
THE PRE-CRISIS MONETARY POLICY IMPLEMENTATION FRAMEWORK

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OVERVIEW

- Before the 2007-09 financial crisis, the Fed's operating framework for monetary policy reflected a banking system in which the scarcity of reserves meant that small changes in reserves would affect fed funds rates.
- The authors assess the framework and find that it met the Fed's monetary policy objectives by keeping rates close to target but had certain negative effects on financial market functioning and employed operating procedures that were rather opaque and inefficient.
- During the crisis, the Fed boosted reserves in a bid to foster economic recovery, and this increase necessitated changes in how the Fed conducts monetary policy. The new approach has also controlled rates well since the crisis, suggesting that alternate frameworks can be effective.

The Federal Reserve's (the Fed's) operating framework for monetary policy changed during the financial crisis of 2007-09. This change occurred because the Fed implemented an accommodative monetary policy to facilitate economic recovery from the crisis by substantially increasing the amount of reserves in the banking system and by reducing interest rates to close to zero (Bech and Klee 2011). By comparison, in the pre-crisis period the supply of reserves was relatively scarce. The aim of this article is to assess the Fed's monetary policy framework prior to the crisis in order to better understand the changes in the implementation of monetary policy since the crisis.

A monetary policy framework is a means of implementing a central bank's monetary policy (Bindseil 2004). Such a framework consists of an operational target and an operating framework for achieving the target. The Fed's statutory mandate in conducting monetary policy is to promote price stability consistent with full employment.¹ To implement this mandate, the Federal Open Market Committee (FOMC) sets a target for the overnight rate in the federal funds market, where banks trade reserve balances ("reserves"), which are deposits held by banks at the Fed.² Changes in the federal

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The views expressed in this article are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System. To view the authors' disclosure statements, visit https://www.newyorkfed.org/research/epr/2018/epr_2018_pre-crisis-framework_sarkar.

funds rate are, in turn, expected to be transmitted to other interest rates and, ultimately, to the real economy. The pre-crisis operational framework consisted of monetary policy instruments (mainly the conduct of open market operations, or OMOs) and procedures for using these instruments to encourage banks to trade fed funds near the stated target rate. The New York Fed's Open Market Trading Desk ("the Desk") carried out OMOs on a daily basis to keep the overnight fed funds rate close to its target.

The fed funds market represents the market for bank reserves. Fluctuations in the fed funds rate reflect changes in the demand for and supply of reserves. Prior to the crisis, the demand for reserves arose mainly from banks' need to meet uncertain intraday payment flows, after satisfying minimum reserve requirements. Because no interest was paid on reserves, banks wished to minimize their reserve holdings. The aggregate demand for reserves was sensitive to interest rates since reserves were scarce—the Fed supplied only a small amount of reserves in excess of what banks were required to hold in the aggregate. The daily variation in the supply of reserves was mainly determined by so-called autonomous factors (such as currency in circulation) outside the direct control of the Fed. Therefore, the Desk's job was to forecast the evolution of the autonomous factors and the demand for reserves and, on an ex ante basis, supply enough reserves to keep the market for reserve balances in equilibrium. The aggregate amount of reserves was distributed to individual banks through the fed funds market.

In this article, we show that during the pre-crisis period the Desk was generally successful in achieving its primary objective of meeting the fed funds target. Overnight rates were generally close to the target fed funds rate, even during periods of relatively high liquidity demand. Further, when the fed funds rate, on occasion, deviated from its target (such as at the end of quarters), it reverted to the target within a day or two. Finally, changes in the fed funds rate were quickly transmitted to other overnight money market rates.

In addition to the primary objective of controlling its operational target, a central bank might consider other criteria to evaluate the effectiveness of its operational framework: efficiency (that is, meeting objectives with as few resources as possible), transparency (that is, operating in a manner well understood by market participants), universality (that is, being able to implement monetary policy under a range of economic conditions), and the promotion of financial stability (that is, ensuring that the operational framework does not impair market functioning).³

While the pre-crisis monetary policy framework was successful in meeting its monetary objectives, the associated operational procedures were complex and opaque. The operational framework relied on a discretionary and interventionist approach (Logan 2017) based on daily management of the supply of reserves that required detailed market intelligence and expert judgment (Bernanke 2005). The Desk had to provide daily forecasts of reserve demand and supply over multiple days, and to conduct repurchase ("repo") or reverse repo operations almost daily. Reserve demand was difficult to forecast daily, and even predictable changes required OMOs on most days (Logan 2017). Forecasting the autonomous factors that caused daily variations in the supply of reserves was also challenging. Liquidity management in such a framework appears more complex than in a "symmetric corridor system" with standing deposit and lending facilities, as operated by some other central banks.⁴ The system also lacked transparency, since the Fed, unlike other central banks, did not publish its forecast of autonomous factors (Hilton 2008). Regarding universality, the pre-crisis operational framework faced difficulties in the post-crisis environment when demand for reserves became highly

volatile (Hilton 2008). Also, supplying reserves to meet forecasted demand became impractical post-crisis, when the amount of reserves in the banking system exceeded demand for reserves by a wide margin.

Turning to the goal of not impairing financial market functioning, we first focus on the functioning of payment systems. In particular, in the pre-crisis period the Fed routinely extended large amounts of (sometimes unsecured) intraday credit to banks to meet payment system demands, for a fee. Since banks needed these funds for only a few hours a day, they did not find it cost effective to borrow overnight in the fed funds market. While these “daylight overdrafts” were necessary to facilitate payments, they also exposed the Fed to the potential for loss. For the banks, the need to avoid overdrafts and meet reserve requirements, combined with the lack of interest payments on reserves, implied that their cash management system was rather costly (Logan 2017).

The Fed affected financial markets in two other areas prior to the crisis: asset eligibility criteria for OMOs and money market functioning. Assets that were eligible for purchase by the Desk, including repo operations, might benefit from enhanced liquidity and the ability to obtain central bank credit, compared with ineligible assets. Since the Fed accepts only highly liquid assets in its OMOs, including Treasury and agency securities, any distortionary effects on asset prices were likely minimized. Regarding money market functioning, the scarcity of reserve balances prior to the crisis (relative to the required and precautionary demand for reserves) resulted in large trading volumes in the fed funds market because, toward the end of the trading day, banks with surplus reserves had an incentive to trade with banks with too few reserves. While it is unclear whether an active fed funds market should be a goal of a monetary policy framework, the market activity likely facilitated both rate discovery (that is, the determination of an equilibrium rate through trading) and the quick transmission of the target rate to related money markets.

The article is organized as follows. Section 1 discusses the basic economic premise underlying the pre-crisis framework, and then describes how rate determination in actuality deviated substantively from the textbook example. Section 2 details how the framework was implemented in practice, and includes a description of the role of the reserve maintenance period. We discuss the effectiveness of the framework in meeting the primary monetary policy objectives in Section 3 and evaluate how well the framework met the objectives of operational effectiveness and financial stability in Section 4. Section 5 concludes with a brief summary and remarks on some aspects of the pre-crisis framework that have changed since the crisis.

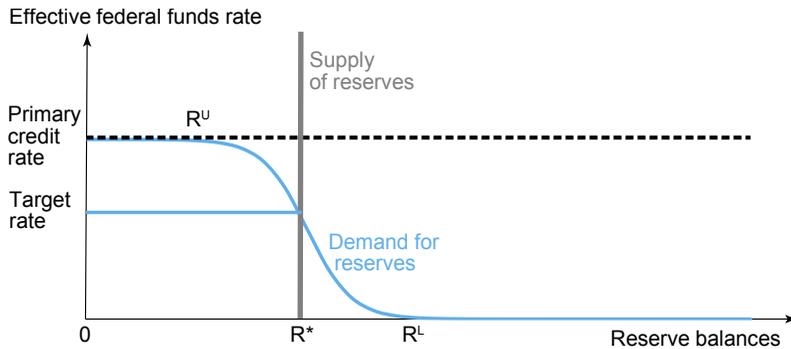
1. THE ECONOMICS OF THE PRE-CRISIS MONETARY POLICY OPERATING FRAMEWORK

In this section, we discuss the economic foundation of the monetary policy operating framework in terms of the demand for and supply of reserves. We show that the pre-crisis monetary regime can be viewed as managing the supply of reserves so that equilibrium is maintained on the steeper, relatively inelastic portion of the demand curve for reserves. However, we further note how the actual framework deviated significantly from this idealized model.

The aggregate demand for reserves is plotted in Chart 1, with the horizontal axis representing the total reserve balances of banks and the vertical axis representing the effective federal

CHART 1

The Market for Reserves



funds rate (EFFR), calculated as a volume-weighted average rate of each business day's fed funds transactions.⁵ A target EFFR was the Fed's primary monetary policy tool prior to the crisis. In the fed funds market, banks traded reserves with each other on an unsecured basis, typically with an overnight tenor. The supply of fed funds was determined exogenously (from the point of view of market participants) by the Federal Reserve, which, through OMOs, targeted a specific amount of reserves, R^* , on a daily basis in order to meet the Desk's forecast of reserve demand.

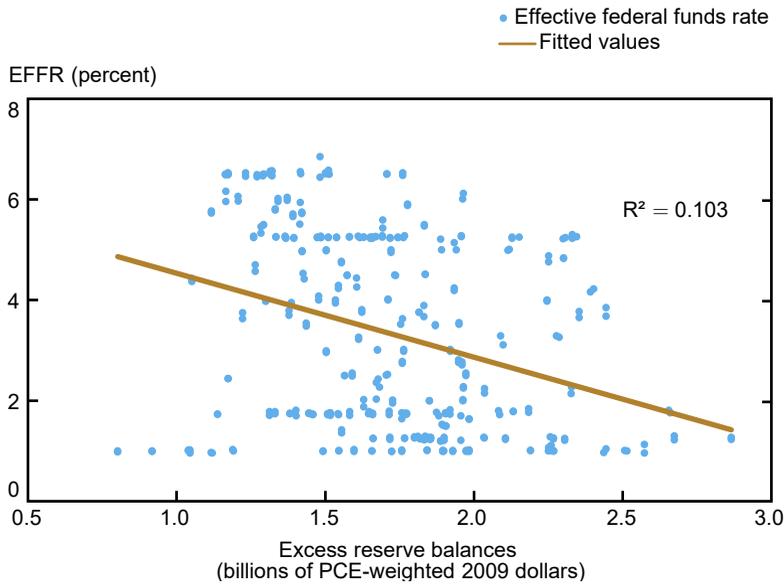
The demand for reserves is downward sloping, reflecting the opportunity cost of holding reserves, except at the ceiling, R^U , and the floor, R^L , of the EFFR, where it is flat (Keister, Martin, and McAndrews 2008). Reserve requirements necessitated that banks hold minimum reserve balances on average (as a percentage of their net transaction accounts) in their accounts with Federal Reserve Banks. However, because of the uncertainty of payment flows, banks could not meet their requirements exactly. In deciding how much additional reserves to hold, banks had to balance the income forgone from holding excess reserves against the cost of borrowing fed funds at the EFFR. Higher levels of the EFFR increase the opportunity costs of holding reserves and reduce the demand for reserves.

The demand for reserves is flat at the lower and upper bounds of the EFFR. The lower bound for the EFFR was zero because banks had no incentive to lend reserves at a negative rate, since they could earn zero interest by simply keeping reserves in their Fed account. At R^L , where the demand curve intersects the horizontal axis, banks hold sufficient reserves to meet all possible payment needs. Thus, banks are indifferent to holding any reserves to the right of R^L because the opportunity cost of holding reserves is zero. Since the discount window's primary credit facility is an alternative to the fed funds market as a source of reserves for financially sound banks with adequate collateral,⁶ the primary credit rate (which exceeds the target rate) acts as the upper bound above which banks would not borrow in the fed funds market.⁷ When the EFFR equals the primary credit rate, banks are indifferent between holding reserves and borrowing at the discount window, and so the demand curve is flat to the left of R^U .

Before the crisis, the Federal Reserve carried out monetary policy by operating in the downward sloping region of the demand curve for reserves. This implies that the Fed raised rates by draining reserves (decreasing supply) and lowered rates by adding reserves (increasing supply) to the system. Empirically, in a simple plot of the effective federal funds rate against excess

CHART 2

The Empirical Relationship between Excess Reserve Balances and the EFFF: 2000-07



Sources: Federal Reserve Bank of St. Louis; authors' calculations.

Notes: The chart shows maintenance period averages from January 1, 2000, through July 1, 2007. Periods with exceptionally high reserve balances, such as around September 11, 2001, have been excluded. PCE is personal consumption expenditures.

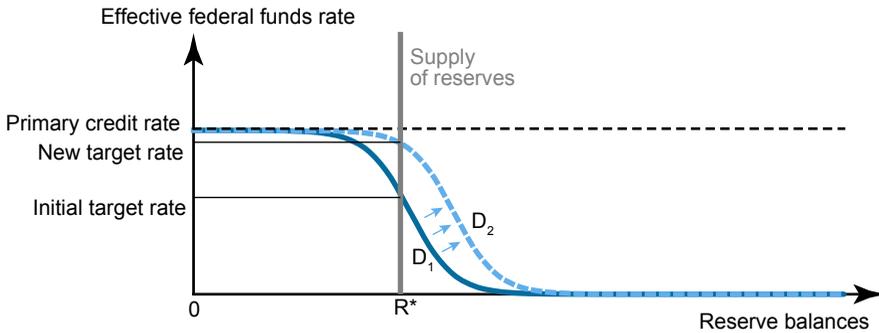
reserves (with both averaged over maintenance periods, a two-week time period over which reserve requirements are applied), the fitted relationship is negative and statistically significant (see Chart 2).

However, as Chart 2 notes, excess reserve balances explain only 10 percent ($R^2 = 0.10$) of the variation in the fed funds rate. The high level of noise in the relationship between rates and reserves in the data indicates that, in practice, the relationship between reserve balances and the fed funds rate is more complicated than the stylized theory illustrated in Chart 1 (as also noted by Judson and Klee [2010]). One complication is that the distribution of reserves across banks matters. Since larger institutions traded excess reserve balances more actively than smaller institutions, a temporary concentration of reserves in large institutions could have entailed lower rates. Therefore, the aggregate amount of reserves was not the only variable that mattered. Nevertheless, Ennis and Keister (2008) show how the basic conclusions from the simple analysis do not change, even after accounting for bank heterogeneity.

An additional complication is that the demand for reserves likely shifts over time because of both long-term changes in the need for liquidity (for example, as a result of technological and regulatory changes) and short-term fluctuations in liquidity needs and expectations of rate changes throughout the maintenance period. For instance, Carpenter and Demiralp (2006a) present evidence of increases in demand for bank reserves in expectation of an FOMC rate increase, illustrated as the shift from D_1 to D_2 in Chart 3. These demand movements

CHART 3

Shifts in the Demand for Reserves



complicate the relationship between the Desk's actions and changes in the fed funds rate, since the EFFR can move in the absence of any intervention by the Desk. Several researchers have identified the demand curve more precisely by estimating unexpected shocks to the supply of reserves (see Hamilton [1997], Carpenter and Demiralp [2006b], Judson and Klee [2010], and Ihrig, Meade, and Weinbach [2015]).

2. CONDUCT OF MONETARY OPERATIONS IN THE PRE-CRISIS ERA

Just as actual shifts in the demand for reserves occurred for reasons absent in the stylized model, the day-to-day implementation of monetary policy also involved complications beyond those discussed earlier. For example, in managing daily liquidity, the Desk had to account for variations within a reserve maintenance period.⁸ Depository institutions only needed to maintain the required reserve balance *on average* over the reserve maintenance period. The task of the Desk was to accurately forecast the supply and demand for reserve balances for each day of the two-week maintenance period, adjusting it daily based on market conditions and the distribution of reserves among banks. In the remainder of this section, we describe the maintenance period structure and the Desk's forecasting exercise.

2.1 The Reserve Maintenance Period

Reserve maintenance periods begin on a Thursday and end on the second Wednesday thereafter. 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 (known as "lagged reserve accounting"). In order to allow depository institutions greater flexibility in maintaining account balances, the Desk averaged banks' holdings of reserve balances over these two weeks when determining whether banks' reserve holdings met requirements.⁹ Averaging allowed banks to effectively manage unexpected payment shocks that would cause them to hold too few or too many reserves

relative to requirements on any given day in a maintenance period. Since the flexibility offered by averaging diminishes as the number of days remaining in a maintenance period declines (until they have no flexibility on the maintenance period settlement day), banks generally tended to hold relatively few balances early in a maintenance period in order to maximize their flexibility in absorbing payment shocks later in the period. Another feature of the reserve maintenance period that helped smooth the volatility of the EFFR toward the end of the period was depository institutions' ability to carry over (subject to restrictions) excess balances from one maintenance period to the next. This ability reduced distortions that could have resulted from the incentive to offload excess reserves in the last few hours of the maintenance period.

2.2 The Desk's Forecasts and Operations

In order to ensure that rates remained responsive to changes in reserves, the Desk typically left a "structural deficit" in the banking system. In other words, the Desk left the total amount of reserves backed by outright Treasury purchases (that is, purchases of Treasury securities in the secondary trading markets) just below the level of aggregate reserves required by the banking system. Maintaining a structural deficit helped the Desk interact efficiently with its primary dealer counterparties. Since primary dealers are the Desk's traditional counterparties, and dealers are natural seekers of funding and providers of collateral, maintaining a repo book of variable size with the dealers was more effective than maintaining a reverse repo book, because dealers typically had limited capacity to invest funds or receive collateral.

An implication of the "structural deficit" was that the Desk effectively faced a downward-sloping demand for reserves (Chart 1). Further, the practice of not paying interest on reserves meant that banks were highly sensitive to the opportunity cost of holding reserves—in other words, the slope of the demand curve was relatively steep. Given its forecasts of the demand for reserves and of changes in the supply of reserves, the Desk would fine-tune the level of reserves by conducting daily repo operations, thereby adding reserves to or subtracting reserves from the system. This procedure, when successfully carried out, ensured that the EFFR remained close to the target rate on a daily basis. The aggregate reserves were then redistributed within the banking system as reserve-deficit banks traded with reserve-surplus banks in the fed funds market.

The demand for reserves had three components: required reserves, contractual clearing balances, and "excess" reserves to meet intraday payment flows (Exhibit 1). For example, in 2004, required reserves averaged \$11 billion, contractual clearing balances averaged \$10.4 billion, and excess reserves averaged \$1.6 billion (Board of Governors 2005). Banks are required to hold reserves against transaction deposits, which are checking accounts and other interest-bearing accounts offering unlimited checking privileges. In practice, changes in required reserves reflected changes in transaction deposits, since the Federal Reserve rarely changed the required reserves ratio (Board of Governors 2005).

Some banks voluntarily held significant levels of contractual clearing balances at their Reserve Banks, in addition to their required reserve balances. Clearing balances provided banks with increased flexibility in holding reserves across the maintenance period. Banks were compensated on their clearing balances based on three-month Treasury bill rates. However, the income credits could only be used to defray the cost of Federal Reserve services, such as

EXHIBIT 1

The Market for Balances at the Federal Reserve before 2007

Required Reserve Balances

- Held to satisfy reserve requirements
- Do not earn interest

SOMA Securities Portfolio

- Holdings of U.S. Treasury and agency mortgage-backed securities (MBS) and repurchase agreements

Contractual Clearing Balances

- Held based on contractually agreed-upon amounts
- Generate earnings credits that defray the cost of Federal Reserve priced services

Discount Window Loans

- Credit extended to depository institutions through the discount window

Excess Reserves

- Held to provide additional protection against overnight overdrafts and reserve or clearing balance deficiencies

Autonomous Factors

- Other items on the Federal Reserve's balance sheet such as Federal Reserve notes, Treasury's balance at the Federal Reserve, and Federal Reserve float

check clearing and Fedwire services, thus limiting their value (Hilton 2008). Penalties applied if a bank had not accumulated sufficient balances over a two-week maintenance period to meet its reserve requirements and clearing balance obligations, or if it ended any day overdrawn on its Fed account (Hilton 2008). Therefore, the sum of reserve requirements and contractual balances created a predictable level of demand for reserves.

“Excess reserves” were the amount of reserves that a bank held in excess of required reserves and contractual balances to meet unexpected intraday payment needs that might otherwise have created an intraday or overnight overdraft on its account. The daily demand for excess reserves was the least predictable element of the demand for reserves, since it depended on the volume and volatility of daily payment flows (Board of Governors 2005). Average reserve balances in 2006 were about \$17.5 billion, of which excess reserves were \$2.0 billion. The total level of reserves was much smaller than daily payment flows, a disparity that had significant implications for banks’ ability to meet payment needs during the day, as we describe in Section 4 and in Box 6.

Using reserve requirements along with the anticipated demand for liquidity, the Desk forecasted the average excess reserves over a maintenance period based on the expectation that different types of banks typically hold different levels of reserve balances. In particular, small banks with limited access to funding markets demanded some level of excess reserves each day—typically between \$1.5 billion and \$2 billion—as a cushion against liquidity shocks (Hilton 2008). The Desk had to take this component of reserve demand into account in its daily calculations of the reserve supply needed to maintain equilibrium in the fed funds market.

The Desk estimated total demand for reserves for the entire fourteen-day maintenance period. For example, if the Desk observed that a bank already held more reserves than it needed to meet its requirement for the entire maintenance period—a situation known as a “lock-in”—then the Desk would increase its estimate for excess reserve demand for that specific maintenance period (since the “locked-in” reserves are not available to be lent to banks with a reserve deficit). In addition, for each day of the maintenance period, the Desk estimated the demand for reserves based, in part, on the maintenance-period-to-date distribution of reserve holdings.

The supply of Federal Reserve balances to banks comes from three sources: the Fed's portfolio of securities and repurchase agreements; loans through the Fed's discount window facility; and liabilities on the Fed's balance sheet that are outside the Desk's control, known as autonomous factors (Exhibit 1). The securities portfolio, which consisted of outright purchases of securities and repurchase agreement operations, was the most important source of reserve supply. Discount window lending was the least important, since banks rarely borrowed from the facility. For example, no discount window loan was outstanding on the Fed's balance sheet on August 8, 2007, the start of the financial crisis (Hilton 2008). Autonomous factors caused large daily variations in the supply of reserves. The major categories of autonomous factors are currency in circulation, the Treasury's balance at the Fed, foreign central bank investments in a "repo pool," and Federal Reserve "float" (see Box 1 for further discussion of the foreign repo pool and other autonomous factors).

The Desk had to forecast changes in autonomous factors extending several weeks into the future (Board of Governors 2005) as well as the resulting impact of these changes on reserves so that these effects could be factored into the desired size of daily OMOs. For example, if changes in autonomous factors were forecasted to increase (reduce) reserves by, say, \$1.0 billion, then the Desk might reduce (increase) the size of its outstanding repo operations by the same amount, all else equal. Federal Reserve notes represent the largest autonomous factor. When the Fed issues currency to a bank, it debits the bank's account at the Fed, causing reserves to fall. The Treasury's account at the Fed is the next largest contributor to fluctuations in autonomous factors. Since the Treasury is not a bank, changes in its account balance result in corresponding changes in the supply of reserves. Treasury balances, the foreign repo pool, and the float are the autonomous factors most difficult to predict on a daily basis (Hilton 2008).

Each day, the Desk compared forecasts of the supply of reserve balances from autonomous factors with its projections of demand for reserves and determined the need for OMOs.¹⁰ In addition to forecasting daily changes in autonomous factors, the Desk also forecasted longer-term trends, such as seasonal growth in currency in circulation (for example, demand for currency tends to increase around Thanksgiving and Christmas) and the long-term growth rate of currency. If these longer-term projections indicated that the supply of reserves was likely to be low for several weeks, then outright purchases of Treasury securities or long-term repos might be needed.¹¹ Outright holdings of Treasury securities were preferred both for operational considerations and to limit direct credit extensions to private market participants (Hilton 2008).

In practice, the Desk generally relied on temporary OMOs to achieve the daily changes in reserves required to keep the fed funds rate near its target. These operations typically involved conducting repos and reverse repos (generally of overnight duration) to increase and decrease, respectively, the supply of reserves with primary dealers.¹² For example, in 2004 the Desk conducted 299 repo operations for about \$1.9 trillion and purchased outright \$50 billion of securities (Board of Governors 2005). Using repos allowed the Desk to easily expand or contract the level of reserves with minimal disruption to the functioning of the market in which the underlying securities were traded. Further, repo transactions reduced the need to make frequent temporary downward adjustments to outright holdings. (Box 2 describes how the Fed conducted repo operations when dealer inventories were low.)

Box 1

What Are Autonomous Factors?

The term “autonomous factors” refers to items on the Federal Reserve’s balance sheet that are outside the control of the Open Market Desk of the Federal Reserve Bank of New York. The Desk needs to forecast changes in autonomous factors because these changes affect the level of reserves in the banking system. For example, when the Treasury’s account balance at the Fed increases, reserves are effectively drained, since funds are de facto transferred from the private sector into the Treasury’s Fed account. Conversely, when the Fed spends money—for example, on employee salaries or remittances to the Treasury—the level of reserves in the system increases. Most daily changes on the Fed’s balance sheet are too small to make a difference in monetary policy implementation. However, changes in some balance-sheet categories were routinely large enough to matter; that is, these types of balance-sheet changes routinely had a significant impact on the overall level of reserves and needed to be considered as the Desk developed its plans for the appropriate size of OMOs. We discuss the Desk’s routine forecasts of these balance-sheet categories, or autonomous factors, below.

Currency in Circulation

Currency in circulation is typically the largest and most important autonomous factor to forecast. When a bank places an order for currency with a Federal Reserve Bank, the latter fills the order and debits the bank’s account at the Fed and total reserve balances decline. Currency is fungible with reserves; a bank’s actions to withdraw (deposit) currency from its Fed account increases (reduces) currency in circulation, thus reducing (increasing) reserves. The outstanding level of currency in circulation varies with both seasonal and longer-term trends. Longer-term trends include transactional demand for currency as well as foreign demand to hold U.S. dollars as a store of value. As the demand for currency grows with the economy, reserves would decline and the fed funds rate would rise if the Fed did not offset diminishing reserves by conducting repo operations or by purchasing securities. The expansion of Federal Reserve notes in circulation is the primary reason that the Fed’s holdings of securities grew over time during the pre-crisis period.

Float

Federal Reserve float is created when credit to the account of the bank presenting a check for payment occurs on a different day than debit to the account of the bank on which the check is drawn. Float temporarily adds reserve balances when there is a delay in debiting the paying institution’s account; conversely, float temporarily drains balances when the payer’s account is debited before the payee receives credit. Float tended to be quite high and variable whenever the normal check-delivery process was disrupted, such as during bad weather when travel delays could slow down the delivery and processing of physical checks. The magnitude of differences in the timing of float has decreased in recent years because more transfers are conducted electronically.

Treasury General Account (TGA) Balance

The Fed serves as fiscal agent for the U.S. Treasury and the TGA functions as the checking account for the U.S. Treasury. The Treasury draws on this account to make payments by check or direct deposit for all types of federal spending. Since the Treasury is not a bank, its payment to the public reduces the TGA balance and increases reserve balances available to banks. Changes in the TGA

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BOX 1 (CONTINUED)

balance tend to be less predictable following corporate and individual tax dates, especially in the weeks following the April 15 deadline for federal income tax payments. Before the crisis of 2007-09, the Treasury could redirect funds from the TGA account to private banks through the Treasury Tax and Loan program (<https://www.newyorkfed.org/aboutthefed/fedpoint/fed21.html>). Doing so helped moderate the day-to-day volatility of this liability on the Fed's balance sheet, volatility that would complicate reserve forecasting.

Foreign Repo Pool

About 250 central banks and foreign official institutions have accounts with the New York Fed's Central Bank and International Account Services (CBIAS) division, which offers payment, custody, and investment services to these accounts (see <https://www.newyorkfed.org/aboutthefed/fedpoint/fed20.html>). CBIAS also offers an investment product, known as the foreign repo pool, in which CBIAS accounts can invest overnight funds in a repo arrangement backed by SOMA collateral. Funds that are held in CBIAS accounts at the New York Fed, whether in the foreign repo pool or in transaction accounts, drain reserves from the banking system. (By definition, funds held at the Fed reduce the supply of reserves held by the private sector).

Until the mid-1990s, the Desk sometimes directed CBIAS accounts to conduct repos with private market participants as a means of fine-tuning the level of reserves in the system. The Desk stopped this process in the mid-1990s by moving to a framework in which CBIAS accounts were encouraged to keep consistent, albeit fairly low, balances in their foreign repo pool accounts. CBIAS staff would counsel accounts to encourage stability in their holdings. Since stability was encouraged in these accounts, the Desk would treat typical foreign repo pool balances as a "permanent" reserve drain and the day-to-day fluctuations in the foreign repo pool became a significant autonomous factor.^a

Before the crisis, balances in the foreign repo pool averaged around \$40 billion. As of early 2018, foreign repo balances tend to be around \$230 billion to \$250 billion. Use of the pool has increased over time as constraints placed on CBIAS customers have been removed (see <https://www.newyorkfed.org/newsevents/speeches/2016/pot160222>). This new paradigm has increased both the level and the variability of the foreign repo pool, but such variability no longer causes issues with monetary policy implementation, since the Desk no longer actively manages reserve balance levels.

CBIAS balances are published under the heading "Reverse Repurchase Agreements – Foreign Official and International Accounts" in the H.4.1 Federal Reserve Statistical Release, which is published weekly (<https://www.federalreserve.gov/releases/h41/current/>).

^a The Desk had another CBIAS investment product that helped control the day-to-day level of reserves. On a voluntary basis, the Desk would sell fed funds as an agent for pooled CBIAS funds. This approach allowed the accounts to earn a return on unexpected end-of-day balances while minimizing disruption to the supply of reserves resulting from unexpected operational issues, such as a failure to receive delivery on the purchase of Treasury securities.

Box 2

How Did the Desk Avoid Conducting Undersubscribed Repo Operations?

As described in this article, the Desk generally conducted daily repo operations in order to change the overall level of reserves in the system to match the Desk's daily forecast of demand for these reserves. The near-daily conduct of these operations, which typically settled on a $T+0$ basis (that is, on the same day as the trade occurred), raises the question of how the Desk avoided having undersubscribed operations, which would have resulted in supplying less reserves than intended. This risk is not insignificant, because dealers submitting winning propositions in repo operations must pledge unencumbered collateral to the Desk through their designated tri-party clearing agent in order for the transaction to settle and for intended reserves to hit the banking system. What if there isn't much unencumbered collateral on dealers' balance sheets?

In practice, the temporary OMOs were rarely undersubscribed, even though the typical operation time of 9:30 a.m. came after the time when most repo volume occurs on a daily basis. The main reason is that the Desk's typical take-down in short-term repo operations totaled about \$7.0 billion a day, much less than the typical overnight repo volumes that are conducted in the private market. In addition, based on experience, the Desk could often anticipate when collateral shortages might develop, and it planned around them accordingly. The following table provides an illustrative example of how the Desk arranged the tenor of repo operations to minimize the risk of conducting undersubscribed operations ahead of the March 2006 quarter-end date.^a

Open Market Trading Desk Repo Operations, March 2016

Date	Term (Days)	Propositions Received (Billions of U.S. Dollars)	Propositions Accepted (Billions of U.S. Dollars)
Wednesday, March 29, 2006	5 (spanned weekend)	37.9	5.50
Thursday, March 30, 2006	5 (spanned weekend)	22.95	5.00
Thursday, March 30, 2006	1	29.65	3.25
Friday, March 31, 2006	3 (spanned weekend)	11.55	4.25

Source: Federal Reserve Bank of New York.

From the table above, we observe that the Desk conducted two short-term repo operations that not only provided reserves on the days they were conducted (Wednesday, March 29, and Thursday, March 30) but the tenor of these repo operations was such that they provided reserves over the upcoming weekend, which included the quarter-end date of Friday, March 31. In this manner,

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^a The table ignores the conduct of "longer-term repos," which are discussed elsewhere in this article.

BOX 2 (CONTINUED)

the Desk added \$10.5 billion of reserves that were outstanding over the quarter-end date. On the quarter-end date itself, the Desk added another \$4.25 billion, such that total short-term repo operations increased reserve levels over the quarter-end date by \$14.75 billion. Since the Desk observed that dealers were more likely to be short of collateral over quarter-end dates, this strategy enabled the Desk to successfully avoid an undersubscribed operation. Note that total propositions submitted for the repo operation conducted on March 31, 2006, were only \$11.55 billion, suggesting that a straightforward, over-the-weekend operation with a desired target amount of \$14.55 billion would have been undersubscribed. The Desk frequently referred to this approach as “layering in reserves.”

2.3 Volatility of Rates during the Reserve Maintenance Period

While the reserve maintenance period allowed depository institutions greater flexibility in managing reserve balances, it also posed challenges to forecasting and interest rate control. One concern was that reduced flexibility toward the end of the maintenance period would make the fed funds rate particularly sensitive to shocks, inhibiting the Fed’s ability to achieve the target. This challenge is evident in the relatively high intraday standard deviation in the fed funds market toward the end of reserve maintenance periods, consistent with the findings of Bartolini, Bertola, and Prati (2000) (see Chart 4). In the next section, we examine the Desk’s ability to manage end-of-maintenance-period volatility.

3. EFFECTIVENESS IN MEETING PRIMARY MONETARY POLICY OBJECTIVES

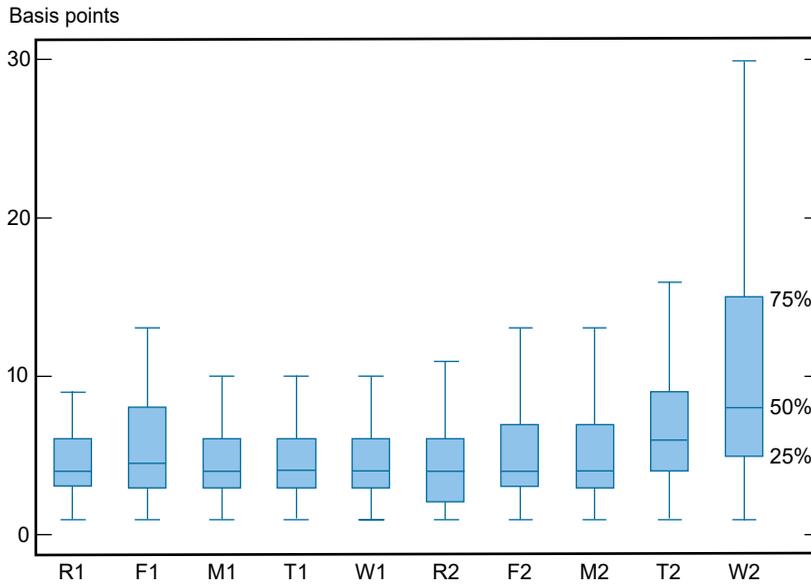
How effective was the pre-crisis framework in meeting the primary objectives of monetary policy? In this section, we focus on the Desk’s control of short-term rates and whether changes in the policy rate were quickly transmitted from the fed funds market to other money markets. First, we show that in spite of increasing intraday dispersion of the fed funds rate toward the end of the maintenance period, the effective rate remained close to target levels. Then, we demonstrate that while the fed funds rate deviated from its target toward the end of quarters (when demand for liquidity was high), it quickly reverted to normal levels within one day. Finally, we document that policy rate changes were rapidly transmitted from the fed funds rate to other money market rates.

3.1 Control of the Policy Rate

Deviations from the target for the federal funds rate rarely exceeded 20 basis points, as the left panel of Chart 5 shows. Moreover, the deviations do not appear to be persistent; instead, larger deviations are generally followed by smaller ones. This was true even toward the end

CHART 4

Intraday Standard Deviation of Effective Federal Funds Rate during Maintenance Period



Sources: Federal Reserve Bank of New York; authors' calculations.

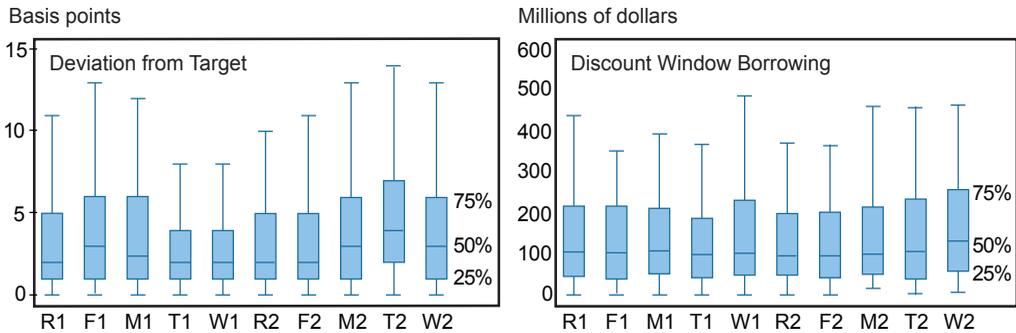
Notes: Using data on the daily standard deviation of the effective federal funds rate (EFFR) (<https://apps.newyorkfed.org/markets/autorates/fed%20funds>) for the period July 3, 2000, through August 1, 2007, the chart shows the rate's distribution by day in the reserve maintenance period. Fifty percent indicates the median level, and 25 percent and 75 percent indicate the 25th and 75th percentiles of the distribution, respectively. The ends of the whiskers represent observations up to 1.5 times the interquartile range. R1/2 is the first/second Thursday of the maintenance period; F1/2 is the first/second Friday of the maintenance period; M1/2 is the first/second Monday of the maintenance period; T1/2 is the first/second Tuesday of the maintenance period; W1/2 is the first/second Wednesday of the maintenance period; W2 is the settlement date.

of the maintenance period when the rates were more widely dispersed (Chart 4); indeed, the EFFR did not drift significantly farther from the target rate at the end of maintenance period than it did on other days in the maintenance period. This small deviation was not the result of banks borrowing heavily from the discount window to meet their demand for reserves. As the right panel of Chart 5 shows, while depository institutions tended to borrow more from the discount window on the last day of the maintenance period, the amount borrowed was small in comparison with the amount of excess reserves. In other words, the low volatility of fed funds during the end of maintenance periods cannot be attributed to banks smoothing their demand for reserves through discount window borrowings. Rather, the evidence from Chart 5 suggests that the Desk was successful in managing reserves throughout the maintenance period and, in particular, the ends of maintenance periods did not significantly impair the Desk's ability to implement monetary policy.

While the fed funds rate, on average, was close to its target, it could occasionally deviate from that target. Typically, autonomous factors could experience movement that the Desk would forecast imperfectly and the difference would result in small supply-demand

CHART 5

Absolute Deviation of Effective Federal Funds Rate from Target and Discount Window Borrowing by Day of Maintenance Period



Sources: Federal Reserve Bank of New York; authors' calculations.

Notes: The left panel shows the distribution of the absolute deviation of the federal funds rate from the target rate by day during the maintenance period, for the time frame from July 1, 2001, through August 1, 2007. The right panel shows the distribution of discount window borrowings by day during the maintenance period, for the time frame from January 1, 2003, through June 30, 2007. Fifty percent indicates the median level, and 25 percent and 75 percent indicate the 25th and 75th percentiles of the distribution, respectively. Ends of the whiskers represent observations up to 1.5 times the interquartile range. R1/2 is the first/second Thursday of the maintenance period; F1/2 is the first/second Friday of the maintenance period; M1/2 is the first/second Monday of the maintenance period; T1/2 is the first/second Tuesday of the maintenance period; W1/2 is the first/second Wednesday of the maintenance period; W2 is the settlement date.

mismatches. Other deviations were generally predictable (and therefore could be anticipated and partially offset by the Desk) and well understood. For example, large rate movements could occur within a reserve maintenance period ahead of a widely anticipated rate change by the FOMC; rates would typically fall on the first Friday of each maintenance period and typically increase on high payment flow days. More important, rates quickly reverted to the target following such deviations.

To illustrate the resilience of the policy rates during periods of high volatility, we consider the behavior of fed funds rates during quarter-ends (see Box 3 for further details). Heightened volatility around quarter-end dates typically caused the fed funds rate to deviate from the target. This deviation increased by an average of 6 basis points on the last day of the quarter (day 60 in Chart 6, page 55) and by 8 basis points the following day (day 1 in Chart 6, which is the first day of the following quarter). By contrast, on more “typical” days (that is, excluding the quarter-end date plus the two days before and after it), the fed funds rate was within a basis point of the target, on average. The fed funds rate sometimes increased sharply at the end of months, which accounts for the spike on day 20, but volatility on these days was not unusually high.

In order to stabilize fed funds rates around quarter-end dates, the Desk supplied extra reserves to meet the surge in demand (see page 54 of Box 3). Moreover, the Desk planned to leave relatively low levels of reserves on other days in the same reserve maintenance period. Otherwise, the supply of reserves would have exceeded demand over the non-quarter-end days of the

Box 3:

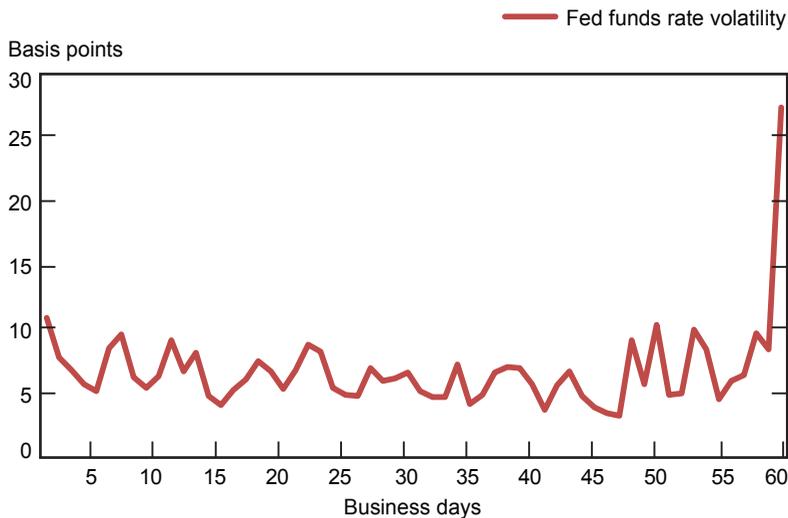
Quarter-End Dynamics of Federal Funds Rates

Volatility of Fed Funds Rates at Quarter-Ends

Quarter-end volatility remained a feature of the fed funds markets in the years before the financial crisis. Chart 3A plots the intraday volatility of the fed funds rate for each day of the quarter, averaged across quarters from the fourth quarter of 2004 to the second quarter of 2007. During this time period, there was a clear trend of elevated intraday volatility on the quarter-end date.

CHART 3A

Volatility of Federal Funds Rate Spikes on the Last Day of the Quarter: 2004:Q4 to 2007:Q2



Source: <https://apps.newyorkfed.org/markets/autorates/fed%20funds>.

Notes: The chart shows, for each day t , the median of the intraday standard deviation of the federal funds rate across quarters. Day 60 is the quarter-end date. Day 1 is the start of the quarter. The quarters are standardized to sixty days by using the first thirty days from quarter-start and the last thirty days from quarter-end, excluding days in the middle for quarters with more than sixty days. Rates are in basis points.

Level of Fed Funds Rates during Quarter-Ends

Heightened volatility around quarter-end dates typically caused the fed funds rate to deviate from the target. This deviation increased by an average of 6 basis points on the last day of the quarter (day 60) and by 8 basis points the following day (day 1), as shown in Chart 6, page 18. By contrast, on more “typical” days (excluding the quarter-end date plus the two days before and after it),

(CONTINUED ON NEXT PAGE)

Box 3 (CONTINUED)

the fed funds rate was within a basis point of the target, on average. The fed funds rate sometimes increased sharply at the end of months, which accounts for the spike on day 20, but volatility on these days was not unusual (as shown in Chart 3A).

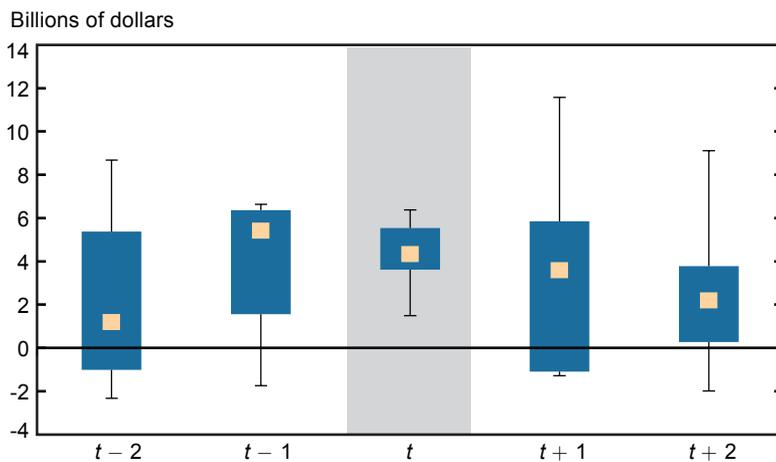
Supply of Reserves during Quarter-Ends

In order to stabilize fed funds rates around quarter-end dates, the Desk supplied extra reserves to meet the surge in demand. Moreover, the Desk planned to leave relatively low levels of reserves on other days in the same reserve maintenance period (that is, the period over which banks' required reserves are calculated). Otherwise, the supply of reserves would have exceeded demand over the non-quarter-end days of the maintenance period, pushing rates below the target once the quarter-end had passed.

The box-whisker plot of the distribution of excess reserves in Chart 3B shows that the Desk left an average of more than \$4 billion of excess reserves around quarter-end dates. In contrast, the Desk on average left less than \$0.5 billion of excess reserves on non-quarter-end days of the maintenance period. The chart further indicates that the *range* of excess reserves was relatively narrow, between \$3 billion and \$6 billion on most quarter-end dates, suggesting that the Fed chose not to eliminate reserve demand shocks completely, as was also found by Bartolini, Bertola, and Prati (2002).

CHART 3B

Excess Reserves around Quarter-End: 2004:Q4 to 2007:Q2

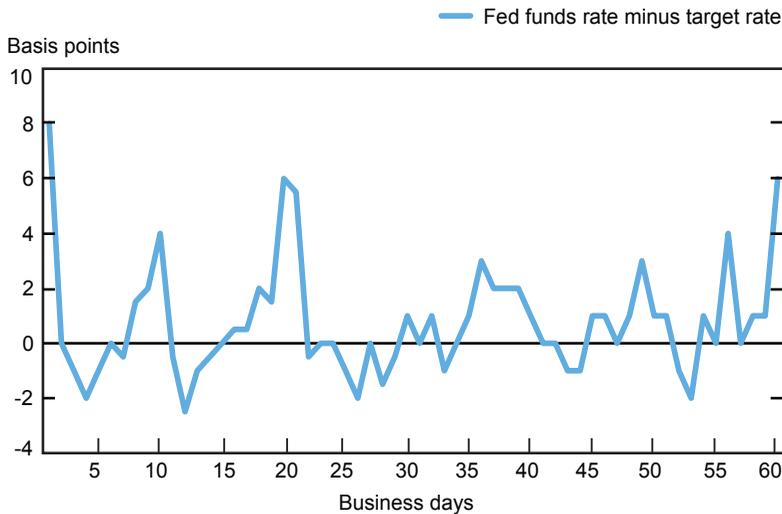


Source: Federal Reserve Bank of New York.

Notes: Day t (shaded) is the quarter-end date. The chart plots the distribution of excess reserves for the five quarter-end dates. For each date, the blue box includes values between the 25th and 75th percentiles of the distribution, with the median indicated by the orange box. The "whiskers" indicate outliers beyond this range.

CHART 6

Federal Funds Rate Spikes around the End of Quarters: 2004:Q4 to 2007:Q2



Source: Federal Reserve Bank of New York.

Notes: The chart shows the median of the difference between the federal funds rate and the target rate across quarters for each day. Day 60 is quarter-end. Day 1 is the start of the quarter. The quarters are standardized to sixty days by using the first thirty days from quarter-start and the last thirty days from quarter-end, excluding days in the middle for quarters with more than sixty days.

maintenance period, pushing rates below the target once the quarter-end passed. Consequently, the deviation of the fed funds rate from its target was short-lived, generally falling back to the target rate on the second day after quarter-end (Chart 6).

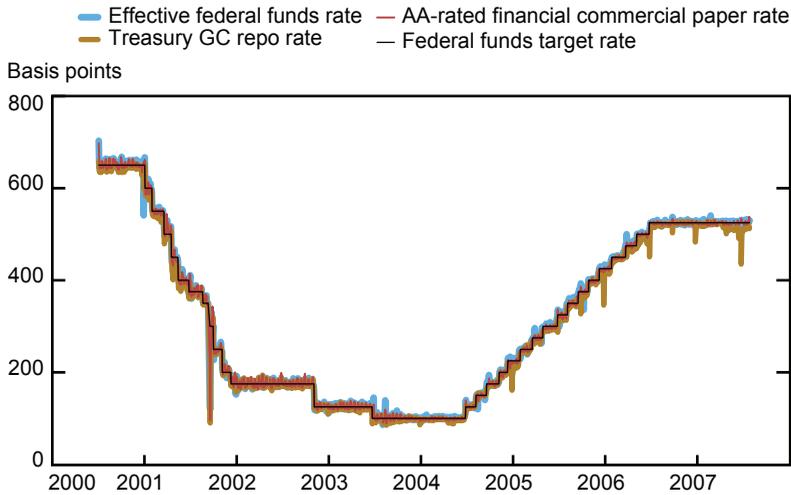
3.2 Transmission of the Policy Rate to Other Money Markets

The FOMC traditionally implements monetary policy by announcing a policy target rate for the EFFR, with the expectation that its decisions will quickly be transmitted to all money market rates. Because the Fed does not directly control market interest rates, it relies on arbitrage forces in money markets to transmit the change in the fed funds rate to other short-term rates.¹³ A variety of market participants can be arbitrageurs, including primary dealers that operate in most short-term money markets and hedge funds that seek to profit from price discrepancies in related markets. In this section, we examine the effectiveness of arbitrage before the recent financial crisis.

In the pre-crisis period, because banks active in multiple money markets could earn a profit when money market rates were misaligned, arbitrage kept those rates aligned and thus facilitated the transmission of monetary policy. As shown in Chart 7, the overnight AA financial commercial paper rate, the EFFR, and the overnight Treasury general collateral (GC)¹⁴ repo rate were highly correlated before the crisis, as would be expected with

CHART 7

Overnight Money Market and Target Federal Funds Rates: July 2000–July 2007



Sources: Federal Reserve Bank of New York; Bloomberg L.P.

Notes: All rates are of overnight tenor. GC is general collateral.

effective arbitrage.¹⁵ Other short-term money market rates, such as Eurodollar rates (not shown in the chart), were also tightly aligned with the EFFR.

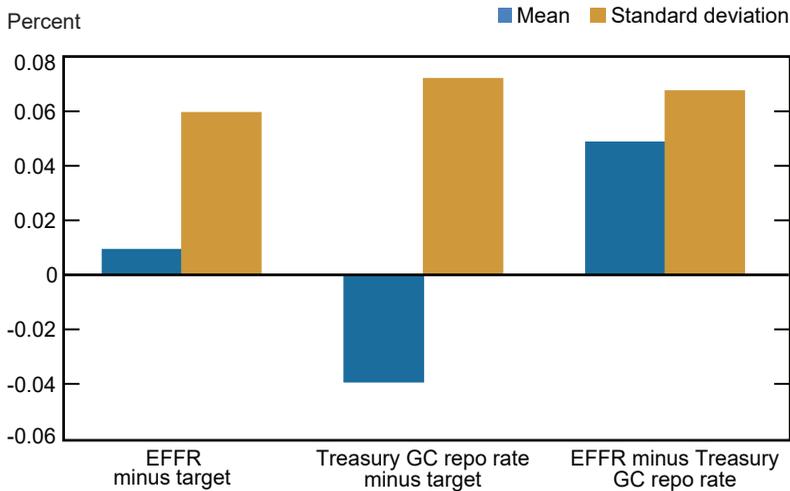
On average, the EFFR and the Treasury repo rate generally remained close to the FOMC's target rate (Chart 8). Also, the repo rate was consistently below the fed funds rate, as should be expected since repos are secured and fed funds are not. As a result, the average difference between the EFFR and repo rates (or the spread) was positive. Of note, the standard deviation of both rates is relatively high compared with the respective means, in particular for the EFFR. To the extent that the volatility is fundamental, the relatively high standard deviation may represent price discovery (that is, discovery of the rate equilibrating the demand for and supply of reserves) occurring in the actively traded fed funds market. We return to this issue in Section 4, where we discuss the advantages of active trading in the money markets for monetary policy implementation.

In Box 4, we present a formal test of monetary policy transmission using Granger causality tests and daily data. We show that past values of the EFFR “cause” (or predict) the current repo rate in the pre-crisis period, a pattern one would expect if arbitrageurs operated to keep intermarket rates aligned. In turn, the existence of arbitrage activity likely facilitated the transmission of changes in the target rate to the repo market. The results further show that the repo rate also Granger-causes the EFFR in the pre-crisis period, indicating two-way flows of information between the fed funds and repo markets. This result indicates that neither market is dominant in an informational sense.

In addition to examining the fed funds market, we analyze transmission between the Eurodollar market and the repo market. We find that changes in the Eurodollar rate are also transmitted to the repo rate (as might be expected, since the Eurodollar and the EFFR have historically been tightly connected).

CHART 8

Deviations from the Target Federal Funds Rate: January 2002–December 2006



Notes: The chart shows the means and standard deviations, respectively, of the effective federal funds rate (EFFF) and the repo rate, measured as deviations from the target federal funds rate during the pre-crisis period. Also shown are the mean and standard deviation of the spread (that is, the EFFF minus the repo rate). GC is general collateral.

4. OPERATIONAL EFFECTIVENESS AND FINANCIAL MARKET FUNCTIONING

While its primary task is controlling the fed funds target, a monetary policy framework can also be evaluated with respect to objectives related to operational effectiveness and financial market functioning. In this section, we evaluate the pre-crisis framework's operational effectiveness by analyzing the efficiency and transparency of the Desk's day-to-day actions and procedures in managing liquidity and by viewing the framework through the lens of universality—whether the framework remains applicable in different states of the economy. We assess the financial objectives by examining the impact of the Fed's collateral policy and by exploring the monetary policy framework's effect on money market and payment system activity (Bindseil 2016).

4.1 Operational Objectives: Efficiency and Transparency of Procedures

Before the crisis, the Desk's procedures for controlling short-term interest rates were complex and resource-intensive, resulting from the need to manage liquidity daily and, consequently, to forecast reserve supply and demand conditions daily, a technically challenging task (Bernanke 2005).¹⁶ In addition, the Federal Reserve did not publish its forecasts, which made the procedures rather opaque to market participants.

Box 4

Testing Monetary Policy Transmission with Granger Causality Tests

To evaluate the strength of monetary policy transmission, we conduct a Granger causality test using daily data. Past values of the effective federal funds rate “caused” (or predicted) the current repo rate in the pre-crisis period (see table), indicating that the Fed’s monetary policy decisions were transmitted to the repo market. Also, the results show that the repo rate Granger-caused the EFR in the pre-crisis period, showing a two-way flow of information between the fed funds and repo markets.

Does the Federal Funds Rate Predict the Repo Rate in the Pre-Crisis Period?

	Result
Does the fed funds rate predict the repo rate?	Yes
Does the repo rate predict the fed funds rate?	Yes

Notes: The table shows results from a Granger causality test for the period January 2002 to December 2006. Rates are measured relative to the target federal funds rate.

One concern with the analysis is that the reporting time of the data is not synchronized: the repo rate is reported as of 9 a.m. EST, whereas the EFR is an all-day rate. To address this issue, we estimate the Granger causality between the one-day lagged value of the EFR and the repo rate and, further, between the General Collateral Finance Repo (GCF Repo[®]) Treasury rate (which is reported at the end of the day) and the EFR.^a In both cases, we obtain a similar result: there is bi-directional causality between the EFR and the repo rate during the pre-crisis period.

We focus on the transmission from the EFR to the repo rate because of the historical importance of the fed funds market and the availability of a long time-series of data for the EFR. However, in an unreported analysis, we also find that Eurodollar rate changes are transmitted to the repo rate (as might be expected, since the Eurodollar and fed funds rate have historically been tightly connected).

^a Another alternative is to use a morning funds rate, such as the Broker’s Fed Funds Open. However, these rates represent quotes and not transactions, and, moreover, they are not based on meaningful volumes.

In a multiple-day reserve maintenance system, the daily distribution of reserves may, in theory, be less important, since reserve requirements only have to be met by the end of the period. But because total requirements were low relative to the daily volatility of autonomous factors, the Desk had to evaluate reserve supply and demand conditions closely every morning. Most days, the Desk conducted the following activities:

- forecast numerous autonomous factors over a multiday horizon;
- forecast reserve demand for multiday horizons and for different types of banks; and
- plan and execute the repo or reverse repo operations.

A description of a typical day in the life of the Desk (as is provided in Board of Governors [2005]) gives a sense of the resources required on a daily basis to conduct monetary operations. The day would start with independent projections of the supply of and demand for reserves by two groups of staff members, one at the Federal Reserve Bank of New York and the other at the Board of Governors in Washington. Then a conference call would be held that included the manager of the System Open Market Account (SOMA) in New York, staff at the Board of Governors, and a Federal Reserve Bank president who was at the time a voting member of the FOMC. Participants would discuss the day's forecasts for reserves and financial market developments, especially in the federal funds market. Based on this information, a plan for conducting OMOs would be formulated and a repo operation with primary dealers would typically be executed at this time. Primary dealers would learn of the size of the repo operation only after it was concluded, and the desired level of reserves resulting from the operation was never published. Longer-term repos would be arranged earlier in the morning, usually on a specific day of the week. If an outright operation was also needed, it would be executed later in the morning, after the daily repo operation was completed.

Unlike at many other central banks, the Desk did not publish its forecasts (Hilton 2008), so market participants sometimes had difficulty interpreting the Desk's actions. For example, market participants would often speculate that day-to-day changes in outstanding repo operations matched the Fed's estimate for daily changes in the demand for reserves. This speculation was inherently flawed, since it ignored the equally important impact of forecasted changes to autonomous factors, into which market participants had limited insight. The Desk did not publish its daily targeted level of reserves on an *ex post* basis, and the intended sizes of repo operations were not announced concurrent with the operations. Repo market participants often had only a vague idea of what the sizes of the repo operations would be at the time they were announced and then had difficulty interpreting the results after they were released.

Would an alternative framework have achieved the intended monetary policy goals with less operational complexity? In theory, a symmetric corridor system, with the target rate in the middle of the standing deposit and lending rates, might have required less daily intervention by the Desk as long as banks were able and willing to access the central bank's standing facilities. This system ensures that expected rates in the maintenance period are around the target rate, since it is equally likely that banks would be in reserve deficit or surplus over the maintenance period and, further, the costs of both outcomes are symmetric around the policy rate (Hilton 2008; Bindseil 2014). However, the interest rate corridor in the United States was not symmetric, since there was no standing interest-bearing deposit facility. Instead, the effective deposit rate was zero, since no interest was paid on reserves. Because banks' opportunity cost of holding reserves was zero, the cost of having surplus reserves was higher than the cost of being in deficit, resulting in a bias toward rates below the fed funds target (Hilton 2008). Bindseil (2014) examines a number of alternative monetary policy frameworks with symmetric corridors and shows that, during the pre-crisis period, they were all effective in meeting their monetary policy objectives, suggesting that the Fed could have met its monetary policy objectives using a simpler framework.

Why was the Desk able to meet its monetary policy objectives in spite of a complex and opaque operating framework? Hilton (2008) suggests that one factor might have been the Desk's daily fine-tuning of the supply of reserves, whereby, when rates deviated from the

target, it responded by adjusting the daily supply of reserves to induce rate movements in the reverse direction. This behavior may have helped to ensure that expected future rates remained anchored around the target rate. Market participants responded appropriately to the Desk's fine-tuning because the Desk had built up a consistent record of success in forecasting reserve demand and supply factors. The Desk's forecasting ability and market confidence were mutually reinforcing elements that anchored market expectations and ensured that the EFFR stayed close to the policy target rate.

4.2 Operational Objectives: Universality

A universal (state-independent) framework is one that remains effective across different financial and macroeconomic conditions. All else equal, a more universal framework is desirable, since it allows the central bank to avoid the fixed costs of designing, testing, and implementing new frameworks as conditions evolve. A more universal framework could also help avoid unexpected shifts in the operating framework if conditions change rapidly (for example, during a crisis). Such sudden alterations to the operating framework could be suboptimal if they are made under time constraints, as during a crisis.

One disadvantage of the pre-crisis framework vis-à-vis universality was that in order to control the fed funds rate, the Desk needed to have control over the size of the Federal Reserve's balance sheet. But if the Federal Reserve needed to change the amount of reserves for a reason other than altering the fed funds rate, the Desk could lose control of the policy rate. This limitation became relevant in 2008 when the provision of large amounts of liquidity undermined control of the interest rate, a topic we explore in the concluding remarks of this article.

A second disadvantage of the pre-crisis framework was that active daily management of reserves, and the attendant forecasts of the conditions for reserve demand and supply, proved to be particularly problematic during crisis periods. For example, during the early stages of the financial crisis (primarily in 2007 and 2008), demand for reserves proved particularly hard to predict, resulting in large intraday swings in the federal funds rate (Hilton 2008).

4.3 Financial Market Functioning Objectives: Asset Eligibility Policy

Central banks affect market functioning through their asset eligibility framework, including collateral eligibility for discount window borrowing. Assets eligible for use as collateral may benefit from increased liquidity and enhanced ability to obtain credit, compared with ineligible assets.¹⁷ Further, to the extent that "haircuts" do not fully reflect risks—for example, if they do not vary by counterparty—the price of eligible assets might be distorted (a "haircut" being the difference between the market value of the asset pledged as collateral and the amount of the loan). These market effects are likely to be higher, the broader the set of collateral assets. For example, if the central bank accepts a wide range of collateral assets, then banks may have an incentive to structure their balance sheets to maximize access to central bank credit (Bindseil 2014).¹⁸

The Federal Reserve Act limits the types of assets that the Federal Reserve may acquire through open market operations. In practice, the Fed accepts only high-quality assets in its

OMOs—namely, Treasury debt and debt issued or fully guaranteed by U.S. federal agencies, which includes agency mortgage-backed securities. A wider variety of assets, including government and private-sector securities, mortgages, and consumer and commercial loans, are eligible to be pledged against discount window loans. Since discount window borrowings were negligible in normal times, the eligibility criteria for OMOs were the binding constraints. The strictness of the OMO eligibility criteria likely reduced the distortionary effects on asset prices, since the additional liquidity benefits of being granted eligibility are likely small for these types of assets.¹⁹

An alternative view is that the central bank should actively use its collateral policy to support an important asset market that is currently illiquid. Indeed, in the 1920s and 1930s, the Fed took an active role in enhancing the liquidity of the U.S. Treasury bond markets, in part by including these securities as collateral for its nascent OMOs (Garbade 2012). Later, the U.S. Treasury bond markets developed into some of the most liquid asset markets, and so the Fed no longer needed to actively support these markets through its collateral policy. Under this view, inclusion of a broader range of assets for collateral eligibility, even if that involves including illiquid assets, may be desirable.

4.4 Financial Market Functioning Objectives: Money Market Activity

A framework based on reserve scarcity is likely to encourage higher interbank trading activity than one with reserve abundance. Indeed, the scarcity of reserve balances relative to required and precautionary demand for reserves that was a feature of the pre-crisis framework resulted in large volumes of trading between banks, since banks with more reserves than necessary would have an incentive to trade with banks that had too few reserves. For example, in the fourth quarter of 2006, brokered fed funds activity averaged \$95 billion per day. In contrast, under an abundant-reserve regime in the fourth quarter of 2015, the volume of brokered fed funds averaged only \$42 billion per day. (See Box 5 for a more detailed discussion of changes in fed funds market activity since the crisis).

As a general matter, it is unclear whether supporting active money markets should be a goal of a monetary policy framework. Active money markets may promote the transmission of changes in policy rates to the broader market by facilitating arbitrage, enabling price discovery, and promoting market discipline. However, alternative markets (such as short-term funding markets) may be available for providing these benefits. The potential signaling benefits from money markets are also hard to quantify. Changes in trading volumes may not be driven by fundamentals but rather by idiosyncratic payment shocks. Further, participants' efforts to monitor the credit quality of counterparties vary considerably, and it may be difficult to value the social good that results from such monitoring, given that contagious credit and liquidity shocks may force lenders to withdraw funding broadly.²⁰

In the particular circumstances of the pre-crisis period, however, activity in the fed funds market likely provided some benefits. An active fed funds market probably promoted rate discovery, which facilitated the quick transmission of changes in the EFFR to other money market rates (see Section 3).

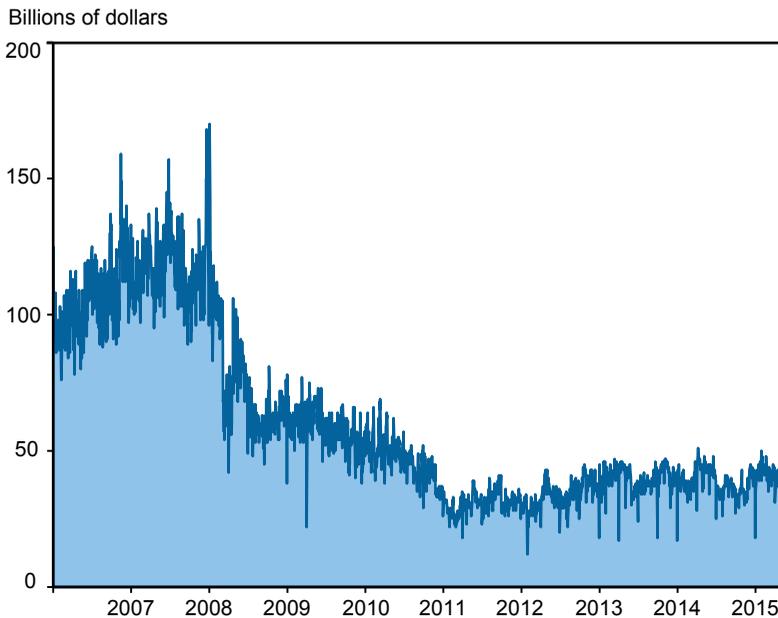
Box 5

Federal Funds Market Activity before and after the Crisis

The pre-crisis period was characterized by significant interbank trading. Banks would trade fed funds for a variety of reasons, including avoiding overnight overdrafts, smoothing daily balances emanating from day-to-day fluctuations in both assets and liabilities, and meeting reserve requirements over the two-week reserve maintenance period. In addition, because the yield curve was typically upward-sloping, some banks established a “structural short” position wherein they would effectively fund longer-term assets through consistent borrowing in the fed funds market.

Along with the shift to abundant reserves following the crisis of 2007-09, fed funds trading volume declined sharply. This decrease is evident in the chart below, which shows a roughly 50 percent drop in the volume of brokered fed funds after the crisis.

Brokered Federal Funds Rate Volume: October 2006–February 2016



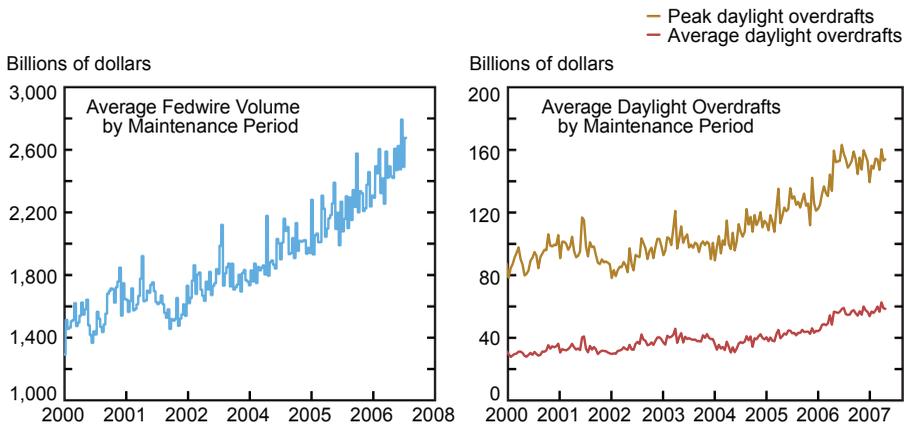
Source: Federal Reserve Bank of New York.

Note: The data are the result of aggregating daily total volumes voluntarily supplied by federal funds brokers.

Activity in the fed funds market is currently dominated by investors that were ineligible to receive interest on excess reserves (IOER) interacting with mostly foreign banking organizations that generally leave the borrowed proceeds at the Fed to earn IOER, in a trade known as IOER arbitrage. As a result, the fed funds market now differs fundamentally from what it was pre-crisis. Most, if not all, of the pre-crisis motivations for borrowing and selling fed funds have changed significantly, and new Basel III regulations discourage banks from funding longer-term assets with short-term liabilities. As a consequence, fed funds trading volumes are now persistently lower than they were pre-crisis.

CHART 9

Time Series of Fedwire Volume and Daylight Overdrafts by Maintenance Period



Sources: Federal Reserve Board; Federal Reserve Bank of New York; authors' calculations.

Note: Both panels reflect data for the period from January 1, 2000, through August 1, 2007.

4.5 Financial Market Functioning Objectives: Payment System Activity

In the pre-crisis period, banks relied on substantial provisions of intraday, or daylight overdraft, credit from the Fed, because the level of reserves was insufficient to cover the clearing needs of the payment system. Since the Fed charged low fees for intraday credit, banks relied on the Fed as a source of intraday funding and did not necessarily borrow in the wholesale funding markets to address shortfalls. With average daily Fedwire volume of \$2.28 trillion and average reserve balances of just \$9 billion held at Federal Reserve Banks in 2006, large daylight overdrafts were a likely consequence of the low levels of reserves in the system. (Box 6, page 64, discusses to what extent private solutions to the problem of intraday credit existed.)

Peak daylight overdrafts (the largest total amount of credit outstanding at any time) as well as average overdrafts by maintenance period over the pre-crisis period are shown in the right panel of Chart 9 (above). In 2006, the use of intraday overdrafts averaged roughly \$51 billion during operating hours, and, on average, \$140 billion was outstanding at peak use over a maintenance period (roughly 6 percent of average payment volume over Fedwire). Peak overdraft use steadily increased in the pre-crisis period starting in 2000.

While daylight overdrafts facilitate payments, they also expose the Fed to the potential for loss, should the institutions incurring negative balances fail to replenish their funds. (See Box 6 for more discussion of the evolution of the Fed's Payment System Risk policy).

Box 6

Changes to the Payment System Risk Policy Regarding Overdrafts

The Federal Reserve's Payment System Risk Policy

The extension of intraday credit by Federal Reserve Banks is governed by the Fed's Payment System Risk (PSR) policy. The policy addresses the risks that payment, clearing, and settlement activities present to the Fed and the financial system as a whole, and it also governs Reserve Banks' provision of intraday credit to accountholders. (For more information, see https://www.federalreserve.gov/paymentsystems/psr_about.htm.)

The policy was first written in 1985 and has been amended multiple times since then. It was modified in 1994 to charge banks fees for their use of intraday credit. In 2001, changes to the PSR policy allowed institutions meeting certain criteria to obtain collateralized overdrafts above their authorized capacity, known as net debit caps. In 2006, the policy was revised to require government-sponsored enterprises (GSEs) and international organizations to pre-fund Fedwire payments of principal and interest due on their outstanding debt, thus precluding the Fed from granting intraday credit to these institutions. In 2008, the policy was once again revised by setting the fee for collateralized overdrafts at zero and raising the fee for uncollateralized overdrafts to 50 basis points. This policy change was intended to improve the efficiency of the payments system while also limiting the credit exposure of Federal Reserve Banks. These changes went into effect in 2011.

Changes in Peak Intraday Overdraft Activity

The chart on page 65 presents peak intraday overdraft activity by quarter since 1986. We observe a temporary slowdown in the growth of intraday credit around the time of the implementation of the GSE restriction. However, it is difficult to attribute causation, since other factors may have been responsible for the slowdown. Peak intraday credit resumed growing later in 2006 and ultimately crested sometime in 2008. (See https://www.federalreserve.gov/paymentsystems/psr_data.htm.)

The most striking feature of the chart is the dramatic decline in the use of intraday overdraft credit once the Fed's balance sheet expanded in the fourth quarter of 2008. Excess reserve balances grew dramatically during this time, first from draws on various liquidity facilities and then from the Fed's large-scale asset purchase programs. As excess reserve levels have remained high, demand from banks to borrow funds from the Fed on an intraday basis has remained low for many banks.

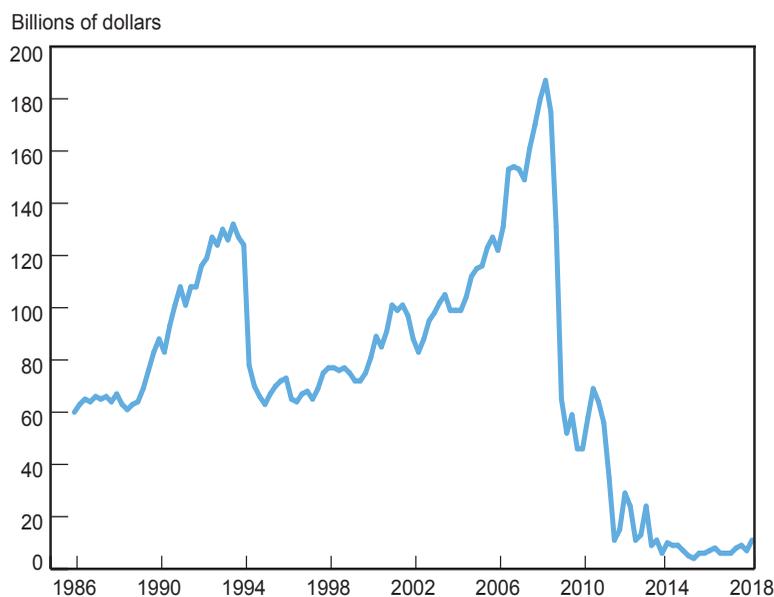
Private Solutions to the Need for Intraday Overdrafts

During the period of high intraday credit use, no private market for providing this specific type of credit materialized. However, there were some informal market-oriented solutions to provide credit on an intraday basis. One solution was for large GSEs to obtain a collateralized intraday credit line from a large money center bank. The other solution for borrowers that were facing large intraday credit needs was to borrow overnight money in the brokered fed funds market on a "fill or kill" basis. With a fill or kill order, the lender agrees to send the funds promptly, say, in a fifteen-minute window, and the borrower returns the funds within a twenty-three-hour window by market convention. The borrower is willing to pay a little more to borrow funds in this manner and thereby receives immediate relief on intraday credit issues by receiving the funds promptly. This solution was widely used by market participants in the pre-crisis period.

(CONTINUED ON NEXT PAGE)

Box 6 (CONTINUED)

Peak Daylight Overdrafts



Source: Federal Reserve Board.

Note: Amounts are based on a 21.5-hour Fedwire day.

5. CONCLUDING REMARKS

Control over the federal funds rate represented the primary policy tool of the Fed's pre-crisis operating framework. In order to exert this control, the Fed relied on a scarcity of reserves to ensure that the fed funds rate would be sensitive to the level of reserves in the system. To adjust the rate, the Desk forecasted the demand for and supply of reserves daily, and then typically increased or decreased the amount of reserves available to banks relative to forecasted demand by changing the size of daily repo operations. The aggregate amount of reserves was distributed among banks by means of trading in the fed funds market. Arbitrageurs aided the framework by transmitting changes in the fed funds rate to other short-term interest rates and to the real economy more broadly. In this article, we discussed the desirability of the pre-crisis framework in the context of meeting monetary policy objectives while conducting monetary operations in an efficient and transparent manner, such that financial market functioning was not impaired.

The pre-crisis framework was effective at meeting monetary policy objectives. First, the Desk successfully maintained the EFFR close to the target rate set by the FOMC, even during

periods of significant volatility in banks' demand for reserves. Furthermore, deviations were not persistent—the Desk generally corrected any short-term movements in the fed funds rate. Finally, changes in the target rate were quickly transmitted to other money market rates.

The pre-crisis framework receives mixed reviews in terms of unimpaired financial market functioning. Having a relatively restricted set of collateral eligible for open market operations ensured that the Desk's operations did not significantly affect the relative pricing of risk. The scarcity-of-reserves paradigm also ensured relatively active trading in the interbank market. However, this same paradigm placed strains on the interbank payment system, leading to heavy use of daylight overdraft credit from the Fed.

The pre-crisis operational framework scores less well in terms of meeting monetary objectives efficiently and transparently. Implementing the operating procedures was complex and the procedures were opaque, which meant that market participants generally found them difficult to understand. In addition, the framework lacked universality in that large changes in aggregate reserve balances could undermine the Desk's ability to control the policy rate. This critique became relevant in 2008 when the Federal Reserve implemented emergency lending programs to combat the effects of the financial crisis. These programs expanded the aggregate amount of reserve balances for reasons other than monetary policy, causing the Desk to lose control over the policy rate. Finally, the daily operational procedures did not adapt well to crisis market conditions as reserves demand became difficult to predict, resulting in high intraday volatility.

In order to regain control of the policy rate, the Fed abandoned the pre-crisis framework in favor of a framework that would allow the Desk to continue to carry out FOMC objectives regardless of the amount of reserves in the banking system. Unlike the pre-crisis framework, the current monetary policy framework is one of reserve abundance, whereby, through the use of administered rates (those rates set by the Fed and not determined in the markets), the fed funds rate is kept within a range set by the FOMC. Using this new framework, the Desk has continued to maintain the policy rate within the target range set by the FOMC. This success demonstrates that while the pre-crisis framework offered effective monetary control, this control was not unique to that paradigm.

The abundant-reserves framework has resulted in changes to other aspects of the pre-crisis framework. With the abandonment of the scarcity-of-reserves approach, banks no longer rely heavily on overdraft credit from the Federal Reserve. As a further by-product, the abundant-reserves framework has diminished banks' need to transact in the fed funds market, causing a reduction in volume (see Box 5). However, the benefits of active money markets are debatable and must be weighed against reduced volatility of the EFRR (Potter 2016).

While the current framework will likely evolve as the FOMC considers its appropriateness in meeting future monetary policy challenges, a return to the pre-crisis framework is not necessarily desirable. As we have shown in this article, the pre-crisis framework had several shortcomings that can probably be addressed.

NOTES

¹ In addition, the mandate requires the Fed to maintain moderate levels of the long-term interest rate (Board of Governors of the Federal Reserve System 1994).

² In this article, we use “bank” to mean “depository institution.” Technically, they are not equivalent, since some nonbank intermediaries, such as credit unions or savings and loan associations, can also take deposits.

³ There is no consensus in the literature regarding the appropriate goals of a monetary policy framework. Our explication is loosely based on Bindseil (2014), who also discusses additional objectives that we do not consider. For example, Bindseil (2014) includes adequate risk-adjusted financial returns on central bank assets as part of financial objectives.

⁴ In a symmetric corridor system, the target rate lies in the middle of the rates for the standing lending and borrowing facilities. The benefits of such a system for liquidity management are discussed in Section 4.

⁵ Since the market fed funds rate varied from trade to trade depending on the creditworthiness of borrowers and other factors, the Fed used a weighted average of market rates as its policy target. Prior to March 1, 2016, the EFFR was calculated as a weighted average based on fed funds transactions as reported to the Desk by fed funds brokers. Effective March 1, 2016, the EFFR calculation was changed from a weighted average mean to a volume-weighted median and the source data were changed to the FR 2420, *Report of Selected Money Market Rates*. The EFFR is published by the Desk on the morning of the business day following the day of the report.

⁶ Under Regulation A, Extensions of Credit by Federal Reserve Banks, as of January 9, 2003, financially strong and well-capitalized banks can borrow under the Fed’s primary credit program at a penalty rate above the target fed funds rate (rather than at a subsidized rate, as was the case prior to this regulation).

⁷ In reality, the stigma associated with borrowing from the Fed deters banks from using the facility, resulting in some borrowing at market rates in excess of the primary credit rate (Armantier et al. 2015; Furfine 2001). Prior to 2003, discount window borrowers had to satisfy the Fed that they had exhausted private sources of funding and that they had a genuine business need for the funds, which likely contributed to the stigma. Since 2003, the discount window has been a “no questions asked” facility but the stigma has continued to exist.

⁸ Theoretical models that incorporate a reserve maintenance period include Gaspar and Rodrigues-Mendizabal (2004) and Ennis and Keister (2008).

⁹ In practice, the Desk managed reserve levels to meet required operating balances, which were equal to reserve requirements plus contractual clearing balances. These were the amounts that some banks voluntarily held at their Reserve Banks to defray the cost of Federal Reserve services (described in more detail in Section 2.2). For simplicity, we refer to “required operating balances” as “reserve requirements” for the remainder of this article.

¹⁰ The Desk also forecast the supply of reserves from discount window lending, but, as previously mentioned, these amounts were generally small. See Meulendyke (1998) for further discussion of the Desk’s daily operations.

¹¹ The Desk may also sell Treasury securities outright, but such transactions are extremely rare. In addition, the Fed may transact with foreign officials and international customers at market prices to make small adjustments to its portfolio without entering the market (see Box 1).

¹² Certain broker-dealers are designated primary dealers. These institutions must meet certain standards and serve as trading counterparties to the Federal Reserve Bank of New York in carrying out monetary policy. They also participate in auctions of government securities and make markets for these instruments.

¹³ See Bernanke (2005).

¹⁴ General collateral Treasury securities are those that have no special features, such as unusually high market demand.

¹⁵ The repo rate is the Desk’s 9 a.m. Primary Dealer Survey Treasury GC Repo rate. Prior to March 1, 2016, the EFFR was calculated by the Desk from broker submissions. Since then, the EFFR has been calculated based on borrowing data submitted by banks in FR 2420, *Report of Selected Money Market Rates*.

¹⁶ Indeed, it could be challenging to explain the daily monetary operations even to experts, as implied by the Board’s own description of the open market policy process (Board of Governors 1963).

NOTES (CONTINUED)

¹⁷ See the European Central Bank *Monthly Bulletin* (2007).

¹⁸ It is possible that, with a wider range of assets, more asset prices are distorted but there is less distortion for each asset.

¹⁹ The ECB, in contrast, accepts a broad range of illiquid collateral but, to avoid distorting prices, uses objective and publicly available criteria in its asset selection and ensures that assets with similar properties are treated in a similar manner. See the European Central Bank *Monthly Bulletin* (2007).

²⁰ See Potter (2016) for a discussion of these issues.

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