of its normal intervention timeframe to stress its commitment to combat upward rate pressures. For the remainder of that period the average funds rate was very low, with some late-day trading occurring at rates near zero. Subsequently, while the Desk aimed to provide a more neutral level of reserves with respect to maintenance period requirements, for several maintenance periods it remained particularly responsive to bouts of upward rate pressure in its daily reserve provisions. As a result, the overnight funds rate was on average below the target for a period of several weeks. More generally since August 2007, the Desk has resisted alternating bouts of high and low rates by leaving either unusually elevated or low daily reserve levels with much greater frequency than before. Even so, with the exception of the 15 August maintenance period, period average levels of reserves provided were generally close to levels of requirements and normal frictional levels of excess demand (Figure 7).

For the most part, the operations of the new discretionary liquidity facilities created by the Federal Reserve did not have a direct impact on the behaviour of the overnight rate. But the standing facilities, both the PDCF for the dealers and term loans under

Figure 7: Average Excess Reserves during the Maintenance Period
Bi-weekly



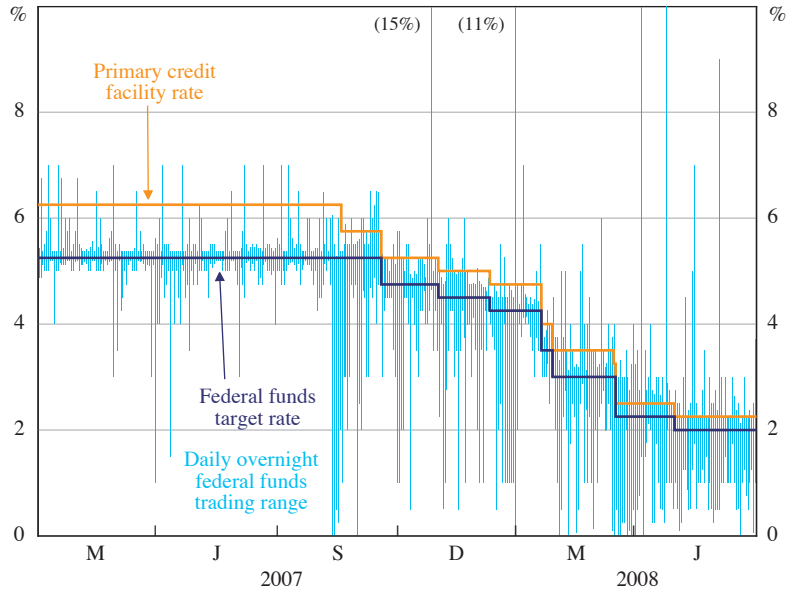
Source: Federal Reserve Bank of New York

the PCF for banks, complicated daily reserve management because reserve supply forthcoming from these facilities was uncertain. Managing daily reserve supply and the funds rate required making projections of both overnight PDCF borrowing and changes to the level of term PCF loans outstanding. On occasion large over-estimates or under-estimates of daily borrowing levels did occur.[39]

The volatility in rates stemming from all the above factors was exacerbated both by the absence of any floor on market rates, given excess reserves are not remunerated, and by the stigma associated with using the discount window. Daily trading ranges show a sharp increase in the incidence of extreme values both above and below the target rate. This volatility reflected both the increased frequency with which the Desk engineered either high or low daily balances to counter rate pressures, as well as the structure of the standing facilities (Figure 8). Nonetheless, despite the elevated levels of intraday and interday rate volatility, the overnight rate – when averaged over longer periods of time – generally was around the target (Figure 9).

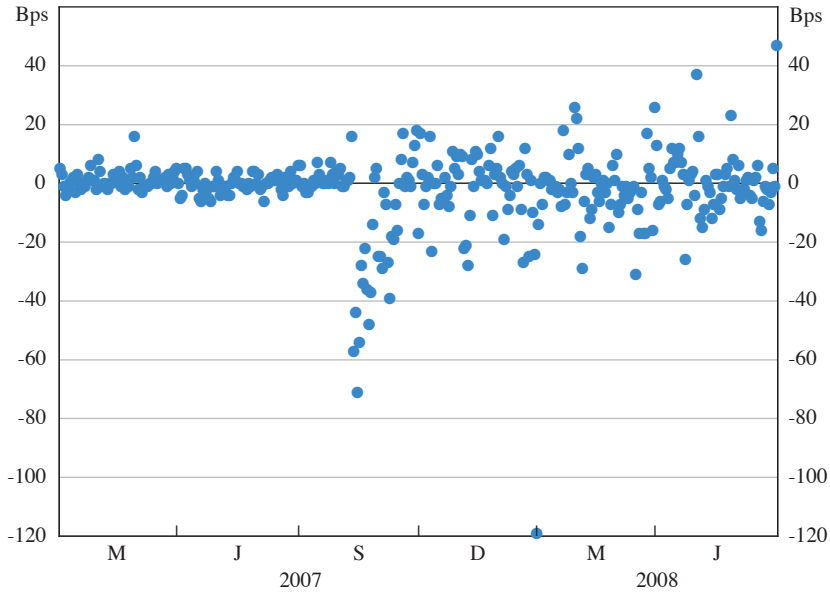
39. Unlike reasons for borrowing at the PCF pre-August 2007, borrowing at the PDCF and term borrowing under the modified PCF were not usually associated with a shortfall of aggregate reserve supply, nor were they influenced by current conditions in the overnight federal funds market. Desk reserve projections and operations were contingent on estimates for this borrowing, just as they always are on estimates for autonomous factors.

Figure 8: Federal Funds and Primary Credit Facility Rates



Source: Federal Reserve Bank of New York

Figure 9: Daily Average Overnight Federal Funds Rate less Target Rate



Source: Federal Reserve Bank of New York

5. Future Considerations

Experiences with reserve operations since the onset of financial market turmoil highlight several important issues regarding the management of the balance sheet. These include: how a significant further expansion of credit on the Federal Reserve balance sheet could be offset or accommodated if it were needed, the ultimate disposition of the new liquidity facilities and their coordination with conventional reserve operations, and the composition of the portfolio of assets held by the Federal Reserve in a new steady state. Financial market conditions have not returned to their pre-August 2007 state, and lessons from the use of new liquidity innovations are still being absorbed, so only some general observations can be offered at this time. The *Financial Services Regulatory Relief Act of 2006* amended the FRA to provide explicit authority to pay interest on all balances held by depository institutions at the Federal Reserve, beginning in October 2011. That authority could have an important influence on possible outcomes.

The fact that the Federal Reserve had accumulated a substantial portfolio of outright holdings of Treasury securities on its balance sheet as of mid 2007 enabled it to fully fund the expansion of the new liquidity facilities in the manner that it did, and the availability of those holdings influenced the design of some of the new liquidity facilities in important ways. Despite the presence of a still large unused pool of Treasury holdings as of June 2008, experience since August 2007 shows that even larger expansions of credit by the Federal Reserve through non-traditional facilities must be viewed as a possibility, however unlikely. Moreover, as a general operating principle, a central bank may not wish for its ability to address financial market strains through its extension of credit to be impeded by the size of its existing portfolio or other balance sheet constraints.

Other central banks have used various methods to support or offset a large expansion of assets on their balance sheets, albeit under different circumstances, and their use could be explored by the Federal Reserve. In some instances, the fiscal authority has increased its issuance of debt to the public, and placed the additional funds raised in its deposit account at the central bank in an amount corresponding to the expansion of assets on the central bank's balance sheet. Alternatively, some central banks have issued their own marketable debt in considerable amounts to sterilise the reserve effects of an expansion of assets. Either approach would raise important policy questions, would require close coordination with the fiscal authority's debt management, and involve new operating practices. Further options for supporting a sustained expansion of the balance sheet become possible with payment of interest on reserves. With that authority, several mechanisms could be devised to insulate market rates from the effects of a large increase in reserve supply, such as would occur with a significant expansion of central bank credit, even if left unsterilised.

Most of the new liquidity facilities introduced since August 2007, when first announced, were described as being temporary programs. Two facilities, the TSLF and the PDCF, were established under provisions of the FRA which require 'unusual and exigent circumstances' for their lending. An eventual phase-out of any of the new liquidity facilities will entail making judgments about the absence or

persistence of the market conditions that gave rise to their creation, but for which few objective measures may be available. Use of the facilities themselves may offer some guidance, although for standing facilities in particular (and even for the new discretionary auction facilities which serve as market backstops), actual use may not always be a reliable measure of underlying market risks.

Policy-makers could explore the possibility of maintaining some of these facilities in a more permanent state, either in their present form or with structural modifications, with corresponding changes to the regulatory and supervisory environment as may be necessary. In the case of the TAF, the possibility of a permanent facility was recognised in the initial announcement, which reads: 'Experience gained under this temporary program will be helpful in assessing the potential usefulness of augmenting the Federal Reserve's current monetary policy tools … with a permanent facility for auctioning term discount window credit'.[40] If made permanent, such a program could take several forms. For example, it could be an off-the-shelf option that is employed only when market conditions warrant or it could be employed from time to time on a planned basis to maintain operational readiness.

Maintaining a large volume of TAF loans outstanding on a permanent basis might not provide any further ability to address market stress than simply having a facility that is small under normal conditions, but which would be expanded significantly when needed. Having regular TAF auctions that are large but fixed in size could serve as a liquidity backstop for individual banks, even ones that did not regularly fund themselves in this way. However, in the absence of a substantial increase in auction amounts, such a facility might be much less effective in addressing periods of general market stress that affect a wide range of financial institutions simultaneously. Maintaining a large volume of TAF loans on a permanent basis would introduce additional collateral and counterparty risk management issues for the central bank. It could also foster reliance by banks on direct central bank credit which is unnecessary in normal periods.

Any winding-down of new liquidity facilities will need to be coordinated with operations to re-stock conventional assets in the portfolio. In the past, the need to expand outright holdings has been driven mainly by growth in banknotes outstanding, which even during years of peak growth was fairly gradual. The largest volume of secondary market purchases in any one year was US$61 billion, made in 2001.[41] An expansion of outright holdings to offset a large and rapid decline in lending through new liquidity facilities would be without precedent.

The composition of the assets traditionally held in the portfolio – outright holdings of Treasury securities and repos against Treasury and agency debt – could be reviewed based on experiences gained managing the portfolio since August 2007. Those experiences have underscored the importance of maintaining a very liquid

40. Board of Governors of the Federal Reserve System (2007).

41. This figure only includes purchases made outright in the secondary market and does not include purchases made directly with foreign central banks. A large portion of the purchases in 2001 offset redemptions that were made to conform to portfolio limits on holdings of individual issues. The largest net expansion in outright holdings in any one year was US$51 billion in 2004.

portfolio, that is, one which can be reduced on a large scale within short timeframes with minimum disruption to the markets in which the central bank operates. Either maintaining a much higher level of repos in the portfolio or holding an even greater share of outright holdings in the form of shorter-term Treasury bills could add to portfolio liquidity, although other portfolio or operational considerations could also influence this composition. Alternatively, operating regimes that become feasible with authority to pay interest on reserves, or a more developed capacity to create liabilities on the balance sheet on a large scale, could affect the minimum liquidity requirements for the Federal Reserve's portfolio.

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