

FINANCIAL MARKET RESPONSES TO MONETARY POLICY CHANGES IN THE 1990s

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The operating target for monetary policy in the United States has changed from borrowings in the late 1980s to a target range for the fed funds rate to a specific fed funds target. In addition, secrecy about the policy target has largely disappeared, and since 1994 policy targets have been announced immediately. This article explores the impact of policy decisions on short-term interest rates as the policy announcements have changed. The authors find that the policy changes had a larger impact when the Fed moved to a specific emphasis on the fed funds rate. However, since the Fed began to announce the targets, policy changes have had a lesser effect on rates. (JEL E52, E58, G14)

The Federal Reserve has made numerous changes in both the way it conducts monetary policy and the way it conveys monetary policy changes to the public. After its brief flirtation with monetary aggregate targets from 1979–82, the Fed introduced borrowed reserves targeting and then gradually moved to federal funds rate (FFR) targeting. Moreover, in the 1990s, the Fed removed both the secrecy that long surrounded the policy targets and the delays in policy announcements. Everyone now knows that the Fed pursues a specific target for the FFR and that the Fed makes an immediate announcement of changes in the target rate. In addition, since the introduction of immediate policy announcements, the Fed has made virtually all target rate changes at regularly scheduled Federal Open Market Committee (FOMC) meetings. These procedures are quite a reversal from previous decades, when the Fed was unwilling to acknowledge its choice of policy target, made no public announcements of

policy changes, and frequently adjusted policy between FOMC meetings.

In this article the authors examine the variation in the financial market responses to policy changes in the 1990s as the Fed altered its policy targets and its procedures for policy announcements. Specifically, the authors investigate several hypotheses concerning the impact and lagged effects on short-term interest rates of changes in the fed funds target. First, the magnitude of the effects should increase when the Fed puts more emphasis on interest rates for both the operating and intermediate targets and is less concerned with the monetary aggregates.¹

Second, the impact of policy changes diminishes when the Fed begins immediate announcements of the policy target because the announcements make policy changes less uncertain and more easily predicted.²

1. This hypothesis relates to the behavior of interest rates when the Fed changes policy targets. Generally, there could be more interest rate variability when the Fed is following a smooth monetary aggregates target.

2. Roley and Sellon (1996) and Pakko and Wheelock (1996) argue that monetary policy became more

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ABBREVIATIONS

FFF: Federal Funds Futures
FFR: Federal Funds Rate
FOMC: Federal Open Market Committee
TB3: 3-Month Treasury Bill Rate

This hypothesis is just the opposite of the argument used by the Fed for decades, that immediate policy announcements would aggravate announcement effects and make policy implementation more difficult (see Belongia and Kliesen [1994]). The policy targets may have become more predictable because the new announcement procedure introduced in 1994 coincided with the Fed beginning to make target rate changes almost exclusively at regularly scheduled FOMC meetings. Finally, immediate disclosure tends to reduce the delayed market response and thereby increases the immediate responses to policy changes.

The major findings of this article are:

- The size of the immediate market responses to policy changes increases when the Fed adopts the funds rate as its target and virtually ceases to monitor the monetary aggregates in the early 1990s.
- The market responses to policy changes decline in 1994 when immediate policy announcements are introduced.³
- Prior to the public policy announcements, market responses to policy changes often continued for several days after the policy change, but since that time there have been no delayed responses.
- The fed funds futures (FFF) market largely anticipates Fed policy changes since immediate policy announcements were introduced.

There is a large literature on financial market responses to changes in monetary policy, particularly money supply announcements in the 1970s and 1980s, and to data announcements in general. More recently several studies (Balduzzi et al., 1997; Cook and Hahn, 1989; Robertson and Thornton, 1997; Roley and Sellon, 1995, 1996) have examined the impact of target rate changes on financial rates. For example, Roley and Sellon (1996) present a model of the term structure's response to target rate changes and conclude that changes in the FFR target affect both short-term and long-term interest rates and that target rate changes have

become more predictable since 1987. As a result, a greater portion of the target rate changes is reflected in interest rates before the policy action is actually taken. Thus, the immediate interest rate response is lessened due to the greater predictability of the target changes.

There have been only a few articles that examine the changes in Fed procedures in the 1990s, and none of these include more than a few observations since 1994, when the Fed started announcing policy changes. In this journal, Belongia and Kliesen (1994) examined the period 1989–93, which begins with the use of explicit federal funds targets for policy and culminates with the decision to announce these targets. Their principal finding was that the financial markets were largely unaffected by the move toward more transparent policy. Two more recent papers in the *Federal Reserve Bank of St. Louis Review* by Thornton (1996, 1998) also conclude that the change in policy announcement procedures did not increase market volatility. Thornton also finds that the magnitude of the market response has not been affected by the immediate disclosure of target changes and that the market response to this immediate disclosure occurs immediately.

Section I of this article describes the evolution of monetary policy from the late 1960s through the 1990s. The data are described in section II. Section III examines the change in market rates from immediately before to immediately after FFR target changes. Section IV examines the degree to which the market rates reflect target changes before they occur and the speed with which target rate changes are reflected in market rates. Section V shows regressions estimates of the market reactions and tests for variation in the responses to target changes.

I. EVOLUTION OF MONETARY POLICY IMPLEMENTATION

The FFR has been the operating target for monetary policy throughout the 1990s. The use of a funds rate target was developed in the 1960s and was used through the 1970s until October 1979 when the Fed introduced a procedure for targeting monetary aggregates instead. The Volcker Fed's experiment with a monetarist approach lasted about three years, after which it was replaced

predictable during the 1990s. Furthermore, Belongia and Kliesen (1994) show that there were no unusual interest rate movements when policy changes were "leaked."

3. The differences are not significant in all interest rate markets. Thornton's (1998) somewhat different conclusion is due to differences in the sample of policy changes.

by a borrowings target. As the demand for discount window borrowing became less stable and less predictable, the Fed increased its emphasis on the target for the funds rate. By the end of the 1980s, the Fed had returned to the explicit fed funds targeting procedure that is in use today.⁴

As the procedures changed, there was considerable variation in market responses to expected or actual changes in policy. An extensive body of econometric literature documents these phenomena (Cook and Hahn, 1989; Thornton, 1998). The earliest studies looked at the effect of weekly announcements of changes in M1 and M2 on interest rates. Interest rates changed because market participants expected the Fed to respond when money growth deviated from the desired rates. Moreover, the response was largest when policy makers emphasized the importance of the monetary aggregates (Urich and Wachtel, 1981).

In addition to changes in the operating target used by the Fed, there have been changes in the information announced about policy and the speed with which it is made public. In fact the public disclosure by the FOMC of information about changes in monetary policy underwent a sea change in the 1990s. The first change occurred in December 1989, when the Fed began to publish information on the midpoint of the FFR range expected to be consistent with its borrowings objective. This was really a formal indication that the Fed had returned to fed funds targeting.

Traditionally, the Federal Reserve has been reluctant to release information about policy deliberations, although they would accede to pressures to do so. In 1989, the start of our data, the FOMC's policy directive to the open market desk and a "policy record" that reported the highlights of the meeting were released a few days after the subsequent meeting (a delay of approximately 45 days).⁵ These procedures,

4. Poole (1999) notes that the current approach to implementing monetary policy is the same as the one used in the era of increasing inflation rates, and thus there is no guarantee that current practice will maintain low inflation.

5. For many years the Fed avoided using the term "minutes" for this information. Currently the terms used are "statement" for the announcement made immediately after the meeting, "minutes" for the directive and policy record, and "transcript" for edited transcripts that are made available with a five-year delay.

which had been introduced in the mid-1970s, were challenged unsuccessfully by Freedom of Information Act suits that tried to force the Fed to provide more timely information (see Belongia and Kliesen [1994] for descriptions of the 1976 and 1981 opinions in the *Merrill v. the FOMC* cases). The delay in the public release of information about monetary policy had prompted some members of Congress, the news media, and some financial market participants to accuse the Fed of being unnecessarily secretive. Critics of the Fed argued that the failure to convey its intentions to the market in a timely fashion increased financial market uncertainty and volatility. The Federal Reserve countered that the immediate disclosure of monetary policy changes would interfere with its conduct of monetary policy and also would cause an announcement effect, thereby producing more, not less, financial market volatility.

The Fed's views began to change in the 1990s. Moreover, in the early 1990s, newspapers frequently reported changes in monetary policy long before the release of the FOMC directive.⁶ On February 4, 1994, the FOMC broke with prior practice and announced that it had decided to "increase slightly the degree of pressure on reserve positions... [an action] expected to be associated with a small increase in short-term money market rates." The immediate announcement of a policy change represented a dramatic shift in the FOMC's attitude toward the public release of information about future monetary policy. From this point forward, the FOMC continued to announce policy changes immediately after a change had been made. These announcements contained both a brief qualitative discussion about the policy decisions and gave an indication of the magnitude of the impact on the FFR. For example, the announcement following the August 16, 1994, meeting disclosed that the FOMC had decided to increase the discount rate 50 basis points and that "this increase would be allowed to show through completely into interest rates in reserve markets" (see Pakko [1995]).

Starting in July 1995, the Fed began to announce the specific target rate immediately

6. Belongia and Kliesen (1994) document leaks found in the *Wall Street Journal* on 11 occasions between 1989 and 1993.

after a decision had been made to change policy. All but 2 of the 14 target changes between January 1994 and December 1998 were made at regularly scheduled FOMC meetings. In contrast, from January 1989 to December 1993, only 7 out of the 30 target changes were made at regularly scheduled FOMC meetings.

Further, after the December 1998 FOMC meeting, the Fed announced that it would make additional information public by issuing explanations of monetary policy on an infrequent basis. It said that these announcements would be used to communicate a major shift in views about the balance of risks or the likely direction of future policy, even at times when interest rates were not changed. This approach soon turned out to be confusing; in January 2000, the Fed announced that a public policy statement would be issued immediately after every FOMC meeting. It now appears that the Fed considers more, not less, public disclosure valuable to its conduct of monetary policy.

Notwithstanding the Fed's earlier arguments against the immediate public disclosure of information about changes in monetary policy, there had been some public disclosure of information about changes in current monetary policy prior to 1994, both through discount rate changes and "leaks" to the financial press. During this period, discount rate changes, which are always made public, had been made at the same time as changes in the FFR target. Furthermore, from 1989 to 1998, the Fed changed the discount rate every time it changed the target rate 50 basis points or more. Thus, a discount rate change implied a strong probability that a FFR target change had also occurred.

II. THE DATA

A. Policy Changes

Federal funds target rates and discount rate changes are shown in Table 1. The authors start in 1989 when, as already noted, the Fed had clearly returned to fed funds targeting. Between January 1989 and December 1998, there were 44 changes in the federal funds target rate and 15 changes in the discount rate. From January 3, 1989, to July 7, 1989, the federal funds target was set as a range that varied from 0 to 12.5

basis points. After that, the federal funds target was a single value. An average of the lower and upper limits of the range was used as the target when a range was specified. The federal funds target was 9% on January 3, 1989, and was increased in six small increments to an average target range of 9.8125% on May 4, 1989. The target was then reduced 24 times between May 5, 1989, and September 4, 1992, to 3%. These 24 reductions consist of 21 reductions of 25 basis point and 3 reductions of 50 basis points. From September 5, 1994, to February 1, 1995, there were seven increases in the FFR target to 6%, three increases of 25 basis points, three increases of 50 basis points, and one increase of 75 basis points. The fed funds target was then reduced 25 basis points in July 1995, December 1995, and January 1996; increased 25 basis points in March 1997; and then decreased 25 basis points in September, October, and November 1998. Most changes in the federal funds target rates took place at least one month apart. However, there were several instances early in the period where as many as four changes in the target rate took place within days of each other.

The 15 discount rate changes were all made on the same day as a funds rate target change and were always made when there was a large (50 basis points or more) change in the FFR target. Discount rate changes are typically made to bring the discount rate into line with the FFR and are perceived by financial market participants as a confirmation of the direction of monetary policy.

B. Interest Rates

The interest rate data are (1) the overnight effective FFR, (2) the secondary market closing discount rates for three-month U.S. Treasury bills (TB3), and (3) the fed funds futures rate (FFF) for the contract that matures in the month following a change in monetary policy.

The FFR and TB3 data are from the Federal Reserve Statistical Release H.15. The settlement prices for the FFF is calculated from the closing prices observed around 3 p.m. EST. The daily effective FFR is a weighted average of reported rates from the day's trading that occurs through New York brokers, where the weights are the dollar amounts of the trades. The TB3 secondary

TABLE 1
Changes in the Federal Funds Rate Target and Discount Rate

Change Number	Date of Change	Scheduled FOMC Meeting = M	New Target	Target Change	Discount Rate	Discount Rate Change
1	1051989		9.00	.25	6.50	
2	2091989		9.06	.06		
3	2141989		9.31	.25		
4	2231989		9.56	.25		
5	2241989		9.75	.20	7.00	.50
6	5041989		9.81	.06		
7	6061989		9.56	-.25		
8	7071989	M	9.31	-.25		
9	7271989		9.00	-.31		
10	10161989		8.75	-.25		
11	11061989		8.50	-.25		
12	12201989	M	8.25	-.25		
13	7131990		8.00	-.25		
14	10291190		7.75	-.25		
15	11141990	M	7.50	-.25		
16	12071990		7.25	-.25		
17	12191990	M	7.00	-.25	6.50	-.50
18	1091991		6.75	-.25		
19	2011991		6.25	-.50	6.00	-.50
20	3081991		6.00	-.25		
21	4301991		5.75	-.25	5.50	-.50
22	8061991		5.50	-.25		
23	9131991		5.25	-.25	5.00	-.50
24	10311991		5.00	-.25		
25	11061991	M	4.75	-.25	4.50	-.50
26	12061991		4.50	-.25		
27	12201991		4.00	-.50	3.50	-1.00
28	4091992		3.75	-.25		
29	7021992		3.25	-.50	3.00	-.50
30	9041992		3.00	-.25		
31	2041994	M	3.25	.25		
32	3221994	M	3.50	.25		
33	4181994		3.75	.25		
34	5171994	M	4.25	.50	3.50	.50
35	8161994	M	4.75	.50	4.00	.50
36	11151994	M	5.50	.75	4.75	.75
37	2011995	M	6.00	.50	5.25	.50
38	7061995	M	5.75	-.25		
39	12191995	M	5.50	-.25		
40	1311996	M	5.25	-.25	5.00	-.25
41	3251997	M	5.50	.25		
42	9291998	M	5.25	-.25		
43	10151998		5.00	-.25	4.75	-.25
44	11171998	M	4.75	-.25	4.50	-.25

Note: Prior to 1994, the date listed is the date the target change was implemented. Starting in 1994, the date listed is the announcement date of the change.

market rates are averages of the bid discount rate quotes by a sample of primary dealers who report to the Federal Reserve Bank of New York at approximately 3 p.m. EST. The FFF is derived from settlement prices for the Chicago Board of Trade 30-Day fed funds futures contract.⁷

III. IMMEDIATE MARKET RESPONSE TO CHANGES IN THE FFR TARGET

Table 2 presents the immediate response in the fed funds cash and futures markets and the Treasury bill market to changes in the FFR target. For the policy changes from 1989 through 1992, the effective FFR is calculated from the day before to the day that the target rate change is implemented. For subsequent policy changes, the change in FFR is calculated from the day of the target rate change announcement to the day after the announcement. Most of the target rate changes are announced in the early afternoon EST, after banks have normally set their reserve positions for the day.⁸ Thus, the announcement of a target rate change should have little impact on FFR on the day of the announcement.

Throughout the sample period, FFR appears to respond to changes in policy targets. Changes in FFR are generally negative for decreases in the target rate and positive for increases in the target rate. The exception is the period of monetary tightening from January 1989 to May 1989 where changes in FFR are negative for increases in the target rate. However, FFR is a noisy signal of changes in Fed policy because there are substantial day-to-day variations in the rate due to changes in the supply and demand

for funds that are not related to changes in monetary policy. Several of the changes in FFR appear to be unrelated to the target rate changes because they are either (1) disproportionately large given both the size of the target rate changes, or (2) disproportionately large and in the wrong direction. For example, on February 1, 1991 (target change number 19), there was a 188-basis-point decrease in FFR in response to a 50-basis-point decrease in the target. Likewise, the roughly 100-basis-point increases on each of November 14, 1990, October 31, 1991, and December 19, 1995 (target change numbers 15, 24, and 39), are both large and in the wrong direction. Examination of the data shows that these changes are due to large changes either on the day before or on the day of the target rate change, which reversed on the subsequent day.

Next, we examine the target rate change effect on the TB3 and the FFF for the contract that matures in the month following the target change. From 1989 through 1992, the changes in TB3 and FFF are calculated from the day before to the day of the target rate change. Subsequently, the changes in TB3 and FFF are calculated from the day before the announcement to the day of the announcement.⁹

Table 2 shows that prior to the change in data announcement at the start of 1994, both FFF and TB3 typically decrease on the day of target rate decreases and increase on the day of target rate increases. The magnitude of the changes increases as the change in procedure approaches. The average changes in FFF and TB3 for the last four target rate changes prior to 1994 (numbers 26–30) are –25 and –26 basis points, respectively, more than twice the average of the changes for the whole period prior to 1994. Note, however, that two of the last four target changes prior to policy announcements started are 50 basis points, whereas most of the earlier changes are 25 basis points. The only other large change in interest rates after a policy change prior to 1994 is number 19 (February 1, 1991)

7. The underlying asset for the futures contract is the average of the effective overnight FFR (as reported in the H15 Statistical Release) during the settlement month. The final settlement price is 100 minus the average daily overnight FFR for the delivery month. The average rate is the average of the rates on every calendar day of the month. Consequently, a normal Friday's rate is used for three days in the average, Friday, Saturday, and Sunday. The final settlement price is set by the exchange on the first bank business day after the last trading day. The last trading day is the last business day of the delivery month. The futures price data are converted to rates (FFF) by subtracting the futures price from 100.

8. Banks normally borrow or lend reserves in the federal funds market early in the day. They typically adjust their reserve positions late in the day only in response to unanticipated changes in their need for reserves.

9. TB3 is a market-closing rate, and FFF is the rate implied by the settlement price of the futures contract. Both rates are taken well after the announcements and reflect the immediate response to the announcement. The exception is target change number 43, which was announced at 3:14 p.m. on October 15, 1998. For this observation, the changes in the TB3 and the FFF rate were calculated from October 15 to October 16.

TABLE 2
Immediate Market Response to Changes in the Federal Funds Target Rate before and after Announcements

Change Number	Date of Change	Target Change	Federal Funds	3-Month Treasury Bill	Fed Funds Futures
<i>Before announcements</i>					
1	1051989	.25	-.35	.02	.00
2	2091989	.06	-.07	-.05	.01
3	2141989	.25	-.01	.01	.04
4	2231989	.25	-.21	.08	.14
5	2241989	.19	.19	.04	.14
6	5041989	.06	-.24	.00	.02
7	6061989	-.25	-.06	-.10	.01
8	7071989	-.25	-.23	-.04	-.05
9	7271989	-.31	.14	-.12	-.06
10	10161989	-.25	-.18	-.17	-.16
11	11061989	-.25	.00	.03	.03
12	12201989	-.25	-.08	-.10	-.10
13	7131990	-.25	-.11	-.08	-.09
14	10291190	-.25	-.10	.02	-.02
15	11141990	-.25	.92	.03	.02
16	12071990	-.25	-.19	-.11	-.14
17	12191990	-.25	-.24	-.11	-.16
18	1091991	-.25	-.06	-.19	-.08
19	2011991	-.50	-1.88	-.19	-.20
20	3081991	-.25	-.26	-.10	-.13
21	4301991	-.25	.05	-.08	-.17
22	8061991	-.25	-.09	-.09	-.09
23	9131991	-.25	-.22	-.06	-.04
24	10311991	-.25	.79	-.02	-.05
25	11061991	-.25	-.19	-.13	-.12
26	12061991	-.25	-.20	-.07	-.11
27	12201991	-.50	-.49	-.30	-.26
28	4091992	-.25	-.11	-.21	-.21
29	7021992	-.50	-.43	-.31	-.32
30	9041992	-.25	-.31	-.22	-.20
<i>After announcements</i>					
31	2041994	.25	.12	.10	.09
32	3221994	.25	.03	.00	-.04
33	4181994	.25	.01	.11	.10
34	5171994	.50	-.01	.05	.05
35	8161994	.50	.37	.17	.10
36	11151994	.75	-.06	.10	.09
37	2011995	.50	.73	.07	.02
38	7061995	-.25	-.29	-.14	-.07
39	12191995	-.25	1.11	-.11	-.11
40	1311996	-.25	-.44	-.08	-.07
41	3251997	.25	.04	.04	.04
42	9291998	-.25	.70	.07	.06
43	10151998	-.25	-.76	-.49	-.20
44	11171998	-.25	-.54	-.17	-.06

when there is a 50-basis-point target change and a 50-basis-point discount rate change.

In the year after the change in announcement procedures (1994), there are several target rate increases, and, except for one target rate change, FFF and TB3 both increase on the days of target rate increase announcements. However, the magnitude of the interest rate response is smaller than just prior to the change in procedure, despite the fact that four of the seven target rate increases are 50 basis points or greater. For these seven target rate increases in the year after the change in the announcement procedure, the average changes in FFF and TB3 are only six and nine basis points, respectively.

Policy begins to loosen in 1995, and FFF and TB3 decrease following five of the six target rate decreases. However, the changes in FFF and TB3 are small when compared to the responses observed just prior to the change in announcement procedure. The exception is target rate change number 43 (October 15, 1998), which caught the market by surprise because it was not made at a regularly scheduled FOMC meeting and occurred only three weeks after the previous target change.

The raw data in Table 2 suggest that the FFR, FFF, and TB3 all respond to changes in the funds target rate. Furthermore, the magnitudes of the changes in TB3 and FFF are very similar to each other throughout our sample interval. However, there is a period of larger responses just prior to the Fed's change in its announcement procedures.

IV. GRADUAL RESPONSES OF THE FUNDS RATE TO TARGET CHANGES

If market participants anticipate a change in the target funds rate, the funds rate may move toward the new target even before any policy change is made. In addition, the impact of a target change may not always be instantaneous. The response may be delayed for some days after the policy change. In this section, the article examines the lags and leads in fed funds reactions—in both the spot and futures markets—to target rate changes before and after the change in announcement procedure.¹⁰

10. The spot FFR may not move toward a new target rate very far in advance of an anticipated change.

Define FT_t as the average deviation on day t of the effective FFR from the new target rate calculated as

$$FT_t = (1/N) \sum_{i=1}^N (FFR_{it} - T_i),$$

where N is the number of target changes in the sample interval, FFR_{it} is the effective FFR on day t relative to target change i , and T_i is the new target rate for target change i .

The response of the FFF to changes in the target rate is examined by looking at the deviation between the FFF and the new target rate. FFT_t is the average deviation at time t of the FFF rate from the new target rate calculated as

$$FFT_t = (1/N) \sum_{i=1}^N (FFF_{it} - T_i),$$

where FFF_{it} is the rate on day t relative to target change i that is implied by the futures contract that matures in the month following the month of the target change i .¹¹

Figure 1 shows FT_t and FFT_t calculated for ten days before to ten days after a target change for two time periods. The top panel shows the target rate changes for the period of monetary easing prior to the change in announcement procedure in 1994. The bottom panel shows the target rate changes following the start of policy change announcements. In this period there is a period of monetary tightening followed by a period of monetary easing. To provide a consistent picture of average deviations from target, the signs are reversed on deviations when there are target rate increases.

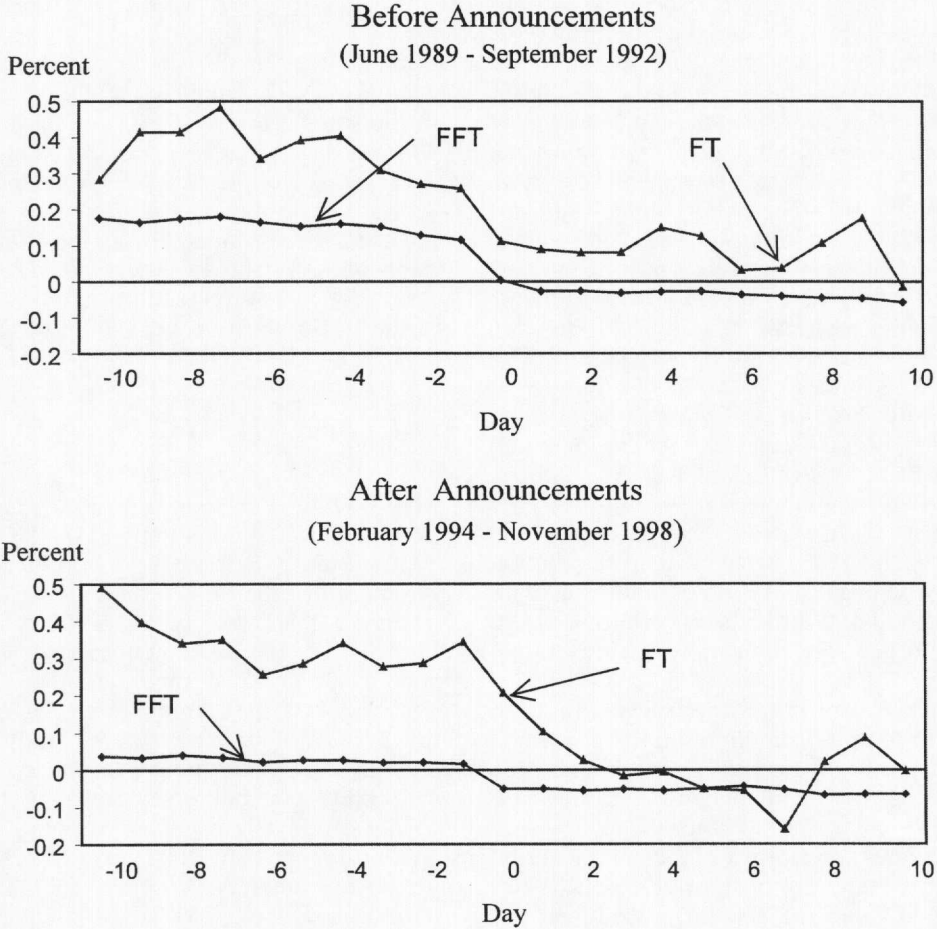
The top panel of Figure 1 also shows that prior to the policy change announcements, the funds rate slowly drifts from roughly 40 basis point above the new target rate a week before the target change, to 25 basis points above the target on day -1 , the day before the change. FT_t then declines 15 basis points

The overnight FFR is the rate for overnight reserve balances. Because reserve balances are perishable, future reserves and immediately available reserves are not good substitutes for one another. The same argument cannot be made for the FFF.

11. The authors also examine the deviations of the futures rate from the final settlement price of the contract and from the average target rate in the settlement month. Results are basically the same as those shown here.

FIGURE 1

FT_t and FFT_t From Ten Days Before to Ten Days After a Target Change Before and After Announcements[#]



[#]In the bottom figure, the signs are reversed on the deviations when there are target increases to provide a consistent picture of average deviations from target.

to roughly 10 basis points above the target on day 0, the day that the target change was implemented, and then slowly drifts to near zero over the next several days.

Target rate changes in this period did not typically occur at regularly scheduled FOMC meetings. Although the FFR declined consistently, the dates and magnitudes of the changes are hard to predict. The FFR decline in the week before the target change may have been due, at least in part, to a lower demand for funds as the economy slowed. Fed watchers have also suggested that the FOMC sometimes lowered its target rate to make it consistent with

the market-determined FFRs. Nevertheless, there appears to be a FFR response to open market operations (and/or a discount rate change) on the day the target changes are implemented. Moreover, it is hard to believe that the Federal Reserve, if it so desired, could not move the effective funds rate to its new target level, about an additional ten basis point on average, on the first day that the new target rate was in place. The delay in reaching the new target level suggests that the Fed let the FFR drift to its new target rate and/or slowly moved the FFR to the new target.

The story told by the futures data is slightly different. Prior to the change in announce-

ment procedure, FFT_t is slightly greater than 15 basis points until about three days before the target change. It then declines five basis points over the next three days to roughly ten basis points on day -1, the day before the change. FFT_t drops to zero on day 0, the day of the target change, and then gradually decreases another five basis points over the next few days. The futures data suggest that the market anticipates a change in the target rate before the end of the next month. As the date of the target change nears, the expectation of a target change in the near future increases. The fact that the futures rate drops to the target rate on the day the target change is implemented indicates that the market is able to ascertain that the target has been changed and accurately predicts the new target rate. This is despite the fact that the Fed did not use open market operations to immediately push the FFR to its new target rate. The average deviations of the futures rate from the settlement rate (not shown in the figure) is approximately 30 basis points ten days before the target change and drops to 15 basis points on day 0. This difference with FFT_t indicates that market participants correctly forecast that there would be another target rate change before the contract maturity in the subsequent month.

After the change in announcement procedure, virtually all target rate changes occur at regularly scheduled FOMC meetings. On average, the funds rate is about 40 basis points away from the target a week before the change and about 20 basis points away on the day the change is announced. It reaches zero within a day or two of the announcement. As expected there is almost no change in FFR on the day of announcement because the funds rate has largely been determined for the day prior to the announcement. The funds market appears to correctly anticipate changes in the target but not always the full amount of the change.

After the change in the announcement procedure, the futures market data show small deviations from the target prior to the target change. The futures rate changes on the announcement date and overshoots the target change by about ten basis points. Thus, it appears that the futures contract fully anticipates the target change before it occurs, and the announcement of a change leads the market to forecast a further change before the

end of the following month. In 1995, the year following the change in the announcement procedure, there are target rate increases four months in succession that are followed by three large target rate increases spread out over several months. The financial markets have a difficult time predicting the timing and magnitude of each of these changes.

V. TESTS FOR A CHANGE IN THE INTEREST RATE RESPONSE TO TARGET CHANGES

In this section the authors present regression estimates of the impact of changes in the FFR targets on interest rates. The immediate market reaction to target changes is examined with the following equation:

$$(1) \quad \Delta R_{it} = \beta_0 + \beta_1 \Delta T_t,$$

where ΔR_{it} = change in rate i from day $t - 1$ to day t , and ΔT_t = change in the FFR target from day $t - 1$ to day t . Table 3 summarizes the results of estimating equation (1) for the 44 target rate changes between 1989 and 1998 using ordinary least squares with White's heteroskedasticity-consistent standard errors reported in parentheses.

The top panel of Table 3 shows the estimates of β_1 with each interest rate. All three coefficients are positive, and the impact on the FFF and the TB3 are significant at the 1% level. The impact on the funds rate is significant only at the 6% level, although the coefficient is the largest of the three, 0.451.

The authors next examine the impact of target rate changes prior to and after the start of policy announcements in 1994, using dummy variables

$$(2) \quad \Delta R_{it} = \beta_0 + \beta_1 \Delta T_t \cdot x1_t + \beta_2 \Delta T_t \cdot x2_t,$$

where $x1_t$ takes on a value of 1 in the preannouncement period and 0 in the postannouncements period, and $x2_t$ takes on a value of 0 in the preannouncement period and 1 in the postannouncements period. β_1 in equation (2) measures the impact of target changes prior to announcements and β_2 measures the impact after announcements. The results are summarized in the bottom panel of Table 3 and indicate that the responses to target changes are positive for the periods both before and after announcements but

TABLE 3
Interest Rate Response to Target Rate Changes

	Federal Funds	3-Month Treasury Bill	Fed Funds Futures
$\Delta R_{it} = \beta_0 + \beta_1 \Delta T_t$			
β_0	-.032 (.060)	-.037 (.012)	-.030 (.011)
β_1	.451 (.241)	.300* (.039)	.268* (.039)
R^2	.083	.497	.555
σ_e	.457	.091	.074
D.W.	2.26	2.20	1.65
$\Delta R_{it} = \beta_0 + \beta_1 \Delta T_t \cdot x_{1t} + \beta_2 \Delta T_t \cdot x_{2t}$			
β_0	-.006 (.091)	-.036 (.020)	-.010 (.013)
β_1	.606 (.478)	.307* (.069)	.381* (.058)
β_2	.318 (.687)	.288* (.084)	.171* (.042)
R^2	.089	.497	.615
σ_e	.461	.092	.069
D.W.	2.25	2.20	1.78
Wald test F -statistic:			
$H_{10} : \beta_1 = \beta_2$	.29	.02	6.67*

Notes: White's heteroskedasticity-consistent standard errors are in parentheses after each regression coefficient. *Statistically significant at 5% level.

smaller in the latter period. However, a Wald test for the equality of the coefficients for the pre- and postpolicy announcement periods differ significantly only for the FFF.

In the postannouncement period almost all policy changes were made at regularly scheduled FOMC meetings, whereas in the earlier period only one-fourth of the changes were made at regular meetings. Although the number of target changes is fairly small, the authors tested for differences in the impact of changes made at regular meetings or at other times. The results (not shown here) indicate that there are no significant differences between the impact of changes made at FOMC meetings or at other times.

In addition to the change in the announcement procedure in early 1994, there are other reasons why the impact of a target change on market interest rates might vary. For example, there are at least two reasons why the impact of target changes should have increased during the preannouncement period. First, both the increased importance of the funds rate target for policy after 1989 and the use of specific policy targets could have resulted in increased impact of target changes. Second, publicity about leaks of policy information both before and after FOMC

meetings led to an increased emphasis on the policy changes.

Thus, it is of interest to examine the variation in the impact of policy target changes on interest rates. However, the irregularity of the time between target changes and the small sample size indicate that a time-varying parameter estimation is not an appropriate methodology to use with this data set to capture variation in the coefficients.¹² Alternatively, the method of recursive residuals can be used to test for coefficient instability.¹³ We examine the cusum and cusum squared plots (not shown here) for the estimates of equation (1) with each of the three interest rates, and find some evidence of coefficient instability, most strongly for the Treasury bill equation.

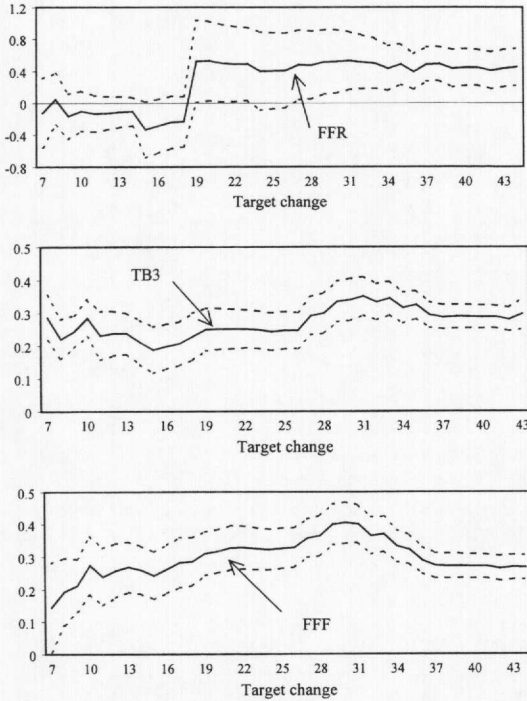
Figure 2 shows the β_1 coefficients from recursively estimating equation (1). These plots show the coefficients as each target change is added to the data until the full set of 44 is used. For FFF, β_1 is negative until target change 19 (February 1, 1991), when it increases sharply and remains at the new level. For TB3 and FFF, there is a

12. A referee suggested this approach.

13. See Greene (2000, 294-97) for a description of this approach.

FIGURE 2

Recursive Coefficient Estimates of β_1 in Equation (1) for the Federal Funds Rate (FFR), the Treasury Bill Rate (TB3), and the Fed Funds Futures Rate (FFF) (Dashed Lines Denote Plus and Minus Two Standard Errors)



strong indication that the impact of the target changes increases prior to the start of policy announcements (starting with observation 31, February 4, 1994) and then declines after announcements start. The coefficient plots show that the impact of target changes increases in 1990 and 1991 (observations 13 to 27), jumps sharply during 1992 (observations 27 to 30), declines in 1994 after the announcements start, and then levels off.¹⁴

The results in the previous section indicate that the response of interest rates to a change in the target rate is often spread out over several days. To examine this, equation (3)

14. Estimating equation (1) for the first and second half of the preannouncement period (not reported here) shows that β_1 is approximately twice as large in the second half of the data interval for all three rates. Further, the difference is statistically significant at the 5% level for the TB3 and FFF and at the 10% level for the FFR.

is estimated with a full daily sample that includes all days with interest rate observations between 1989 and 1998:

$$(3) \quad \Delta R_{it} = \beta_0 + \beta_1 \Delta T_t + \beta_2 \Delta T3_t,$$

where $\Delta T3_t = \Delta T_{t-1} + \Delta T_{t-2} + \Delta T_{t-3}$. The coefficients on $\Delta T3_t$ represent the delayed market response to target rate changes from day $t - 3$ to day $t - 1$.¹⁵ Equation (3) is also estimated with dummy variables (as in equation (2)) to capture the impact of target changes before and after announcements started.

The results are summarized in Table 4 and show (as in Table 3) that the immediate responses are positive and statistically significant both before and after January 1994. A Wald test indicates that the response before and after the change in announcement were significantly different at the 5% level for FFF and at the 10% level for the TB3, but not significantly different for the FFR. The delayed responses are positive and significant in the preannouncement period for the FFF and the TB3 but not for the FFR itself. For the funds rate, there is only a large immediate impact. As expected, the delayed market responses on the Treasury bill and futures rates are not statistically significant after January 1994, when the Fed started announcing target changes immediately following a policy change.

Tests for the equality of the response in the two time intervals indicate that the total response and the delayed response are significantly different after January 1994 for the TB3 and FFF. The results in Table 4 indicate that the immediate impact of the change in the FFR target decline when the Fed began making its explicit targets known. Further, the small delayed impacts on the TB3 and on the FFF largely disappear.¹⁶ The Fed adopted the explicit targets gradually (before

15. Thornton (1996) uses a similar specification to capture the delayed market response to target changes. The article finds that a three-day delayed market response provides the best results.

16. These results contradict Thornton's (1996) conclusion that the Fed's change in policy announcements has no effect on the magnitude of the interest rate impact of target changes. This article shows that Thornton's estimate for the preannouncement period when the Fed is still using borrowings targets overlooks the evolution of the announcement effect over time.

TABLE 4
Delayed Interest Rate Response to Target Rate Changes

	Federal Funds	3-Month Treasury Bill	Fed Funds Futures
$\Delta R_{it} = \beta_0 + \beta_1 \Delta T_t + \beta_2 T3_t$			
β_0	-.001 (.003)	-.001 (.001)	-.001* (.001)
β_1	.736* (.165)	.333* (.052)	.291* (.046)
β_2	.003 (.064)	.011 (.013)	.025* (.007)
R^2	.237	.082	.148
σ_e	.268	.045	.029
D.W.	2.06	1.88	1.85
$\Delta R_{it} = \beta_0 + \beta_1 \Delta T_t \cdot x1_t + \beta_2 \Delta T_t \cdot x2_t + \beta_3 \Delta T3_t \cdot x1_t + \beta_4 \Delta T3_t \cdot x2_t$			
β_0	-.001 (.003)	-.000 (.001)	-.001 (.001)
β_1	.842* (.163)	.401* (.049)	.414* (.046)
β_2	.613* (.175)	.253* (.075)	.148* (.035)
β_3	-.026 (.067)	.038* (.018)	.042* (.012)
β_4	.036 (.073)	-.021 (.017)	.004 (.004)
R^2	.238	.088	.180
σ_e	.267	.046	.028
D.W.	2.06	1.88	1.80
Wald test <i>F</i> -statistics:			
$H1_0 : \beta_1 = \beta_2$	.92	2.72	21.17*
$H2_0 : \beta_3 = \beta_4$	.40	5.68*	8.23*
$H3_0 : \beta_1 + \beta_3 = \beta_2 + \beta_4$	.59	4.91*	26.23*

Notes: The regressions with the FFR as the dependent variable were corrected for serial correlation. White's heteroskedasticity-consistent standard errors are in parentheses after each regression coefficient. *Statistically significant at 5% level.

they began to announce them), and the public learned about this slowly from information leaks and other discussions. Thus, the change in the interest rate response might have evolved over time. That is, we imagine that it increased over time as market participants learned about the Fed's emphasis on the target and then declined as the changes in target rates came to be largely anticipated.

VI. CONCLUSION

From the mid-1980s until the present, the Fed has changed its views of the operating target for monetary policy and its views about how to make monetary policy changes public. As it evolved toward a greater emphasis on the funds rate target, the market impact of changes in the target increased. However, as it increased the flow of information about the policy targets (from innuendo to information leaks to formal announcements), the amount of new information in a target change decreased and the impact on market interest rates diminished. The Fed continues to

review and revise the way it conveys information about monetary policy to the public. Most recently, it changed the language used to convey information about its policy intentions and started making a policy statement after every FOMC meeting. It remains to be seen how these changes will affect financial markets and expectations about monetary policy.

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