Retrospective on Federal Funds Rate Behavior: 1987 - 2004

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Monetary Policy Implementation: lessons from the past and challenges ahead
ECB Workshop
January 20, 2005

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I. Introduction

The overnight interbank borrowing and lending rate plays a key role in the implementation of monetary policy at most major central banks. In the case of the Federal Reserve, this rate, known as the Federal funds rate, has been the operating target of policymakers for many years. Even amongst other central banks that do not formally target an overnight interbank rate, operating procedures and standing facilities for implementing policy often have their most direct and predictable effects on this rate, and the behavior of the interbank rate remains of considerable interest to policymakers.

This paper examines the evolution of the behavior of the overnight U.S. Federal funds rate since 1987, and identifies some of the major factors or developments that have influenced the behavior of this rate over that time. This review is intended to put the current behavior of the Fed funds rate, which has exhibited relatively low levels of volatility in recent years, into broader perspective, and to highlight the kinds of factors within and outside the control of the central bank that can influence its behavior. As the essential features of the framework for implementing monetary policy adopted by the Federal Reserve are broadly similar to those used by many other central banks, the kinds of developments that have influenced the behavior of the Fed funds rate could be relevant for other central banks.

An inspection of the historical record reveals that the behavior of the Fed funds rate has undergone some substantial changes since 1987, despite there having been relative stability in the operating procedures and framework used by the Federal Reserve to implement monetary policy. Changes in the level of total requirements for banks to hold reserve balances with the Federal Reserve have probably had the greatest impact. But many other developments, including measures taken by the Fed in response to higher rate volatility and developments within the banking sector itself, have also had an impact on the interbank rate.

The paper begins with an overview of the Federal funds market, and of the framework and procedures used by the Federal Reserve System to implement monetary policy. The different measures of rate behavior used in this paper are described next. The review of the behavior of the Fed funds rate since 1987 is divided into two parts around the year 2000, which marks the onset of a period of marked decline in most

measures of rate volatility. The following section examines the persistence of deviations of the daily Federal funds rate from its target, and reviews evidence on the impact of volatility of the Federal funds rate on broader financial markets. A final section summarizes.

II. The Federal Funds Market and the Federal Funds Rate Target

Depository institutions operating in the U.S. directly borrow and lend balances in accounts maintained at the Federal Reserve ("reserves") with one another on an unsecured basis in the Federal funds market.[2] While largely an interbank market, government securities dealers and certain federal government agencies that maintain accounts at the Fed also can participate in this market as lenders. The liabilities created when a bank borrows in this market are exempt from reserve requirements (which are briefly described later).[3] Most Fed funds trades settle on a same-day basis and mature the next business day. These transactions settle over Fedwire—the electronic real time gross settlement payments system operated by the Federal Reserve—when the lending institution instructs the Fed to transfer reserve balances out of its Fed account into the account of the borrowing bank.

The funds market is somewhat bifurcated between "brokered" and "direct" trading segments. In the brokered segment, trades are initially arranged anonymously through a handful of brokers, who are not themselves direct principals to the trade. Participation in the brokered segment is largely confined to institutions actively involved in the settlement of wholesale financial transactions. By contrast, in the "direct" segment of the funds market, trades are usually arranged directly over the phone between the borrowing and lending parties. Transactions in this segment typically involve more retail-oriented banking institutions trading with larger correspondent banks that may also participate in the brokered segment.

The brokered segment is highly competitive, with dozens of large banking institutions active participants. The Federal Reserve Bank of New York (FRBNY)

[2] The term "bank" is used interchangeably in this paper with "depository institution," and includes U.S. affiliates of foreign banks.

[3] These liabilities have also remained exempt from all interest rate ceilings that have applied to certain other bank liabilities over the years.

calculates a trade-weighted average Federal funds rate which it publishes daily, using only data for overnight activity collected from major brokers. Hereafter, the expression "Federal funds market" will be used in this paper to refer to this brokered segment, and all measures of the Fed funds rate are based on the data collected by the FRBNY.[4]

The nature of the Federal funds rate objective that the Federal Open Market Committee (FOMC) sets at its meetings has evolved over time. At present, the FOMC directs the FRBNY to use open market operations to maintain the Federal funds rate "at an average of around" a specified level. (The "Desk" is the informal term used to refer to the area within the FRBNY responsible for formulating and executing these open market operations.) This specified level is commonly referred to as the "target" rate. Since February 1994, the FOMC has immediately announced to the public all changes to the targeted level of the funds rate. In the preceding four years or so, the Desk had operated with an implicit target level for the Fed funds rate, and policy changes had been "signaled" through the Desk's choice of open market operations.[5]

At present, the Desk has no specific tolerance band for the funds rate, but in practice even small deviations in the rate from its target, if they have or are expected to persist for more than brief periods, are likely to elicit some response by the Desk. The Desk's tolerance for deviations in the funds rate from target, while never explicit and always difficult to quantify, has undergone subtle changes. The general trend over the period reviewed by this paper has been towards less tolerance for deviations. In fact, going back to the late 1980s, the stance of policy was usually associated with a trading range, and the funds rate was sometimes free to move within that range with minimal interference or by the Desk.[6]

III. Federal Reserve Framework for Implementing Monetary Policy

[4] The choice of 1987 as a starting point for this review was determined by the availability of complete data.
[5] The specification of the operating target went through several incarnations in the decades leading up to the period covered by this paper, including a period in the 1970s when there was a specific Fed funds target level.
[6] For some periods in these early years the desired funds rate was expressed as a 25 basis point range rather than as a specific level. A more detailed review of historical operating procedures during this period is provided in U.S. Monetary Policy & Financial Markets, Ann-Marie Meulendyke, Federal Reserve Bank of New York, 1998.

The basic framework for implementing monetary policy has been relatively stable for the past twenty years, since the move from one-week to two-week reserve maintenance periods in 1984.[7] However, there have been numerous modifications to the basic framework over time, some of which have been prompted by and/or have influenced the behavior of the Fed funds rate. While institutional details may differ, in outline form the basic framework is similar to that used by other central banks to implement monetary policy.

Banks must hold balances at the Federal Reserve in order to meet various requirements. Total requirements have two components: the portion of reserve requirements not met with vault cash holdings, and a "voluntary" form of requirements called contractual clearing balance requirements. Reserve requirements are not remunerated. Banks earn income credits on balances held to meet their clearing balance requirements, at a rate linked to the Fed funds rate. Earned income credits can only be used to pay for certain priced services offered by the Federal Reserve that banks use, thereby placing a ceiling on the potential level of clearing balance requirements a bank might want.

Since August 1998, reserve requirements have been lagged. Clearing balance requirements have always been lagged in the sense that banks must declare the level of any contractual clearing balances before the start of a maintenance period. Banks are subject to monetary penalties if at the end of any two-week reserve maintenance period they fail to satisfy all their requirements within certain allowable bands or carryover limits, or if they end any day overdrawn on their balance at the Fed; but otherwise complete reserve "averaging" is allowed.

A bank that is in generally sound financial condition may borrow on a short-term basis directly from the Fed at a discount window facility called the primary credit facility, at a rate that is normally set 100 basis points above the target level of the Fed funds rate. This facility has been in operation since January 2003. Previously, under the adjustment credit facility, the discount rate had typically been set slightly below the target funds rate,

[7] More institutional detail, which is not particularly relevant for understanding the behavior of the Federal funds rate, may be found in various Federal Reserve publications that are available on the public websites of the Board of Governors, the Federal Reserve Bank of New York, and other District Banks.

and borrowing behavior was controlled by more administrative measures. The Federal Reserve offers no facility to banks for investing, nor does it pay any interest on, excess balances.

The Desk influences the Federal funds rate by using open market operations to adjust the supply of reserve balances each day relative to the period-average level of requirements banks have to hold reserve balances. Estimates of the available supply of reserves are completed early each morning, and with few exceptions no further information on the actual supply of reserves on a given day will be available until the following morning.

The Desk works with rules of thumb for the daily level of reserve supply relative to the level of period-average requirements that is needed to maintain the funds rate around the target. These rules of thumb are highly flexible and have been developed largely on the basis of experience. As it happens, the pattern of daily reserve supply within a maintenance period that keeps the funds rate close to target is usually quite uneven.

Any needed adjustment to the supply of reserve balances will be completed via an open market operation arranged early to mid-morning each day. The Desk is authorized to arrange open market operations by buying or selling U.S. Treasury securities or debt that is issued or guaranteed by any agency of the U.S., either on an outright basis or under temporary repurchase (RP) or reverse RP agreements. The Desk may use a combination of outright and temporary operations to manage its portfolio of domestic securities on any day, but only temporary operations are used to adjust reserve supply on a same-day basis. The final (or last marginal) adjustment to the level of reserve supply will be made mid-morning using a short-term RP or reverse RP, shortly after reserve estimates for the day are complete.[8]

Counter parties on all Desk operations in the market are a subset of the dealers ("primary dealers") active in the U.S. government securities market; the Desk does not operate directly with banks in the Federal funds market.

[8] The timing has shifted over this sample period, from about 11:30 a.m. at the start to about 9:30 a.m. currently.

III. Data Description and Measures of Volatility Used

A complete set of daily Federal funds rate observations from January 1987 through December 2004 has been compiled, based on the information provided by major brokers in the funds market to the FRBNY. Several different measurers of funds rate behavior are used in this analysis.

The deviation of the trade-weighted average daily Fed funds rate calculated at the FRBNY (called the "effective" rate) from the target rate is the most commonly used measure of the Desk's success in keeping the funds rate around the target. Although this difference is not strictly speaking a measure of "volatility," it correlates highly with measures of day-to-day rate movements (e.g., first differences in the daily effective rate) because of the tendency for deviations of the daily effective rate from target to be relatively short-lived. For these reasons, and because it is visually much less noisy than first differences, this measure is used in much of the graphical analysis to capture day-to-day movements in rates. We also measure the absolute values of the daily deviations of the effective funds rate from target.

Several measures are available for capturing intra-day movements in the funds rate. The most direct measure is just the range between the highest and lowest recorded rates on a given day; however, this measure suffers the drawback that the volume of trading that occurs at the extremes each day is typically very small. The intra-day standard deviation of rates around the daily effective is a trade-weighted measure of intra-day volatility that is used in much of the analysis. This series is constructed using the same data used to calculate the daily effective rate.

Calendar Events and Outliers

The Fed funds rate tends to behave differently around certain calendar events. In particular, deviations of the daily effective funds rate from target and intra-day volatility tend to be elevated on so-called high payment flow days, which correspond to the first, middle, and final business day of each month. These are days in which financial payments and settlements are much heavier and more uncertain than usual, with banks often not knowing what their net inflows or outflows will be in their account at the Fed until shortly before the close of trading in the funds market. At that point in the day, wide swings in the rate occasionally occur. Reflecting this potential, rates tend to be at

least somewhat firm on average on these days. Outliers, e.g., observations whose value is far outside normal ranges, are much more likely to occur on high payment flow days (and maintenance period settlement days), but can occur on any day as a result of, say, a large imbalance between aggregate reserve supply and demand or from dislocations in the distribution of supply.

Charting Methods

In this analysis, we are interested in the frequency with which outliers occur and the behavior of the funds rate on high payment flow days, when the potential for more extreme rate movements is seen. But just as importantly we wish to measure what might be called "normal" behaviors of the funds rate, i.e. deviations of daily effective rates from target and intra-day volatility characteristic of the vast majority of days not marked by any noteworthy calendar events or other unusual circumstances. For this reason, in some of the charts the behavior of the funds rate is measured separately for high payment flow days and for other days.

Daily observations for these series can be very "noisy" and difficult to decipher, so various techniques are used to smooth the series. For this reason, summary statistics are sometimes calculated for each individual reserve maintenance period or annually, and medians of daily values are sometimes favored over averages. In some cases, values of observations have been truncated to fit on the edges of the desired scale. These methods allow us to focus on "prevailing" levels of rate behavior in different periods, while still also giving a sense when changes in the size or frequency of outliers have occurred.

The content of the charts (and tables) referenced in the text are described:

Chart 1 – Levels of total and contractual clearing balance requirements, and the target Federal funds rate since 1987.

Chart 2 – All daily observations of deviations in the effective Federal funds rate from its target, since 1987.

Chart 3 – Maintenance period averages of daily effective rates from the target since 1987 (Friday observations are weighted by 3).

Chart 4 – Annual medians of the daily effective funds rate from the target since 1987. High payment flow days and other days are shown separately.

Chart 5 – Medians within each maintenance of the absolute values of the daily effective funds rate from target.

Chart 6 – Annual medians of the absolute values of the daily effective funds rate from target. High payment flow days and other days are shown separately.

Chart 7 – Daily observations of the intra-day standard deviation of the Federal funds rate since 1987.

Chart 8 – Median deviation of the intra-day standard deviations of the funds rate within each maintenance period since 1987.

Chart 9 – Annual values of the median of the daily intra-day standard deviations of the Fed funds rate. High payment flow days and other days are shown separately.

Chart 10 – Daily high-low range of the Fed funds rate and the effective rate measured relative to the target funds rate for 1997 to 2000.

Chart 11 – Daily high-low range of the Fed funds rate and the effective rate measured relative to the target funds rate for 2001 to 2004, with the deviation of the primary credit facility rate from the Fed funds target indicated.

Chart 12 – Daily effective Fed funds rate and the target rate since June 2004.

Chart 13 – Frequency of daily interventions in which the Desk arranged a temporary operation that settled on that same day, since 1993

Chart 14 – Estimated auto regressive relation of daily deviations of the effective Fed funds rate from its target, in each year since 1987.

Table 1 – Chronology of select events since 1987 associated with changes in the framework for implementing monetary policy or that are believed to have influenced the behavior of the funds rate.

Table 2 – Correlations between changes in the standard deviation of daily effective Fed funds rate deviations in a maintenance period volatility with changes in the other interest rates.

IV. Federal Funds Rate Behavior from 1987 to 2000

Declines in Total Requirements

During the decade of the 1990s, one of the most significant developments that affected the behavior of the funds rate was the decline in total requirements (Chart 1).[9] In short, with lower requirements, banks have less scope for "averaging" their reserve holdings over a maintenance period, and banking institutions that settle large financial payments in particular face heightened risks of either ending a day overdrawn on their Fed account, or ending a maintenance period having held more or fewer reserves than needed to meet their total requirements.

This decline in total requirements came in several waves and had more than one immediate cause. Requirements fell abruptly when the Board of Governors eliminated reserve requirements on all non-transaction deposits around year-end 1990. Requirements again fell in April 1992 when the Board reduced the maximum requirement ratio on transaction deposits from 12 percent to 10 percent. The impact of these cuts was soon offset by the effects of rapid growth in monetary aggregates in a declining interest rate environment, and by some increase in contractual clearing balance requirements at large banks seeking to blunt the effects of lower reserve requirements. Then, for several years beginning in 1996, rapid expansion of "sweep" programs at commercial banks designed to reduce deposits subject to reserve requirements brought total requirements down to historically low levels.[10] By 1999, banks had largely exhausted opportunities for expanding sweep programs.

These declines in requirements were associated with a subsequent rise in intra-day rate volatility. Intraday standard deviations jumped in 1991, on both high payment flow days and other days (Chart 8 and 9). Some time after the cut to requirement ratios in 1992, intra-day volatility began to recede, likely helped by a rise in requirements brought on by a decline in interest rates. But intra-day rate volatility rose as the expansion of sweep programs gained momentum starting in 1996, and remained somewhat elevated for several years as this process unfolded.

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[9] In addition to the specific developments cited in this section, the level of reserve requirements has been sensitive to the interest rate cycle, through the impact that interest rate levels have had on the opportunity cost of holding the kinds of bank deposit liabilities that are subject to reserve requirements.

[10] The incentive for these sweep programs is the lack of remuneration by the Federal Reserves on reserve balances banks hold to meet reserve requirements.

The impact on deviations of the daily effective funds rate from target a bit more difficult to summarize. The most profound effects were on the ability to keep the Fed funds effective rate around the target on high payment flow days (Charts 4 and 6). On other days, deviations of the effective from target did appear to become somewhat greater in the wake of the 1991 cuts to requirements, but not from the cuts associated with the spread of sweep accounts. And the ability of the Desk to keep the average daily funds rate around the target over maintenance period intervals did not appear to deteriorate, except in the immediate aftermath of the 1991 cuts (Chart 3).

Federal Reserve and Bank Responses to Declining Requirements

The rise in rate volatility created by the decline in requirements set in motion a number of responses within the Federal Reserve, and among banks themselves, which mitigated the extent of the rise and eventually contributed to a measurable decline in volatility.

Several changes were made to the reserve maintenance accounting framework. Under the contemporaneous reserve accounting rules in effect since 1984, reserve requirements for a two-week reserve maintenance period were based on banks' deposit levels over a two-week computation period that ended just three days before the end of the maintenance period. This arrangement sometimes led to surprises in estimates of total requirements, often coming late in a maintenance period. The Fed shifted to a lagged reserve accounting structure in August 1998. Around this same time, the Federal Reserve increased the size of allowable carryover positions, providing banks with more flexibility for dealing with surprises to reserve positions or responding to movements in the Fed funds rate on maintenance period settlement days.

The Desk also altered some of its daily intervention practices. It became more sensitive to day-to-day movements in the supply of and demand for reserves which, if not accommodated under lower requirements, could lead to more pressure on rates. A by-product of this greater sensitivity has been a significant increase in the frequency of its use of daily interventions to adjust reserve supply around 1996-1997 (Chart 13). Also since that time, the Desk has gradually expanded the number of larger banks on which it collects daily reserve position reports. The primary purpose of this information is to identify situations where a bank has become "locked into" holding unwanted levels of

excess reserves prior to the last day of a maintenance period, as a result of unexpectedly high balances held earlier in a maintenance period. As the incidence and size of these lock-ins grew with the decline in requirements, knowledge of their size became more critical for accurately measuring the cumulative level of reserves that banks would need to square their positions on a maintenance period settlement date.[11]

Developments within the banking community also served to limit the rise in Fed funds rate volatility associated with lower requirements. Perhaps most importantly, banks that are especially active in settling large financial payments on their Fed account invested to reduce the uncertainty of these payment flows. Better information systems and procedures were adopted within institutions that have complex organizational structures for tracking and anticipating payment flows. In some cases this was achieved by assessing costs associated with poor reserve management results on the responsible area within an organization. These kinds of initiatives reportedly received an additional boost as part of the general preparation for the century date change. The trend towards consolidation within the banking sector is believed to have improved the overall efficiency within the banking system for anticipating large payment flows, even as the gross payments volume has grown. And as noted previously, large banks took advantage of the existing, but largely unused, contractual clearing balance program to increase their total requirements. However, the program structure limits the amount by which a bank may usefully increase this component of their total requirements.

Other Developments affecting Volatility

The FOMC's policy to announce changes in the target funds rate immediately, adopted in February 1994, does not seem to have had much impact on rate behavior. This is likely because in the few years even prior to this change, the market had become very adept at reading the Desk's signals intended to communicate the stance of policy. The declines in the deviation of the effective rate from the target in 1989 (Charts 4 and 6), which was not matched by a similar decline in intra-day volitility (Chart 9), reflect the

[11] In the absence of this information and prior to the significant declines in requirements in the 1990s, the Desk implicitly assumed that lock-ins were not significant. Thus, as lock-ins became larger but still went unrecognized, there was greater potential for the Desk to underestimate final reserve needs late in a maintenance period.

gradual shift towards having clearer single target level for the funds rate, albeit one that was still communicated via open market operations.

Certain market episodes have been associated with significant, if transient, increases in rate volatility during these years.[12] Over the second half of 1990 (and lasting into 1991), the financial position of many banking institutions deteriorated markedly. The sense of financial fragility contributed to funding pressures and an increase in measures of intra-day funds rate volatility at the time (Chart 8), and somewhat greater deviations of the daily effective rates from target during that time (Charts 3 and 5). To some degree, increases in measures of intra-day volatility at this time reflected a marked tiering of rates paid in the funds market, particularly by branches and agencies of foreign banks.[13] Fearing the intense scrutiny that might result even from market speculation that a particular bank had borrowed at the discount window in this climate, "stigma" attached to discount window borrowing increased, which acted as a catalyst for increasing rate volatility in the funds market.[14] Rate volatility accelerated as year-end approached, and it was in this environment that the Federal Reserve made its round of big cuts to reserve requirements.[15]

Financial turmoil in the last quarter of 1998 led to increases in the intra-day standard deviation of the funds rate and some incipient upward pressure on rates (Chart 8). The Desk responded by providing abundant liquidity, which on balance led to some tendency for lower daily effective rates during these maintenance periods (Chart 3). In contrast, rate volatility was only slightly elevated in the period around Y2K.

V. Federal Funds Rate Behavior from 2001 to 2004

Factors behind the Decline in Volatility

By 2000, most measures of rate volatility had returned to the lowest levels experienced since 1987. Over the past several years, measures of both intra-day rate volatility and deviations of daily effective rates from target have drifted steadily lower.

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[12] These events do not stand out in the annual charts because of their limited duration.
[13] This development marks a significant departure from the general observation that tiering of rates has been generally quite muted or non-existent in the Federal funds market.
[14] The Federal Reserve has never published the identity of borrowers at the discount window.
[15] These cuts in requirements were made in part to provide some financial relief to the banking sector.

This continued decline in volatility is evident in measures of rate behavior both on high payment flow days and on days not marked by any noteworthy calendar events. The frequency and sizes of outliers in the data are also down dramatically.[16] This decline in volatility can be attributed to several factors.

Several of the trends that helped bring down measured volatility towards the end of the decade of the 1990s have persisted and have continued to reduce volatility. The Desk has steadily expanded the set of larger banking institutions for which reserve positions are collected daily, enabling it to improve further the estimates of period-average demands for excess reserves. This additional information has also served as a useful platform for expanding our routine market contacts, helping us better understand banks' daily preferences for holding reserves within each maintenance period.[17] All these sources of information, and the further increases (albeit slight) in the frequency of daily Desk interventions have allowed the Desk to act more decisively to preempt, and not just respond to, anticipated rate pressures.

The low absolute value of the target Federal funds rate has helped reduce rate volatility through both direct and indirect channels. With the target funds rate having been at historically low levels of either 1 percent or 1 ¼ percent from late-2002 to mid-2004, the potential for abrupt downward moves in the rate has been directly curtailed. It is less clear how upward moves in the funds rate would be similarly limited by a low absolute target rate (even prior to the adoption of the primary credit facility, which is discussed below).

The low target funds rate has indirectly helped reduce volatility by lifting the level of total requirements banks have to hold balances at the Fed. Falling rate levels have spurred growth in demand for transaction deposits at banks subject to reserve requirements, thereby lifting required reserve levels. And a lower target funds rate has lowered the rate of return on contractual clearing balance requirements, increasing the level of these requirements that would be needed to generate income credits sufficient to

[16] Volatility reflected in the daily standard deviation, and in the deviation of the effective rate from target, was elevated briefly in the immediate aftermath of September 11, 2001, the direct result of the supra-abundant levels of liquidity provided by the Desk.

[17] As for estimates of reserve supply, the accuracy of the Desk's same-day projections, as measured by the average absolute forecast "miss," has not changed significantly since 1995, the first year for which we have complete data.

pay for all the Federal Reserve services consumed by a bank. All told, total requirements have risen from prevailing levels of around $13 billion in early-2000 to about $20 billion today.

The impact of the primary credit discount window facility, established in January 2003, on volatility of the Fed funds rate has been difficult to gauge. This new facility does appear to have been fairly effective in capping upward rate movements in the funds market (Charts 10 and 11). Only twice has the market rate exceeded the primary credit rate (and then only by a modest amount and for a small volume of trading), and on several other occasions upward spikes in the market rate halted at the rate on primary credit. Anecdotally, reserve managers have indicated that the new facility has removed some of the old "stigma" that had been associated with borrowing at the discount window. However, in the year or so preceding the establishment of this new facility, the market rate rarely rose as much as 100 basis point above the target funds rate. Given the general absence of market conditions that might give rise to discount borrowing, it is difficult to assess the effect the primary credit facility has had on the behavior of the funds rate, either by directly limiting upward rate spikes, or operating through its influence on market expectations about the potential for upward moves in the funds rate.[18]

Recent Rise in Rate Volatility

Volatility in the Fed funds rate has picked up during the second half of 2004. Daily standard deviations are a bit higher, and deviations of daily effective rates from target are somewhat greater than before, although these measures of volatility are still well below levels prevailing even just a few years earlier. It's tempting to attribute at least some of this increase in rate dispersion and volatility to the higher absolute levels of the target Fed funds rate, but insufficient time has passed to determine how much an impact this has had.

[18] The direction of impact of this last channel is ambiguous. Clearly, the highest potential rate that might develop in the market is lower under the primary credit facility. However, it is equally true that market rates would need to be 100 basis points above the target before a bank would choose to borrow at the discount window. In contrast, under the old discount window arrangements, many banks had demonstrated a willingness to borrow when market rates reached a level that was less than 100 basis points above the target rate, especially if the amount to be

An important contributory factor behind the observed rise in volatility over the past half-year has been the impact of episodes of expectations of policy tightening on the funds rate. For the most part, these effects were confined to the maintenance periods in which policy was expected to be changed—five out of thirteen maintenance periods since mid-year. In all cases, expectations about FOMC policy actions (for a 25 basis point hike) at each of its meetings since mid-year were nearly universally correct, and the funds rate was pressured up towards the expected higher target rate in the days of the maintenance period leading up to the FOMC meeting (Chart 12). The Desk has limited ability to counter these expectations, given banks' ability to arbitrage reserve holdings across a maintenance period for purposes of meeting their total requirements. In some cases when the Desk more aggressively attempted to combat the impact of market expectations on rates ahead of an FOMC meeting, it created imbalances between reserve supply and demand which elevated intra-day rate volatility in the days both preceding and following the date of the FOMC's policy change.

VI. Persistence of Fed Funds Rate Deviations from Target, and Implications of Volatility for Other Interest Rates

Decline in Persistence in Deviations of Rate

Regression techniques were employed to estimate how the persistence of deviations of the daily effective Federal funds rate from its target has changed over the period 1987 to 2004.[19] Time-varying estimates of the coefficients of an auto regressive AR(1) process were obtained, using daily data based on the following specified system:

$\text{Disturbance}_t = \text{Effective}_t - \text{Target}_t$
$\text{Disturbance}_t = A_t * \text{Disturbance}_{t-1} + B_t * \text{HPF}_t + C_t * \text{dTarget}_t + e_t,$
vector $\mathbf{v}_t = (A_t, B_t, C_t) = \mathbf{v}_{t-1} + \mathbf{u}_t$, where

"Effective" is the daily effective Fed funds rate, and "Target" is the target level of the funds rate (or midpoint of any specified range). "HPF" is a dummy variable indicating a

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borrowed was large. Other banks, though, would not borrow until market rates had reached much higher levels.

[19] These regression results are based on work done by Charles Sims, Monetary Projections Staff, FRBNY.

high payment flow date, and "dTarget" is a dummy variable indicating a change in the funds rate target. "$\mathbf{u}_t$" is a vector of normally distributed innovations, each with a mean equal to zero, and subscripts refer to individual days.

The coefficients were allowed to evolve over time and change each day, but were smoothed making use of a Kalman filter. A large portion of the "Disturbance" variable cannot be explained by these three series, although all the variables (especially the autoregressive term) were found to be statistically significant. The average annual value of the coefficient on the AR(1) term, A_t, is plotted in Chart 14. It fell from a value of .75 in 1987 to a level of about .32 in 1996, where it has remained since.

Mechanically, these estimates suggest that at present about one-third of a deviation in the funds rate from target on a given day might be expected to persist into the next day, compared to about three-quarters in 1987. And after two days, less than ten percent of a deviation would be expected to persist at present, compared to over one-half at the start of this sample period. Qualitatively, the persistence of deviations of the funds rate from its target seem fairly small at present, virtually disappearing after just one day. This decline in the autoregressive component reflects several factors that have been mentioned before, including a shift towards a more explicit target for the Fed funds rate since 1987, and less tolerance for deviations from the target, enforced by more frequent open market interventions by the Desk.

Importance for Fed funds rate volatility for other interest rates

Historically, the Desk has succeeded in maintaining the funds rate on average around its target over time, though sometimes with considerable volatility around this target. Movements in the level of the Fed funds rate would be expected to influence other short-term rates, and maybe have some direct impact on rates a bit further out the curve. Likewise, volatility in the funds rate would be expected to be correlated with volatility in rates in other short-term markets that can serve as partial substitutes for the funds market. But available evidence suggests that idiosyncratic movements in Fed funds rate volatility would not have significant effects on interest rate premiums or credit spreads in fixed-income markets. Nor would swings in Fed funds rate volatility

necessarily affect the level of volatility of longer term rates or levels of other short-term interest rates.[20]

To examine this issue empirically, changes in the variability of the Fed funds rate around its target were correlated against a series of other interest rate measures. Because intraday data are generally lacking for these other interest rate measures, all measures of volatility and risk are calculated based on daily data. The basic measure of Fed funds rate volatility used was the standard deviation of the differences between the daily effective rate and the target for the ten days within a maintenance period; changes in this measure of funds rate volatility were calculated by taking the first difference of this biweekly series. Corresponding measures of interest rate premiums, risk, volatility, and levels for each maintenance period were based on daily observations of several other proxy variables, which are described in Table 2. In no case were these correlations found to be significant, supporting the hypothesis that idiosyncratic changes in the volatility of the Federal funds rate do not seem to have much influence on interest rate premiums or risks in other markets.

VII. Conclusions

Examination of Federal funds rate volatility measured at high frequencies shows that funds rate behavior has been influenced by a number of developments or events over the past seventeen years. Perhaps foremost among these have been changes in the level of total requirements. Periods of market stress have shown through to the behavior of the funds market, and in recent years so has a low absolute level of the targeted funds rate. Measures undertaken by the Federal Reserve (including the Desk's operating practices) in response to higher volatility, shifts in the level of "transparency" in the stance of monetary policy, and developments within the banking sector itself on balance have tended to reduce funds rate volatility over time. But not all these developments have influenced the behavior in the funds rate in the same manner. Some have affected both intra-day rate volatility and deviations of daily effective rates from target, while others have had their primary impact on intra-day volatility.

[20] These results are based on work done with staff at the Board of Governors. Only data from 1994 to 2004 were used, limiting results to the period in which the FOMC has been operating

Looking ahead, one of the major factors behind the decline in rate volatility in the inter-bank market over the past several years—the decline in the target funds rate to historically low levels—has already begun to be reversed. So far, however, the modest increases in Fed funds rate volatility experienced in the second half of 2004 seem to be mostly the result of expectations for policy changes on the interbank rate within a maintenance period arising from banks' "averaging" capabilities. The impact that the new primary credit facility has had on the behavior of the Fed funds rate is difficult to assess, other than the direct effect of limiting the potential for rates to rise above the primary credit rate. However, experience with the facility has been limited to an era where financial market stress or turmoil has been largely absent.

Empirical analysis suggests that the tendency for deviations of the Fed funds rate from target to persist has gradually diminished over time, most likely reflecting a reduced tolerance for deviations of the funds rate from the target implicit in the Desk's actions. Furthermore, volatility in the Fed funds rate does not tend to spill over into other financial markets, either in the form of higher rates, more volatile rates, or higher risk premiums.

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with a publicly announced operating target.