WORKING PAPER SERIES

The Relationship Between the Federal Funds Rate and the Fed's Federal Funds Rate Target: Is It Open Market or Open Mouth Operations?

Daniel L. Thornton

Working Paper 1999-022B
http://research.stlouisfed.org/wp/1999/99-022.pdf

Revised December 2000

FEDERAL RESERVE BANK OF ST. LOUIS
Research Division
411 Locust Street
St. Louis, MO 63102

The Relationship Between the Federal Funds Rate and the Fed's Federal Funds Rate Target: Is It Open Market or Open Mouth Operations?

Daniel L. Thornton
Federal Reserve Bank of St. Louis
Phone (314) 444-8582
FAX (314) 444-8731
Internet Address: thornton@stls.frb.org

December 2000

Abstract

It is widely believed that the Fed controls the funds rate by altering the degree of pressure in the reserve market through open market operations when it changes its target for the federal funds rate. Recently, however, several economists have suggested that open market operations may not be necessary for controlling the funds rate. Rather, they suggest that the Fed controls the funds rate through open mouth operations. The Fed merely indicates its desire to change the funds rate and the market does the rest. This paper investigates the extent to which the close relationship between the federal funds rate and the federal funds rate target is due to open market or open mouth operations. Finding little evidence to support either the open market or open-mouth hypothesis, the possibility that many target changes represent the endogenous actions of the Fed real shocks and inflation surprises is briefly considered.

JEL Classification: E40, E52
Key Words: federal funds rate target, monetary policy, open market operations, open mouth operations

The views expressed here are the author's and do not necessarily reflect the views of the Board of Governors of the Federal Reserve System or the Federal Reserve Bank of St. Louis. I would like to thank Clemens Kool, Matt Canzoneri, Alex Cukierman, Adam Posen, Lucio Sarno and members of the Economics Departments of the University of Missouri-Columbia, North Carolina State University and the University of North Carolina for helpful comments and Jonathan Ahlbrecht, Kathy Cosgrove and Stephen Majesky for their valuable research assistance.

1. Introduction

During much of its history, the Federal Reserve has implemented monetary policy by targeting the federal funds rate [Goodfriend (1991)]. Consistent with this view of the Fed's operating procedure, recently available data on the Fed's funds rate target [Rudebusch (1995)] shows that the relationship between the funds rate and the funds rate target is very close for the period 1974-79 and since the early 1980s. The conventional view is that the close relationship is due to open market operations. The Fed raises the funds rate by reducing the supply of reserves through an open market sale when the funds rate target is raised and reduces the funds rate by purchasing securities when the target is lowered. Similarly, the Fed is thought to keep the funds rate close to the target level by adding reserves when the funds rate goes above the target and draining reserves when the funds rate goes below the target [e.g., Taylor (2001)].

Recently, however, it has been suggested that open market operations are not essential to funds rate control. Following up on McCallum's (1995) observation that the Reserve Bank of New Zealand (RBNZ) appears to move the interbank rate without conducting open market operations, Guthrie and Wright (2000) develop a model where private agents motivated by self-interest drive the interbank rate to the level desired by the monetary authority. The monetary authority need only communicate its desire for the overnight rate. Guthrie and Wright report several instances where the RBNZ signaled its willingness to enforce the rate; however, they find no systematic relationship between changes in the interbank rate and open market operations conducted by the RBNZ. They speculate that *open mouth operations* might "explain the difficulties in substantiating liquidity effects in empirical work, despite the apparent ease with which overnight rates, as well as other rates, move substantial amounts when changes are desired

by the monetary authority."[1] Moreover, Meulendyke (1998) and Hanes (1998) suggest that open market operations have not been an essential element of funds rate control since 1994.

This paper investigates whether the close relationship between the funds rate and the funds rate target during the 1974-79 period and since the early 1980s is due to open market or open mouth operations. The methodology is similar to that used by Cook and Hahn (1989a). Specifically, I estimate the response of interest rates to changes in the Fed's funds rate target. Unlike Cook and Hahn, who only investigated the response of Treasury rates, I also investigate the response of the federal funds rate. If the Fed controls the funds rate through open market operations, the funds rate should change when the Fed changes the funds rate target. Hence, it is possible to test for open market operations by testing whether the funds rate responds to changes in the funds rate target.

If the Fed controls the funds rate through open mouth operations, however, the funds rate should respond immediately to target changes only when the public is aware that the target changed. Testing for open mouth operations is accomplished by partitioning target changes into those that the market was aware had occurred and those that the market was not aware had occurred. This is accomplished for the 1974-1979 period by comparing Cook and Hahn's (1989a) series with a series of actual target changes report by Rudebusch (1995). Because not all of the changes that Cook and Hahn report occurred, it is also possible to partition their series into target changes that occurred and those that the market only thought had occurred. Because there is no series similar to Cook and Hahn's another procedure is used to partition target changes into those that the market was and was not aware of since the early 1980s.

It is important to emphasize that the question being addressed is *has* the Fed changed the funds rate through open market operations, not *can* the Fed change the funds rate through open

[1] Guthrie and Wright (2000), p. 513.

market operations. Given the size of the market for reserves relative to the Fed's capacity to alter reserve availability, there is little doubt that the Fed can affect the federal funds rate through open market operations. The fact that the Fed has the capacity to affect the federal funds rate does not, *ipso facto*, establish that it has done so.

Finding no evidence that the observed close relationship between the federal funds rate and the federal funds rate target is due to open market and little support for open mouth operations over the entire sample period, I consider the possibility that many target changes are the endogenous response to shocks to which the market has already responded. While this possibility is given virtually no consideration in everyday discussions of monetary policy, it has long tradition in monetary theory and is the maintained hypothesis in the interest rate smoothing models of Goodfriend (1987) and Barro (1989). It is also consistent with models of monetary policy, traditional [e.g., Friedman (1968)] and modern [Woodford (1999)].

2. The Relationship between the Funds Rate and the Fund Rate Target

Figures 1 – 3 present the historical relationship between the federal funds rate and the Fed's funds rate target that paper attempts to explain. The observations are daily and cover the periods September 13, 1974 to October 5, 1979 and March 1, 1984 to December 31, 1997. The latter period is divided into the periods March 1, 1984 to September 29, 1989 and October 2, 1989 to December 31, 1997. The federal funds rate is the effective federal funds rate published by the Federal Reserve Bank of New York. Prior to January 3, 1985 the Fed's funds rate target is from Rudebusch (1995ab). From January 3, 1985 to December 31, 1997 the funds rate target is from the Federal Reserve Bank of New York.[2] Settlement Wednesdays and the first two and

[2] Prior to August of 1989, the New York Fed's funds rate target was occasionally presented as a range of about a quarter percentage point. On these occasions, the target was taken to be the midpoint of the reported range. In addition, for a period after the stock market crash in 1987, specifically from October 19, 1987 to November 4, 1987, no funds rate target was reported. For these days the target level is taken to be the level on October 16, 1987.

last two days of the year have been excluded because large and transient moves in the funds rate that sometimes occur on these days can distort statistical measures of the relationship between these rates.

During the 1974-79 period, when the Fed was explicitly targeting the funds rate, the funds rate stayed very close to the funds rate target. The average absolute spread was just 9 basis points and the standard deviation was just 13 basis points. On 72 percent of the days the funds rate deviated from the funds rate target by fewer than 10 basis points.

There is also a close relationship between the funds rate and the funds rate target during the 1984-89 period, shown in Figure 2. While the relationship is not as tight as during the 1974-79 period, the absolute average difference between the funds rate and the funds rate target was just 17 basis points, with a standard deviation of 26 basis points. Moreover, on nearly half of the days the funds rate deviated from the funds rate target by fewer than 10 basis points.

The relationship between the funds rate and the funds rate target for the 1989-97 period is presented in Figure 3. In late 1989 the Fed began the practice of adjusting its funds rate target only in multiples of 25 basis points. Prior to that target changes were made in various amounts, with changes as small as 6.25 basis points. Moreover, rate adjustments became less frequent. The Fed made 32 adjustments to the funds rate target during the period from 1989-1997, an average of about one change every 13 weeks. In contrast, the Fed changed its funds rate target 98 times during the 1974-79 period, an average of about once every 2.5 weeks, and 76 changes during the 1984-89 period, an average of about one change about every 4 weeks. Despite the fact that the funds rate target was changed relatively infrequently and by large amounts, the funds rate stayed nearly as close to the funds rate target during this period as during the 1974-79 period. The mean absolute spread was 11 basis points and the standard deviation was 19 basis

points. Moreover, on 67 percent of the days the funds rate deviated from the funds rate target by fewer than 10 basis points.

3. The Market's Reaction to Target Changes

Cook and Hahn (1989a) were the first to investigate the market's reaction to changes in the funds rate target.[3] Noting that the relatively "little support for the view that the Fed can influence interest rates, except perhaps through the positive impact on inflation expectations…conflicts with the standard view among participants in the financial markets that the Fed has a strong influence on interest rate movements," Cook and Hahn (1989a, p. 331) proposed testing the standard view by investigating the market's reaction to federal funds rate target changes. They found that during the period from September 13, 1974 to October 5, 1979 rates on Treasury securities from three months to 20 years responded significantly to funds rate target changes reported in the *Wall Street Journal* (hereafter, *WSJ*). The 3-, 6- and 12-month bill rates moved about 50 basis points for a one-percentage-point change in the WSJ-announced target change, while the response of longer-term securities declined as the term to maturity lengthened.

3.1 *Distinguishing Between Open Market and Open Mouth Operations*

The responses of the markets to funds rate target changes can provide evidence of whether the Fed influences the federal funds rate through open market or open mouth operations. If the Fed influences the funds rate through open market operations, the funds rate should respond immediately and significantly to funds rate target changes, whether the market is aware that they occurred or not. If, on the other hand, the Fed controls the funds rate through open

[3] Cook and Hahn's work generated a literature showing that market interest rates and foreign exchange rates respond significantly funds rate target changes [e.g., Bonser-Neal, Roley and Sellon (1998), Hardy (1998), Thornton (1998)].

mouth operations the funds rate should respond only when the market is aware that the target is changed.

Distinguishing between target changes that the market knew had occurred and those that the market was unaware of is accomplished by comparing WSJ-announced target changes actual target changes provided by Rudebusch (1995). The Rudebusch uses a funds rate target series that is constructed from the weekly *Report of Open Market Operations and Money Market Conditions*, prepared by the Trading Desk of the Federal Reserve Bank of New York. According to this series, the funds rate target was changed 99 times during Cook and Hahn's sample period—23 more target changes than the 76 reported in the *WSJ*.[4] Cook and Hahn (1989b) undertook a similar analysis, but only for days close to the dates when the *WSJ* reported a target change. Rudebusch notes that his series matches the funds rate target series supplied by the Federal Reserve Bank of New York for the period 1985-92.[5]

The dates and magnitudes of federal funds rate target changes reported by the *WSJ* and Rudebusch (1995) are presented in Table 1. There are 38 instances when the actual target change reported by Rudebusch (1995) occurred on the day that the *WSJ* reported the change had occurred.[6] Hence, the market was correct about the timing of Fed actions about 40 percent of the time. Even when the market got the timing correct, it frequently missed the magnitude.[7]

---

[4] This number is similar to the 21 "gaps" in the *WSJ*'s target level reported by Cook and Hahn (1989b). A gap occurred when the difference between the last reported target level and the currently reported level is more than the currently reported target change. When the number of gaps is added to the 76 *WSJ*-reported changes, the total number of changes is only one short of the 98 target changes reported by Rudebusch.

[5] Rudebusch (1995) constructed his series from the *Report of Open Market Operations and Money Market Conditions*, which was prepared weekly by the Federal Reserve Bank of New York. Rudebusch notes that "For a few target changes, the exact date that the Desk began to enforce the new target could have been a day or two sooner or later than the one that I have designated."

[6] This number is similar to that of Cook and Hahn (1989b), who reported that the market got the timing of the change right about half of the time. Specifically, 37 of the 76 target changes reported by the *WSJ* were reported to have occurred "on the same day they were decided on by the Desk." For the remainder of the cases, the actual target change preceded the date it was announced by the *WSJ* by one or more days.

[7] The evidence does not support Cook and Hahn's (1989a, p. 332) claim that "market participants could identify most changes in the funds rate target on the day they were first implemented by the Fed…"

That the market frequently missed the timing or magnitude of target changes in the 1970s is not surprising. The Fed was intentionally more secretive in the 1970s than it is today. In its landmark Freedom of Information Act case, Merrill vs. FOMC the Fed argued that monetary policy was most effective when the market was surprised.[8] Motivated in part by a desire to be secretive, the Fed entered the market frequently during this period, often buying and selling government securities on the same day.[9]

3.2 *The Exogeneity Assumption*

The key to Cook and Hahn's interpretation of their regression results is the exogeneity assumption.[10] Specifically, Cook and Hahn (1989a) noted that,

> "The interpretation of the regression results in this section rests on the assumption that movements in the funds rate target caused movements in other rates and not the reverse. We believe that this assumption is entirely defensible. As discussed above, the Desk changed the funds rate target in this period either under explicit instructions from the FOMC or under the Desk's interpretation of the latest FOMC directive…in all but five of the former cases the actual change in the

[8] In 1975 the FOMC denied a Freedom of Information Act request by David R. Merrill, a student at Georgetown University Law Center, for access to the Record of Policy Actions at its January and February 1975 meetings. This action led to the famous Merrill vs. FOMC, which ultimately was resolved by the U.S. Supreme Court [e.g., Goodfriend (1986)].

[9] Indeed, Milton Friedman chided the Fed for excessive churning of its portfolio. See Friedman (1981, 1982ab) and Levin and Meulendyke (1982).

[10] Specifically, Cook and Hahn (1989a, p. 343) note that "the standard interpretation by market participants of movements in Treasury bill rate on days of changes in the funds rate target is that the movements are due to changes in expectations of the funds rate over the life of the bill. This interpretation of our regression results provides strong support for the expectations theory of the term structure of interest rates." While it is tempting, and perhaps some might contend reasonable, to attribute the response as evidence of the expectations hypothesis, Cook and Hahn do not test the expectations hypothesis *per se*, but rather interpret their results in light of it. This practice is dangerous. For example, it is well established that Treasury rates respond significant to nontechnical changes in the discount rate; however, there is no evidence that discount rate changes have a permanent effect on the structure of rates [Thornton (1994)] nor is there clear evidence favoring any one of several possible explanations for why markets respond [Thornton (1998)]. Moreover, it is well known and accepted that the discount rate follows market rates rather than leading them. Cook and Hahn were aware that their interpretation of their evidence was at odds with a number of direct tests of the expectations hypothesis that "found little, if any, support for the expectations theory," Cook and Hahn (1989a, p.345) [see Goodfriend (1991, p. 25) for a similar statement]. They argued, however, that these direct tests were biased toward rejecting the expectations hypothesis because of a time varying risk premium. Hardouvelis (1994) has noted, however, that the time-varying-risk premium explanation for the failure of the expectations hypothesis requires a highly volatile risk premium that is inconsistent with the data. Indeed, Bekaert and Hodrick (2000, p.3) note, "the literature has had surprisingly little success generating risk premiums that explain the empirical evidence." More recently, Thornton (2000a) shows that the test these studies use is biased in favor of the expectations theory and that the evidence in favor of the expectations hypothesis is particularly weak when the short-term rate is the federal funds rate.

> target lagged the FOMC instructions by one or more days, and in about half of the latter cases the market's perception of a change in the target lagged the Desk's decision to change the target by at least one day."[11]

The *WSJ* stories from which Cook and Hahn constructed their funds rate target series provide a reason to doubt the exogeneity assumption. The *WSJ* announced target changes are based on reports from market analysts. Market analysts concluded that the target had changed by observing the open market operations the Fed undertook relative to the behavior of the federal funds rate. Specifically, market analysts relied on four types of signals in concluding that the target had changed. These are:

> Type 1: The Fed injected or drained reserves when the funds rate was at the funds rate target.
>
> Type 2: The Fed injected [drained] reserves when the funds rate was trading below [above] the previously targeted rate.
>
> Type 3: The funds rate moved above or below the previous target before the Fed took action to restrain the funds rate from moving further.
>
> Type 4: The funds rate moved above or below the target without the Fed taking action.

The first type is the textbook example of an exogenous open market operation. The funds rate is trading at the target level and the Fed attempts to push the rate higher [lower] by draining [injecting] reserves. The second type is similar, except that the funds rate had already moved before the Fed took an action consistent with pushing the funds rate further in the same direction. For type 3 and type 4 changes, the causation goes from the funds rate to the funds rate target. For type 3 changes, the Fed acts to restrain further movement in the funds rate. For type 4

[11] Cook and Hahn (1989a), p. 342. In a footnote on this same page, Cook and Hahn argue that a lag between the time the Desk decided to change the target and the market's perception of the target change does not necessarily mean that market participants failed to pick up a clear Desk signal earlier because although the Desk made the decision to change the target on one day it might not take actions until latter in the maintenance period. But this statement clear conflicts with most of the reason analysts gave for deciding that the Fed had changed its target for the funds rate.

changes, it is the lack of open market operations in the face of a change in the funds rate that caused the market to conclude that the Fed had changed the target.[12]

The type of each *WSJ* target change is noted in Table 1. Of the 76 *WSJ* target changes, there were three instances when market analysts concluded that the Fed had changed its funds rate target without stating how they reached this conclusion. These changes are called type 5 target changes. Of 73 *WSJ* target changes that could be classified, there were 35 occasions when the Fed was passive: 22 were classified as type 3 changes and 13 were classified as type 4 changes. There were 19 each of type 1 and type 2 changes.

The reason market analysts concluded that the Fed had changed the funds rate target is important for investigating whether the Fed controls the funds rate through open market operations. The funds rate responding significantly to type 1 changes but not to the others would be strong evidence that the Fed controls the funds rate through open market operations. This conclusion would be somewhat less justified if the funds rate responds significantly to type 2 changes because the federal funds rate had already moved in the direction of the target change before the Fed undertook open market operations to move it further. This conclusion would be unjustified if the funds rate responds significantly to type 3 or type 4 target changes, because the change in the funds rate caused the market to concluded that the Fed had changed the target.

It should be noted that neither rate will respond to anticipated target changes. This is not a serious problem for this analysis, however, because for target changes to be completely anticipated the market would have to correctly anticipate both the timing and magnitude of target changes. Consequently, it is reasonable to assume that there is an unanticipated component to nearly every target change. Indeed, the fact that the T-bill rate responds significantly to *WSJ*

[12] Photocopies of these stories are available upon request.

target changes indicates that these changes were not completely anticipated.[13] Because type 1 target changes (and to a lesser extent, type 2 changes) appear to be exogenous with respect to the funds rate, they are more likely to be anticipated than type 3 or type 4 target changes. If this is the case, the response of the T-bill rate should be smaller for type 3 and 4 target changes than for type 1 and 2 changes.

4. The Model Specification and Results

The data are daily observations on changes in the effective federal funds rate, Δff, and changes in the 3-month Treasury bill rate, $\Delta tb3$. There are two series on changes in the federal funds rate target, *WSJ* announced changes, $\Delta fftar^{WSJ}$, and actual target changes, $\Delta fftar^{A}$, identified by Rudebusch. *WSJ* target changes are partitioned into those that coincided with actual target changes, $\Delta fftar_{A}^{WSJ}$, and those that did not, $\Delta fftar_{NA}^{WSJ}$. Similarly, $\Delta fftar^{A}$ is partitioned into those that coincide with *WSJ* announced target changes, $\Delta fftar_{WSJ}^{A}$, and those that do not, $\Delta fftar_{NWSJ}^{A}$. Descriptive statistics for these target changes and various partitions of each are presented in Table 2.[14]

[13] The degree of the bias cannot be determined without making additional assumptions. To illustrate, assume that $\Delta y = \beta \Delta x^{U} + \varepsilon$, where Δx^{U} is the unanticipated portion of Δx. Assume further that $E\Delta x = \delta \Delta x$, so that, δ is the measure of bias. If δ=1 the market's expectation is unbiased. If δ>1 the market overestimates the change and if δ< 1 the market underestimates the change. By definition $\Delta x^{U} = \Delta x - E\Delta x = (1-\delta)\Delta x$. Substituting this expression into the above expression yields, $\Delta y = \beta(1-\delta)\Delta x + \varepsilon = \beta' \Delta x + \varepsilon$. Note that if the market correctly anticipates Δx on average, the estimate of β' will be insignificantly different from zero. On the other hand, if the market under or over estimates Δx, the estimate of β' will differ form zero. It is clear that the degree of the bias can be determined only if one knows the true value of β. Cook and Hahn (1989a) argue that their estimates indicate that about half of the change was anticipated. They arrive at this conclusion from their implicit assumption that β=1, i.e., the value consistent with the expectations hypothesis.

[14] The similarity of descriptive statistics over various partitions of actual and *WSJ*-announced target changes suggests that the differences shown later are not due to fundamental differences in the target changes over the various partitions.

Treasury rates are determined simultaneously with the federal funds rate. Indeed, there is considerable evidence that these rates are cointegrated [e.g., Stock and Watson (1988)]. To control for the dynamic interaction between these rates, the vector error correction model,

$$(1) \qquad \Delta x_t = \Psi(L)\Delta x_{t-1} + EC_{t-1}\delta + \Delta fftar_t\beta + \varepsilon_t,$$

is estimated, where $\Delta x_t' = (\Delta ff_t, \Delta tb3_t)$. The error correction term is denoted EC, δ denotes a 2 by 1 vector of coefficients that measure the speed with which the federal funds and T-bill rates return to their long-run equilibrium relationship, β denotes a 2 by 1 vector of coefficients that measure the response of the T-bill and federal funds rates to changes in the funds rate target and $\Psi(L)$ is the usual matrix polynomial in the lag operator L.[15]

The model is estimated using *WSJ* target changes and actual target changes, with various partitions of each. Cook and Hahn (1989a) omit the target change that occurred on November 1, 1978, the day on which the Fed and the Treasury announced a program to support the dollar. The results are insensitive to whether this observation is included or excluded, so it is included here for completeness.[16] In addition, one *WSJ* reported target change came on the heels of a very soft federal funds market on the last reserve settlement day of the year. On settlement Wednesday, December 31, 1974, the funds rate was 3.87 percent—470 basis points below the

[15] In the case of the federal funds rate, the lack of a statistically significant response is due to the conditioning variables. For example, when Equation 1 is estimated using the 38 target changes, the estimate of β is 0.35 and the adj. R^2 is 0.3719. When the 60 target changes are used, the estimate of β drops to 0.19 and the R^2 drops to 0.0565. When the funds rate is conditioned on its and the T-bill rates' past behavior, however, the coefficient on the 38 target changes drops dramatically and the significance level rises. Moreover, a detailed analysis of changes in the funds rate and changes in the funds rate target for the 60 target changes that were not simultaneously announced in the *WSJ* reveals that this coefficient is greatly affected by two relatively large changes in the funds rate that are associated with 0.125 percentage point changes in the funds rate target. These occurred on April 21, 1976 (32 basis points) and July 19, 1978 (64 basis points), both settlement Wednesdays. When these observations are omitted, or a dummy variable for settlement Wednesdays is included, the coefficient drops dramatically and becomes statistically insignificant.

[16] There was a very large reaction in foreign exchange markets in response to this action [e.g., Mudd (1979) and Batten and Thornton (1985)] and a significant fall in longer-term interest rates. This action appears to have had little effect on the T-bill rate.

previous day's level. On January 2, 1975 market analysts observed the Desk adding reserves when the funds rate was trading below the presumed target of 8.5 percent and concluded that the Fed had reduced the funds rate target. Because the funds rate was uncharacteristically low on the previous market day, the change in the funds rate associated with this *WSJ* target change was 468 basis points. Such a large positive change in the funds rate associated with this negative target change could bias the results in the funds rate equation away from finding a significant response of the funds rate. Consequently, a dummy variable that is one on this day and zero elsewhere is included in the funds rate equation. Two dummy variables, one for settlement Wednesdays and one for the next day, are included to control for a possible end-of-maintenance-period effect.[17]

4.1 ***Market Perceptions and Reality***

The model is estimated assuming a constant in the cointegrating vector. In all cases, the usual likelihood ratio test indicates a single cointegrating vector. Because the estimated cointegrating vector is relatively insensitive to the funds rate target series used, the estimated cointegating vector is held constant for all of the estimates reported in Tables 3-5. The standard errors are estimated using White's (1980) heteroskedasticity consistent covariance estimator.

Estimates of the model using *WSJ* target changes are presented in Table 3. To conserve space, only estimates of the constant term, δ and β are presented. The estimate of β for the T-bill rate, 0.5263, is similar to Cook and Hahn's (1989a) estimate, 0.554.[18] The response of the T-bill rate to *WSJ* reported target changes does not appear to be affected by the conditioning

[17] The equations were also estimated deleting target change (*WSJ* or actual, depending on the specification) that occurred on settlement Wednesdays or the following day. The qualitative conclusions are the same as those reported here.

[18] Cook and Hahn estimated the equation only using days when the target was changed. When this is done, the estimates are nearly identical to those reported in Table 1, and the Adj. R^2 and estimated standard error are nearly identical to theirs. Differences are likely attributable to small differences in the T-bill rate used.

variables in the model.[19] The response of the T-bill rate is smaller when *WSJ* changes do not coincide with actual target changes, but the difference is not statistically significant. Hence, the evidence indicates that the market's reaction to the announcement of a target change is the same, whether the target was changed or not.

The federal funds rate also responds significantly to *WSJ* announced target changed; however, the magnitude of the response is considerably smaller than that of the T-bill rate. Moreover, the funds rate responds significantly to *WSJ* target changes only when they coincide with actual target changes, suggesting that the significant movement in the funds rate might be due to open market operations.

The interpretation of the response of the funds rate, however, depends on whether the change is endogenous or exogenous. Consequently, the 76 *WSJ* target changes are partitioned according to type. The results are presented in Table 4. While the magnitude of the response of the T-bill rate varies somewhat by type, the hypothesis of equality cannot be rejected for any possible pairing of types or for the equality of response of all types. Indeed, the market responded significantly to the three changes that could not be classified. When market analysts announced that the target had changed, the market reacted regardless of whether the target had actually changed. Consequently, the response of the T-bill rate to *WSJ*-announced target changes is an announcement effect.[20] What matters is the market's belief.

The results for the federal funds rate do not support the open-market-operation interpretation. Specifically, the funds rate responds significantly only to endogenous target

[19] This finding was confirmed through additional analyses. The same is not true for the federal funds rate, however.
[20] Announcement effects are common. Market rates have, at various times and under various circumstances, responded significantly to a variety of news: money surprises [e.g., Hardouvelis (1987), Dwyer and Hafer (1989) Thornton (1989)], changes in the discount rate [e.g., (1994, 1998, 2000b), Roley and Troll (1984), Smirlock and Yawitz (1985), Cook and Hahn (1988), Batten and Thornton (1984, 1985)], the employment report [e.g., Hardouvelis (1987) and Cook and Korn (1991)] and other special announcements [Cook and Hahn (1988)]. What is often not know is precisely why markets react to this information.

changes and not to type 1 or type 2 target changes. The statistically significant relationship between the funds rate and type 3 and type 4 *WSJ* target changes is due to reverse causation: changes in the funds rate caused analyst to conclude that the target had changed. Indeed, consistent with market analysts' observations, the coefficient for type 3 changes is larger than for type 4 changes; however, the difference is not statistically significant.

4.2 *The Market's Response to Actual Target Changes*

The conclusion that the Fed did not influence the funds rate through open market operations is supported by estimates of the response to the 99 actual target changes presented in Table 5. Consistent with the previous findings, the T-bill responds significantly to the 39 target changes that were reported in the *WSJ*. The response of the T-bill rate to the 60 target changes that were not reported in the *WSJ* is significantly different from zero, but significantly smaller than that to the 39 reported changes.

The response of the T-bill rate to the 60 actual target changes is fragile, however.[21] This is illustrated in Figure 4, which shows $\Delta tb3$ plotted against $\Delta fftar^{A}_{WSJ}$ and $\Delta fftar^{A}_{NWSJ}$, in Panels A and B, respectively. Panel A reveals a fairly strong positive relationship between changes in the target and changes in the T-bill rate. In Panel B, however, shows that the relationship between $\Delta tb3$ and $\Delta fftar^{A}_{NWSJ}$ is weak. Not surprisingly, both the magnitude of the estimated response of the T-bill rate and the corresponding "significance" are easily changed by judiciously deleting observations.[22]

[21] Rudebusch (1995, p. 252) notes that "for a few target changes, the exact date that the Desk began to enforce the new target could have been a day or two sooner or later than the one that I have designated. Hence, it is possible that the lack of response of the funds rate to the 60 target changes is due to the missed timing in the implementation of the new target. When this equation is estimated with two leads and two lags of the 60 target changes none of the coefficients on the leads or lags is statistically significant.

[22] Sensitivity to outliers is not unusual in studies of the market's reaction to specific news, [e.g., Thornton (1989)].

The response of the funds rate to the 99 actual target changes is small but statistically significant. Moreover, the response remains significant when the target is partitioned into the 39 changes that coincide with *WSJ* reported changes and the 60 that do not. Figure 5 shows Δff plotted against $\Delta fftar^{A}_{WSJ}$ and $\Delta fftar^{A}_{NWSJ}$ in Panels A and B, respectively. Panel A reveals a strong positive relationship between changes in the funds rate and changes in the target on days when the *WSJ* reported a target change. This relationship, however, is a consequence of reverse causation. When type 3 and type 4 target changes are accounted for, the coefficient on drops to $-.0287$ and is insignificantly different from zero. As is the case for the T-bill rate, Panel B shows that there is no particular relationship between changes in the funds rate and changes in the target when the *WSJ* did not report a target change.

Contrary to popular belief, the evidence suggests that Fed did not implement monetary policy with open market operations during the period 1974-79. If it had, the funds rate should have changed significantly when the Fed changed the target. The evidence cannot rule out open mouth operations, however. While the Fed was much more secretive then than it is now, it was widely known that the Fed was targeting the funds rate and considerable resources were devoted to "Fed watching." Even though the market frequently missed the timing or magnitude of target changes, it seems reasonable to assume that the market would be able to determine the new target within a few days of the change.

If open mouth operations accounts for the close relationship between these rates, one would expect to find relatively large deviations between the funds rate and the funds rate target a few days after target changes that the market was unaware had occurred. This is not the case, however. The standard deviation of the funds rate from the funds rate target for the three days after target changes that were missed by the *WSJ* is 0.15. This is only slightly larger that the

standard deviation of .13 for the entire sample period. Likewise, the average absolute spread between the funds rate and the funds rate target was 10 basis points for the three days following target changes that the market was unaware of, only one basis point higher than the 9 basis point average for all days during the period.[23] The relationship between the funds rate and the funds rate target is about the same around target changes that the market was unaware of as it is when the market is aware that the target had change. This would not be the case if the relationship were the result of open mouth operations.

5. Evidence From The Post-Nonborrowed Reserves Targeting Period

A stronger test of the open mouth hypothesis can be obtained by estimating the market's reaction to funds rate target changes in the post-nonborrowed reserves targeting period.[24] In October 1979 the Fed switched from an explicit funds rate targeting procedure to a nonborrowed-reserves operating procedure that was specifically designed to control M1. When the relationship between M1 and nominal GNP broke down in the early 1980s, the Federal Open Market Committee, FOMC, abandoned M1 targeting and, *ipso facto*, the nonborrowed reserves targeting procedure.

Officially, the Fed switched to a borrowed reserves targeting procedure, [e.g., Wallich (1984), Strongin (1995) and Meulendyke (1998)], however, there is evidence that the Fed was targeting the federal funds rate during this period. Thornton (1988a) showed that during the

[23] The results are nearly identical if 2 days are used.

[24] During this period, borrowing was particularly sensitive to the spread between the funds rate and the discount rate. Hence, borrowing would offset, at least in part, the effect of open market operations on reserve supply. It is this feature of discount window borrowing that led to the discussion of whether the discount mechanism offsets [e.g., Friedman (1960)] or reinforces [e.g., Samuelson (1960)] the monetary policy objectives of the Fed. Aware of the relationship between borrowing and the funds rate spread, the Fed made an estimate of the level of discount window borrowing. The initial borrowing assumption, as this estimate was called, was as an integral part of the nonborrowed reserves operating procedure, [e.g., Meulendyke (1998) and Thornton (2001a)]. Meulendyke (1998), Strongin (1995) and others have suggested that the Fed would implement policy by changing the initial borrowing assumption and, hence, force banks to the discount window. However, Thornton (2001a) has shown that changes in the initial borrowing assumption significantly lagged changes in actual borrowing.

early 1980s the funds rate stayed closer to the funds rate target than borrowing did to the borrowing target, suggesting that the Fed was targeting the funds rate rather than borrowed reserves. Consistent with this evidence, Greenspan (1997) has acknowledged recently that, "increasingly since 1982 we have been setting the funds rate directly in response to a wide variety of factors and forecasts."[25] That the Fed was directly targeting the funds rate in the early 1980s is also borne out by the close relationship between the federal funds rate and the funds rate target during this period and by the verbatim transcripts of FOMC meetings.[26]

5.1 ***When Did the Market know that the Fed was targeting the Funds Rate?***

It is well known that the Fed is targeting the funds rate. The critical question is when did the market become aware that the Fed was targeting the funds rate? Answering this question is difficult because, unlike the switch to nonborrowed reserves targeting in 1979 and the switch to borrowed reserves targeting in 1982, the Fed has never formally acknowledged switching from a borrowed reserves targeting procedure to a funds rate targeting procedure. The Federal Reserve Bank of New York did not publish the federal funds rate target in its annual summary of monetary policy until 1991. Even then, the funds rate target was euphemistically referred to as the *associated federal funds rate,* defined as "the middle of the federal funds rate trading area that is expected to be consistent with the borrowing assumption."[27] This language suggests that as late as 1991, the Fed was reluctant to acknowledge that it was explicitly targeting the federal funds rate.

---

[25] Greenspan (1997), p. 3.

[26] For example, at the July 12-13, 1983 FOMC meeting Chairman Volcker sought the Committee's views on whether the so-called "proviso range" for the federal funds rate range should be 6 to 10 percent or 7 to 11 percent, indicating that he would be happy with either. After a very brief discussion, the Chairman asked for a show of hands. Finding that 5 favored 6 to 10 and 3 opposed it, the Chairman noted that "Some people are not voting again." At this point an unnamed participant said, "I don't care. As long as you're planning on somewhere between 9-1/4 and 9-1/2 percent, I'm for either." Transcript (1983), p. 78.

One way to estimate when the market became aware that the Fed was targeting the funds rate is to date the first reaction of the T-bill rate to federal funds rate target changes. Assuming that the market could identify at least some of the target changes on the date they were made, the T-bill rate should respond to target changes fairly soon after the market became aware that the Fed was targeting the funds rate.

Hence, it is possible to date when the market became aware that the Fed was targeting the funds rate by estimating the equation,

$$(2) \qquad \Delta i_t = \Psi(L)\Delta i_{t-1} + EC_{t-1}\delta + \Delta fftar_t(k)\beta_1 + \Delta fftar_t(K-k)\beta_2 + \varepsilon_t,$$

where *i* is either the T-bill or federal funds rate. Equation 2 assumes that there is a structural break in the market's response to changes in the funds rate target, where $k = q, q+1, q+2, \ldots, K-q$ is the target change at which the structural break occurs, and *K* is the number of target changes during the sample period.

When *i* is the T-bill rate, estimates of β_1 should be small and insignificantly different from zero until the market becomes aware that the Fed is targeting the funds rate and is aware of funds rate target changes. Defined in this way, the $k+1$ target change is the first time the market responded significantly to a funds rate target change. When *i* is the federal funds rate, estimates of β_1 and β_2 should be positive and statistically significant if the Fed controls the funds rate through open market operations.

The sample period is March 1, 1984 to December 31, 1997. There were 108 changes in the funds rate target during this period, i.e., K = 108. Equation 2 is estimated with $q = 25$ and

[27] The FOMC did not explicitly state its funds rate target in the operational paragraph of its policy directive until August 1997.

$\sup_{k\in\Omega} LR_K(k)$ is chosen.[28] Separate likelihood ratio statistics are obtained for the federal funds and T-bill rates. The distribution of the test statistic is non-standard because the parameter *k* does not exist under the null hypothesis [Andrews (1993)]. Consequently, the critical value for λ under the null hypothesis is determined by a Monte Carlo experiment with 10,000 replications. The 1-percent critical value is 10.51.

For the T-bill rate the $\sup_{k\in\Omega} LR_K(k)$ occurred on August 9, 1988. The significant break in the T-bill rate is associated with the 0.375 percentage point increase in the funds rate on that date. All Treasury rates moved by large amounts on that date, but the T-bill rate does not appear to respond significantly to target changes made for some time thereafter. When the change made on August 9, 1988 is omitted, $\sup_{k\in\Omega} LR_K(k)$ for the T-bill rate also occurs on December 7, 1990.

The December 7, 1990 break point is interesting because it coincides with the elimination of the *proviso clause* from the FOMC's operating directive. At the October 1990 meeting, just as Chairman Greenspan was calling for a vote on the operating directive, Governor Angel raised concern about the directive's proviso clause, which stated,

> *"The Chairman may call for Committee consultation if it appears to the Manager for Domestic Operations that the reserve conditions during the period before the next meeting are likely to be associated with a federal funds rate persistently outside a range of 6 to 10 percent."*

Governor Angel suggested that "in light of our abilities on the funds rate, I wonder whether it would be a little more accurate to pull that range in a bit." The Chairman directed the staff to prepare a recommendation on what he termed an "anachronism" for consideration at the November meeting. While staff presented five options, only the option to drop the proviso

[28] To simplify the estimation, the error correction term, EC_t, was constructed using the cointegrating vector estimated using data over the entire sample period.

clause got serious consideration. At its November 13, 1990 meeting, after a brief discussion about the potential political consequences of dropping the proviso clause, the Committee voted to drop it.[29]

Estimates of Equation 2 with both break points are presented in Table 6. The federal funds rate does not respond significantly to target changes before or after either break point, and the likelihood ratio test indicated no statistically significant break point. The lack of a significant response of the funds rate to changes in the funds rate target suggests that the Fed has not implemented policy through open market operations. The evidence against open market operations is consistent with recent findings by Thornton (2001b) who investigates the direct relationship between nonborrowed reserve and changes in the funds rate target.

The T-bill rate also does not respond significantly to target changes before either break point, suggesting that the market was unaware that the Fed was targeting the funds rate until after the December 7, 1990 meeting. Of course, the market might have been aware that the Fed was targeting the funds rate, but unable to determine the timing of any target changes until December 1990. This explanations seems unlikely in view of the 1974-79 experience.[30]

It appears that the market was unaware that the Fed was targeting the funds rate from until the late 1980s or perhaps the early 1990s. Consequently, open mouth operations cannot account for the close relationship between the federal funds rate and the federal funds rate target shown in Figure 2. It also seems unlikely that open mouth operations accounts for the close

[29] Governor Angel began the discussion by saying "Well, it does seem to me that there might be one alternative that would get us a little more volatility in the fed funds rate. And if we did have more volatility in the fed funds rate, then the 4 percent rate specified could be a clear indication of what we were doing. Now, it may be unlikely that there will be a majority who would wish to do that." To that, Greenspan responded, "I think that happens to be true. But I'm not sure that solves the problem because you're talking about substance and we're talking about public relations." Transcript (1990), p. 9.

[30] The other possibility, that the market correctly anticipated the timing and magnitude of all of the target changes, also seems unlikely. Among other reasons, federal funds futures market has had difficulty anticipating target

relationship between the funds rate and the funds rate target during the 1974-1979 period. If it had, one would expect to find relatively large differences between the funds rate and the funds rate target for a few days after target changes that the market was unaware had taken place, but this is not the case.

6. If Neither Open Market Nor Open Mouth Operations, What?

If open mouth operations do not account form the close relationship between these rates during the 1984-1990 period or for during the 1974-1979 period, it may not account for the relationship between these rates since 1990 either. If neither open market operations nor open mouth operations account for the close relationship between the federal fund rate and the funds rate target, what can? One possibility comes from looking at the relationship the other way around. Specifically, it could be that the target changes follow changes in market interest rates. Given the extent to which both the Fed and the market has focused on the Fed's target for the federal funds rate in recent years, some might think it folly to even consider such a possibility, but the idea is hardly revolutionary. Indeed, it is the maintained hypothesis in the interest rate smoothing models of Goodfriend (1987, 1991) and Barro (1989). As Goodfriend (1991, p. 10), puts it,

> "…it should not be said that a Federal funds rate target change causes a change in market rates since the Fed is merely reacting to events in much the same way as the private sector does. More generally, to the extent that we believe the Fed reacts purposefully to economic events, we should not say that funds rate target changes are ever the fundamental cause of market rate changes, since both are driven by more fundamental shocks. Of course, such shocks may originate either in the private sector or the Fed, the latter as policy mistakes or shifts in political pressure on the Fed."

Goodfriend's statement reflects the widely accepted proposition that monetary policy has no lasting effect on real variables in the long run. This proposition, together with the Fisher

---

changes [e.g., Robertson and Thornton (1997)], in many cases, even the day before the target change [e.g., Poole

equation, implies that the stance of monetary policy is not independent of the economic environment. This is why in nearly all theoretical models, e.g., Woodford (1999), monetary policy is measured by the "interest rate gap"—the difference between the rate that the central banks controls and *natural rate of interest*. In Woodford's model, and most others, the natural rate is "determined by purely real factors," and is defined as the "the nominal interest rate consistent with an equilibrium with constant prices."[31]

Under a nominal interest rate targeting procedure, real shocks and inflation surprises alter the stance of policy. In the case of Woodford's model, the former—exogenous shocks to real spending or to the natural rate of output—alter the natural rate and the stance of monetary policy unless the Fed adjusts the funds rate target. The critical question for assessing the performance of monetary policy is whether the central bank changes its target rate by more or less than the shock to the natural rate.[32]

This is the basis for what McCallum (2001, p. 23) calls *Taylor Principle*—"that an interest rate policy rule should respond by more than point-for-point to inflation or its expectation." Using an argument reminiscent of Friedman (1968), Taylor (1999, p. 331) suggests that a systematic policy of raising the funds rate by less than inflation would lead to "ever increasing inflation."

6.1 *Policy Inertia*

It is widely acknowledged that the Fed does not adjust its funds rate target immediately in response to new information. For example, Goodfriend (1991, p. 10) notes that the target is adjusted at "irregular intervals only after sufficient information has been accumulated to trigger a

---

and Rasche (2001) and Kuttner (1999)].

[31] Woodford (1999), p. 16.

[32] Like nearly everyone else, Woodford (1999, p. 2) assumes that the Fed keeps the funds rate close to it operating target "through its daily interventions," however, the process is not explicitly modeled.

target change."[33] Several possible reasons for the slow response of policymakers have been offered. Some argue that the delay is due to a data lag and/or because it takes time to form a consensus. Others suggest that policymakers are uncertain about the structure of the macroeconomy or the efficacy of policy and, hence, delay acting until they are more certain that policy action is required. The delay may be exacerbated by an unwillingness to make policy errors.

In contrast to these explanations, Goodfriend (1991) and Rudebusch (1995) suggest that inertial behavior is consistent with optimal monetary policy. Rudebusch (1995) states this proposition concisely, noting that

> "…for the Fed to attain its macroeconomic goals, it must be able to manipulate these longer-term rates. However, such rates are determined by market expectations for future funds rates; thus, by presenting the market with a clear path for the future funds rate, the Fed can influence longer-term rates. A constant funds rate is the path that likely communicates policy intentions most clearly and perhaps most credibly to markets. Thus, the pursuit of macroeconomic stabilization may impart a high degree of persistence to the funds rate."

Recently, Woodford (1999) has formalized this argument. He shows that policy inertia can be optimal when policymakers realize that the efficacy of policy depends on private agents responding "appropriately" to shocks. This requires that policymakers make credible comments, which, in turn, constrains policymakers to fulfill previous commitments—implicit or explicit.

If policymakers are slow to respond to shocks to the economy (for whatever reason), one might expect such shocks to be reflected in wide array of economic variables—including market interest rates—before the Fed acts. If market rates move in advance of the funds rate target, it does not necessarily mean that the Fed responded to the change in rates *per se*, since, as Goodfriend suggest, both events are driven by the same cause. One event occurs in advance of the other simply because one group of agents respond more slowly.

[33] Goodfriend (1991), p. 10.

Nevertheless, Goodfriend (1987, 1991) argues that the Fed smoothes interest rates by adding reserves when interest rates are rising to keep rates from rising too fast, and by draining reserves to restrain the downward movement of rate when rates are falling. The implication would seem to be that if the Fed did nothing, the funds rate would rise.

6.2 *A Structural Change in the Federal Funds Market*

Why might policymakers restrain the behavior of rates as Goodfriend suggest? The answer lies in a change in the structure of the reserve market that began in the mid-1960s. Prior to the mid-1960s the federal funds rate behaved considerably different than it does now. Specifically, the discount rate was a ceiling for the federal funds rate. During this period banks used the funds market to adjust their reserve positions. When the federal funds rate was below the discount rate, most banks adjusted their reserve positions in the federal funds market.[34] When the federal funds rate rose to the level of the discount rate, it cheaper to borrow at the discount window than in the funds market so banks simply turned to the discount window.

Meulendyke (1998) notes that "there was considerable surprise when the funds rate first rose above the discount rate, briefly in 1964 and more persistently in 1965." She attributes the marked change in the behavior of the federal funds rate to a trend among large banks toward actively managing their liabilities. Specifically, she argues that "changes in liability management techniques meant that individual banks could expand credit even when they did not have free reserves if they were willing to bid aggressively for wholesale funding from other banks."[35] As part of this trend, banks introduced large negotiable certificates of deposit, CDs, in 1961. CDs were subject to both reserve requirements (until 1991) and Regulation Q interest rate ceilings (until 1970). Funds obtained in the federal funds market were subject to neither. Large

[34] While all banks use the discount window, the largest volume of borrowing is by "large" banks [Clouse (1992, 1994)].

banks discovered that they could borrow continuously in the overnight federal funds market to support their loan portfolio.[36] This practice was given a considerable boost in 1966 when a change in Reg. Q interest-rate policy temporarily limited the rise in CD rates.[37]

The impact of this structural change in the use of federal funds is shown in Figure 6, which shows the effective federal funds rate, the discount rate, DR, the 3-month CD rate, CDR, and the 3-month T-bill rate from January 1955 to December 1975.[38] The CD rate is only available since July 1964. Until the mid-1960s, there was a close relationship between the federal funds rate and the T-bill rate when the T-bill rate was at or below the discount rate. When the T-bill rate went above the discount rate, however, the funds rate rose only to the level of the discount rate. After the mid-1960s, the funds rate rose above the discount rate and has generally remained there. Over time, the funds rate rose to the level of the CD rate. The funds rate has remained close to the CD rate since the late 1960s. Moreover, the relationship between the funds rate and the T-bill rate changed in the late 1960s.

This fundamental change in banks' use of the federal funds could have caused the Fed to respond to shocks. To see why, consider the effect of an increase in loan demand. As loan demand increases banks bid up the rates on CDs and other sources of loanable funds, including funds acquired in the federal funds market. If the Fed wishes to maintain the funds rate at the target level, it must increase the supply of reserves. Indeed, the Fed has to increase the supply of reserves as long as the funds rate remains significantly below the CD rate. The Fed can keep the funds rate and, hence, the CD rate from rising only by increasing the supply of reserves until all

---

[35] Meulendyke (1998), p. 38.
[36] This practice is well known among banks and individuals at the New York Fed. I have personally confirmed this will private discussions with account managers of three large New York banks.
[37] See Gilbert (1986) for a discussion of this and other aspects in Reg. Q. Gilbert argues that this change in policy was motivated by policymaker's belief that rising interest rates were the result of increased competition among commercial banks and thrifts and not to rising inflation.
[38] The choice of 1975 is arbitrary. Extending the figure to the late 1990s would make it difficult to see the detail.

of the increase in loan demand is satisfied by the Fed at the existing federal funds rate. In effect, the Fed would have to accommodate the rise in loan demand at the existing target funds rate. Conversely, if rates fell the Fed would have to be willing to substantially restrict the monetary base.

If there are large shocks to the natural rate or inflation, the Fed might adjust its funds rate target rather quickly rather than generate large changes in the supply of money. Indeed, this might account for the rapid adjustment of the funds rate target during the 1974-1979 period. During this period, the Fed adjusted its funds rate target 99 times, on average one target change about every 2.5 weeks. Indeed, the median number of days between target changes during this period was 6. Such frequent adjustments of the funds rate target are difficult to justify if the Fed is exogenously changing interest rates by changing the funds rate target. This behavior is entirely consistent with the idea that the sharp acceleration of inflation was driving both the funds rate and the Fed's funds rate target.

6.3 *The 1989 Experience*

An example of what can happen when the Fed is slow to adjust its funds rate target is illustrated by the experience in 1989. After rising in 1988 and early 1989, interest rates peaked in March 1989 and began to fall. At the time, inflation was running at an unacceptably high rate—in excess of 4 percent. Indeed, on February 24, 1989 the Board of Governors raised the discount rate by 50 basis points, citing a desire "to implement in a visible way the System's continuing commitment to the fight against inflation…"[39] The Fed further indicated its desire for a restrictive monetary policy by raising the funds rate target modestly from 9.75 percent to 9.8125 percent on May 4.

[39] Board of Governors (1989), p. 67.

Despite increases in the discount rate and the funds rate target, other short-term interest rates declined. The T-bill rate declined by about 85 basis points between its March peak and June 5—the day before the first of three 25 basis point cuts in the funds rate target. A second target reduction occurred on July 7 and a third on July 27. An additional 6.25 basis point cut occurred on August 10. These actions occurred even though the Fed's outlook for the economy and inflation was essentially unchanged.[40] CPI inflation in 1989 was about 75 basis points higher than in 1988.

Consecutive monthly decreases in reserves are uncommon owing to the need to increase the monetary base to meet the growing demand for currency. Nevertheless, during the period from February to May total reserves decreased by $0.89 billion. This is the largest three-month decline in total reserves in the entire period from January 1959 to March 1995.[41]

The effort to keep the federal funds rate from moving with the market was successful. Despite the significant decline in other short-term interest rates, the federal funds rate remained close to the Fed's target during the period of the unchanged target. However, M1, which had been growing at about a 3.5 percent rate during the previous year, declined by $11 billion between February and June 1989.

6.4 *Temporal Ordering*

If the market and the Fed respond to the same shocks, but the Fed responds more slowly, changes in market rates should tend to precede changes in the funds rate target. Of course, by their nature term rates are forward looking. Consequently, one would expect market rates

[40] Greenbook's fourth-quarter to fourth-quarter forecasts for economic growth and inflation [fixed weighted GDP deflator], respectively were: February 1 meeting, 3.0 and 4.4 percent; March 22 meeting, 2.9 and 4.7 percent; May 10 meeting, 2.8 and 4.7 percent; June 28 meeting, 2.2 and 4.5 percent; and the August 16 meeting, 2.4 and 4.3 percent.

[41] Banks began implementing sweep programs in March 1995 in order to avoid the reserve tax. Since these programs have been implemented, reserve growth has been negative.

precede changes in the funds rate target, if the market forms rational expectations of Fed policy.[42] Nevertheless, if changes in the rate target only reflected exogenous policy actions of the Fed, one would think that on some occasions the market correctly predict the Fed's behavior and on others it would not. The change in the target would precede changes in market rates when the market is surprised by the Fed's action and follow when the market anticipates the Fed's action. On some occasions market rates should move in advance of the target and on other occasions, the target should move in advance of market interest rates. This would not be the case if the market and the Fed are being driven by the same shocks and the Fed is simply responds slowly.

The temporal ordering is investigated with a Granger causality test. The results of Granger causality tests between the 3-month T-bill rate and the funds rate target over the three sample periods used in Figures 1-3 are presented in Table 7.[43] There is a strong tendency of market rates to change in advance of changes in the funds rate target.[44] Indeed, the results indicate unidirectional temporal ordering from the T-bill rate to the funds rate target for all but the 1974-79 period, where the test indicates bi-directional temporal ordering. Bi-directional temporal ordering during this period is not surprising given the frequency of target changes. In the periods when the funds rate target was changed less frequently, the test indicates unidirectional temporal ordering from the T-bill rate to the funds rate target.

There are two possible interpretations of the unidirectional temporal ordering since the early 1980s. Either the Fed and the market rates responded to the same shocks and the Fed

[42] In its strict form, the expectations theory has received little support, [e.g., Campbell and Shiller (1991) and Shiller, Campbell and Schoenholtz (1983)]. This is especially true when the short-term rate is the federal funds rate [Hardouvelis (1988), Simon (1990), Roberds, Runkle and Whiteman (1996) and Thornton (2000a)].
[43] The results are qualitatively the same if the tests are performed using first differences.
[44] This argument has been historically make for the discount rate, which also has a strong tendency to follow the market

responds more slowly, or the market consistent forecast the direction of exogenous changes in monetary policy. It is, of course, impossible to determine which explanation is correct without additional information. Nevertheless, Goodfriend's suggestion that the market and the Fed respond to the same information would appear as plausible an explanation as the expectations hypothesis.

7. Conclusions

Historically there is a close relationship between the federal funds rate and the Fed's funds rate target. It is widely believed that the Fed controls the federal funds rate by altering the degree of pressure in the reserve market through open market operations. It is thought that the Fed increases the funds rate when it raises its funds rate target by draining reserves from the banking system and reduces the funds rate by injecting reserves when it reduces the target. There is no evidence, however, of a significant negative relationship between narrow monetary aggregates, which are most directly affected by open market operations, and short-term interest rates.

Recently, several analysts [McCallum (1995), Guthrie and Wright (2000) and Meulendyke (1998)] have suggested that open market operations may not be essential to the Fed's ability to control the funds rate. They suggest that the Fed controls the funds rate through open mouth operations. That is, the Fed controls the funds rate simply by making its intentions for the funds rate known. The lack of evidence of a liquidity effect and the increased openness of the Federal Reserve about its target for the federal funds rate since the mid-1990s has caused an increased interest in the open-mouth-operations hypothesis.

This paper investigates whether the historically close relationship between the federal funds rate and the federal funds rate target is due to open market operations or open mouth

operations. This is accomplished by testing the market's reaction to actual and perceived changes in the funds rate target. If changes in the funds rate target represent exogenous policy actions that the Fed implements through open market operations, the funds rate should respond significantly to unanticipated changes in the funds rate target regardless of whether the market knows that the target has changed (or is even aware that the Fed is targeting the funds rate). If, on the other hand, the Fed controls the funds rate through open mouth operations, the funds rate should change with the target only when the market is aware that the target has changed.

The lack of a statistically significant relationship between changes in the funds rate and changes in the funds rate target suggests that the Fed has not moved the funds rate through open market operations. Indeed, the funds rate did not respond significantly even when the market was aware that the target had changed. The market had considerable difficulty determining the timing an magnitude of target changes the 1974-79 period and the T-bill rate responded significantly to target changes that the market knew (or thought) had occurred. These results suggest that the funds rate did not respond because the market anticipated the Fed's actions.

Open mouth operations requires that the market be aware that the Fed is targeting the federal funds rate. Evidence, both documentary and empirical, suggests that the market was not aware that the Fed was targeting the funds rate between 1984 and 1990. Hence, open mouth operations cannot account for the relationship between the funds rate and the funds rate target during this period. It is unlikely that open mouth operations accounts for the close relationship between these rate during the 1974-1979 period either. It frequently took the market several days to determine that the target had been changed. If the relationship between these rates is due to open mouth operations, the spread between these rates should have been unusually large on such occasions, but that is not the case.

Finding essentially no evidence to support either open market operations or open mouth operations, I consider a possibility that changes in interest rates are primarily driven by real shocks and inflation surprises and the markets respond to such shocks before the Fed does. This possibility is a direct consequence of the view, widely accepted by classical and neoclassical economists [e.g., Humphrey (1983ab)] and by traditional [e.g., Friedman (1968)] and modern [e.g., Woodford (1999), McCallum (2001)] monetary theorists, that the equilibrium natural rate of interest is determined by real factors. Shocks to the real economy or inflation surprises cause monetary policy to become easier or tighter at an unchanged nominal interest rate target. Faced with such shocks, policymakers must change the funds rate target simply to maintain the stance of monetary policy.

If policymakers respond more slowly to shocks than the market, market rates can move in advance of changes in the funds rate target. This does not imply that changes in interest rates "caused" the Fed to change its target, per se. Rather both rate changes are driven by the same shock: one group of economic agents simply moves more slowly than the other. In the interest rate smoothing models of Goodfriend (1987) and Barro (1989) policymakers add reserves when interest rates rise and drain reserves when interest rates fall in order to slow the progression of rates. The structure of the reserve market (and particularly the use of federal funds by large banks) suggests why the Fed might respond this way automatically when its funds rate target is unchanged. Rising or falling interest rates will put pressure on the Fed to increase or decrease the supply of reserves, respectively, if it wishes to maintain its rate unchanged.

The possibility that some target changes reflect endogenous responses to exogenous shocks does not imply that all are. Target changes that are larger than required to restore policy to its pre-shock stance represent changes in the stance of policy. Taylor (1999) has recently

suggested that failure to make such "aggressive" adjustments to the funds rate target "have been associated with either high and prolonged inflation or drawn-out periods of low capacity utilization, much as simple monetary theory would predict. Consistent with observations made by Taylor (1999), Clarida, Gali and Gertler (2000) find that the funds rate rose by less than inflation before 1979 and by more than inflation after, and conclude that monetary policy accommodate inflation before 1979 but not after.[45]

The view that monetary policy is not independent of economic circumstances raises doubts about the claim—implicit or explicit—that all persistent changes in the federal funds rate represent exogenous policy actions of the Fed. Distinguishing between exogenous and endogenous target changes is likely to be difficult. Nevertheless, the idea that some target changes are necessitated by the desire to maintain the stance of policy is consistent with classical and contemporary monetary theory and several prominent models of interest rate smoothing. Moreover, this view is consistent with a wide variety of empirical evidence: the failure of open market or open mouth operations to account for the relationship between the funds rate and the funds rate target presented here; the inability of researchers to find a significant liquidity effect[46]; the historically positive relationship between narrow monetary aggregates and short-term interest rates[47], and the strong tendency of the funds rate target to follow changes in market interest rates.

[45] Whether this approach will ultimate be successful identifying policy actions that exogenous remains to be seen. For one thing, Clarida, Gali and Gertler (2000) and Taylor (1999) only determine whether policy has been accommodative on average over long periods of time. In addition, it was commonly believed that interest rates responded less during the 1970s because the persistence of inflation took markets by surprise. Consequently, actual inflation was considerably higher than expected inflation [Clarida, Gali and Gertler (2000) estimates are based on a forward-looking model, but the horizon is only one quarter]. It is also widely believed that markets had reservations about the speed of the disinflation in the early 1980s, so inflation expectation lagged experience. Finally, as noted earlier, the behavior of the federal funds rate was considerably different over a significant portion of pre-1979 sample period. It is not clear how this difference may effect the estimates over the pre-1979 sample period.
[46] See Thornton (1988b) and Pagan and Robertson (1995) for a summary of much of this research. Also see Thornton (2001ab) for an explanation (and evidence) of why two recent methodologies [Pagan and Robertson (1995) and Christiano, Eichenbaum and Evans (1996ab), and Hamilton (1997)] did not identify the liquidity effect.
[47] See Christiano, Eichenbaum and Evans (1996ab) and Pagan and Robertson (1995) for a discussion of this relationship.

References:

Andrews, Donald W. K. "Tests for Parameter Instability and Structural Change with Unknown Change Points," *Econometrica* (July 1993), 821-56.

Barro, Robert J. "Interest Rate Targeting," *Journal of Monetary Economics* (January 1989), 3-30.

Batten, Dallas S. and Daniel L. Thornton. "Discount Rate Changes and the Foreign Exchange Market," *Journal of International Money and Finance* (December 1984), 279-92.

_____. "The Discount Rate, Interest Rates and Foreign Exchange Rates: An Analysis with Daily Data," Federal Reserve Bank of St. Louis *Review* (February 1985), 22-30.

Board of Governors of the Federal Reserve System. *Annual Report*, 1989.

Bonser_Neal Catherine, V. Vance Roley and Gordon Sellon, Jr. "Monetary Policy Actions, Intervention, and Exchange Rates: A Reexamination of the Empirical Relationships Using the Federal Funds Rate Target Data," *Journal of Business* (April 1998), 147-77.

Campbell, John Y. and Robert J. Shiller. "Yield Spreads and Interest Rate Movements: A Bird's Eye View," *Review of Economic Studies* (May 1991), 495-514.

Christiano, Lawrence J., Martin Eichenbaum and Charles Evans. "The Effects of Monetary Policy Shocks: Evidence From the Flow of Funds," *Review of Economics and Statistics* (February 1996a), 16-34.

_____. "Identification and the Effects of Monetary Policy Shocks," in M Blejer, Zvi Echstein, Zvi Hercowitz and Leonardo Leiderman, eds., *Financial Factors in Economic Stabilization and Growth*, Cambridge University Press, 1996b.

Clouse, James A. "Arriving at the Window: An Analysis of the Slowdown in the Number of Adjustment Credit Borrowers," Board of Governors of the Federal Reserve System, working paper, 1992.

_____. "Recent Developments in Discount Window Policy," *Federal Reserve Bulletin* (November 1994), 965-77.

Cook, Timothy and Thomas Hahn. "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s," *Journal of Monetary Economics* (November 1989a), 331-51.

_____. "A Comparison of Actual and Perceived Changes in the Federal Funds Rate Target in the 1970s," Federal Reserve Bank of Richmond Working Paper no. 1989-4, 1989b.

_____. "The Information Content of Discount Rate Announcements and Their Effect on Market Interest Rates," *Journal of Money, Credit and Banking* (May 1988), 167-80.

Cook, Timothy and Steven Korn. "The Reaction of Interest Rates to the Employment Report: The Role of Policy Anticipations," Federal Reserve Bank of Richmond *Economic Review* (September/October 1991), 3-12.

Dwyer, Gerald P. and R. W. Hafer. "Interest Rates and Economic Announcements," Federal Reserve Bank of St. Louis *Review* (March/April 1989), 34-46.

Friedman, Milton. *A Program for Monetary Stability*. New York: Fordham University Press, 1960.

_____. "The Role of Monetary Policy," *American Economic Review* (March 1968), 1-17.

_____. "Churning at the Fed," *Newsweek* (August 31, 1981), p. 38.

_____. "Monetary Policy: Theory and Practice," *Journal of Money, Credit and Banking* (February 1982a), 98-118.

_____. "Monetary Policy: Theory and Practice, A Reply," *Journal of Money, Credit and Banking* (August 1982b), 404-06.

Gilbert, R. Alton. "Requiem for Regulation Q: What It Did and Why It Passed Away," Federal Reserve Bank of St. Louis *Review* (February 1968), 22-37.

Goodfriend, Marvin. "Interest Rates and the Conduct of Monetary Policy," *Carnegie-Rochester Conference Series on Public Policy*, (1991), 7-30.

_____. "Interest Rate Smoothing and Price Level Trend-Stationarity," *Journal of Monetary Economics* (1987), 335-48.

_____. "Monetary Mystique: Secrecy and Central Banking," *Journal of Monetary Economics* (1986), 63-92.

Greenspan, Alan. "Remarks by Chairman Greenspan," at the 15th Anniversary Conference of the Center for Economic Policy Research at Stanford University, September 5, 1997.

Guthrie, Graeme and Julian Wright. "Market Implemented Monetary Policy with Open Mouth Operations," *Journal of Monetary Economics* (October 2000), 489-516.

Hamilton, James D. "Measuring the Liquidity Effect," *American Economic Review* (March 1997), 80-97.

_____ and Oscar Jorda. "A Model for the Federal Funds Rate Target," unpublished manuscript, November 1997.

Hanes, Christopher. “Reserves, Fed Funds and Repo: How the Federal Reserve Controls Interest Rates under Federal Funds Rate Targeting,” unpublished manuscript, 1998.

Hardouvelis, Gikas A. “Macroeconomic Information and Stock Prices,” *Journal of Economics and Business* (May 1987), 131-40.

_____. “The Predictive Power of the Term Structure during Recent Monetary Regimes,” *Journal of Finance* (June 1988), 339-56.

_____. “The Term Structure Spread and Future Changes in Long and Short Rates in the G7 Countries: Is There a Puzzle?” *Journal of Monetary Economics* (April 1994), 255-83.

Hardy, Daniel. “Anticipation and Surprises in Central Bank Interest Rate Policy,” *International Monetary Fund Staff Papers* (December 1998), 647-71.

Humphrey, Thomas M. “The Early History of the Real/Nominal Interest Rate Relationship,” Federal Reserve Bank of Richmond *Economic Review* (May/June 1983a), 2-10.

_____. “Can the Central Bank Peg Real Interest Rates? A Survey of Classical and Neoclassical Opinion,” Federal Reserve Bank of Richmond *Economic Review* (September/October 1983b), 12-21.

Kitten, Kenneth N. “Monetary Policy Surprises and Interest Rates: Evidence from the Federal Funds Futures Market,” Federal Reserve Bank of New York, November 26, 1999.

Levin, Fred J. and Ann-Marie Meulendyke. “Monetary Policy: Theory and Practice, A Comment,” *Journal of Money, Credit and Banking* (August 1982), 399-403.

McCallum, Bennett T. “New Zealand’s Monetary Policy Arrangements: Some Critical Issues,: Reserve Bank of New Zealand Discussion Paper No. G95/4, 1995.

_____. “Monetary Policy Analysis in Models Without Money,” Federal Reserve Bank of St. Louis *Review*, forthcoming (2001).

Meulendyke, Ann-Marie. *U.S. Monetary Policy & Financial Markets*, Federal Reserve Bank of New York (1998).

Mudd, Douglas R. “Did Discount Rate Changes Affect the Foreign Exchange Value of the Dollar During 1978?” Federal Reserve Bank of St. Louis *Review* (April 1979), 20-26.

Pagan, Adrian R. and John C. Robertson. “Resolving the Liquidity Effect,” Federal Reserve Bank of St. Louis *Review* (May/June 1995), 33-54.

Poole, William and Robert H. Rasche, “Perfecting the Market’s Knowledge of Monetary Policy,” *Journal of Financial Services Research*, forthcoming (2001).

Roberds, William, David Runkle and Charles H. Whiteman. "A Daily View of Yield Spreads and Short-Term Interest Rate Movements," *Journal of Money, Credit and Banking* (February 1996), 34-53.

Robertson, John C. and Daniel L. Thornton. "Using Federal Funds Futures Rates to Predict Federal Reserve Actions," Federal Reserve Bank of St. Louis *Review* (November/December 1997), 45-53.

Roley, V. Vance, and Rick Troll. "The Impact of Discount Rate Changes on Market Interest Rates," Federal Reserve Bank of Kansas City *Economic Review* (January 1984), 27-39.

Rudebusch, Glenn D. "Federal Reserve Interest Rate Targeting, Rational Expectations, and the Term Structure," *Journal of Monetary Economics* (April 1995a), 245-74.

_____. "Erratum," *Journal of Monetary Economics* (December 1995b), 679.

Samuelson, Paul A. "Reflections on Monetary Policy," *Review of Economics and Statistics* (August 1960), 263-69.

Shiller, Robert J., John Y. Campbell and Kermit L. Schoenholtz. "Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates," Brookings Papers on Economic Activity (1983), 173-217.

Simon, David P. "Expectations and the Treasury Bill-Federal Funds Rate Spread over Recent Monetary Policy Regimes," *Journal of Finance* (June 1990), 567-77.

Smirlock, Michael and Jess Yawitz. "Asset Returns, Discount Rate Changes, and Market Efficiency," *Journal of Finance* (September 1985), 1141-58.

Stock, James H. and Mark W. Watson. "Testing for Common Trends," *Journal of the American Statistical Association* (December 1988), 1097-107.

Strongin, Steven. "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle," *Journal of Monetary Economics* (August 1995), 463-97.

Taylor, John B. "A Historical Analysis of Monetary Policy Rules," in John B. Taylor, ed., *Monetary Policy Rules*, University of Chicago Press, Chicago, Illinois, 1999.

_____. "Expectations, Open Market Operations, and Changes in the Federal Funds Rate," Federal Reserve Bank of St. Louis *Review*, forthcoming (2001).

Thornton, Daniel L. "The Borrowed-Reserves Operating Procedure: Theory and Evidence," Federal Reserve Bank of St. Louis *Review* (January/February 1988a), 30-54.

_____. "The Effects of Monetary Policy on Short-Term Interest Rates," Federal Reserve Bank of St. Louis *Review* (May/June 1988b), 53-72.

_____. "The Effect of Unanticipated Money on the Money and Foreign Exchange Markets," *Journal of International Money and Finance* (December 1989), 573-88.

_____. "Why Do T-Bill Rates React to Discount Rate Changes," *Journal of Money, Credit and Banking*, (November 1994), 839-850.

_____. "The Information Content of Discount Rate Announcements: What's Behind the Announcement Effect?" *Journal of Banking and Finance* (January 1998), 83-108.

_____. "The Predictive Power of the T-Bill/Federal Funds Rate Spread: Resolving the Anomalies at the Very Short End of the Term Structure," unpublished manuscript, Federal Reserve Bank of St. Louis, 2000a.

_____. "Lifting the Veil of Secrecy from Monetary Policy: Evidence from the Fed's Early Discount Rate Policy," *Journal of Money, Credit and Banking* (May, 2000b), 155-67.

_____. "The Federal Reserve's Operating Procedure, Nonborrowed Reserves, Borrowed Reserves and the Liquidity Effect," *Journal of Banking and Finance*, forthcoming, 2001a.

_____. "Identifying the Liquidity Effect at the Daily Frequency," Federal Reserve Bank of St. Louis *Review*, forthcoming, 2001b.

Transcript of the Meeting of the Federal Open Market Committee, July 12-13, 1983.

Transcript of the Meeting of the Federal Open Market Committee, November 13, 1990.

Wallich, Henry C. "Recent Techniques of Monetary Policy," Federal Reserve Bank of Kansas City *Economic Review* (May 1984), 21-30.

Wheelock, David C. and Daniel L. Thornton. "A History of the Asymmetric Policy Directive," Federal Reserve Bank of St. Louis *Review*, (September/October 2000), 1-16.

White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix and a Direct Test for Heteroskedasticity," *Econometrica* (May 1980), 817-838.

Woodford, Michael. "Optimal Monetary Policy Inertia," unpublished manuscript, January 1999.

Table 1: WSJ Announced and Actual Target Changes

Date	$\Delta fftar_t^{wsj}$	$\Delta fftar_t^{a}$	*Date*	$\Delta fftar_t^{wsj}$	$\Delta fftar_t^{a}$
09/13/74	-0.5000 (2)	-o.25000	05/28/76	0.0000	0.0625
09/20/74	0.0000	-0.3750	07/02/76	0.0000	-0.1250
09/23/74	-0.2500* (2)	0.0000	07/09/76	-0.2500 (3)	-0.1250
09/27/74	0.0000	-0.1250	10/01/76	0.0000	-0.0625
10/04/74	-0.2500 (1)	-0.3750	10/08/76	-0.2500 (3)	-0.1875
10/11/74	0.0000	-0.3750	11/19/76	-0.2500 (2)	-0.1250
10/18/74	-0.5000 (4)	-0.5000	11/26/76	0.0000	-0.1250
11/01/74	0.0000	-0.2500	12/10/76	0.0000	-0.0625
11/25/74	0.0000	-0.2500	12/14/76	-0.1250** (2)	0.0000
11/29/74	0.0000	-0.1250	12/17/76	0.0000	-0.0625
12/03/74	-0.2500** (4)	0.0000	01/19/77	0.0000	0.0625
12/09/74	0.0000	-0.2500	04/15/77	0.0000	0.0625
12/13/74	0.0000	-0.1250	04/25/77	0.1250*** (5)	0.0000
12/16/74	-0.2500* (3)	0.0000	04/27/77	0.1250*** (3)	0.0000
12/20/74	0.0000	-0.5000	04/29/77	0.0000	0.2500
12/27/74	0.0000	-0.2500	05/05/77	0.0000	0.2500
01/02/75	-0.2500*** (2)	0.0000	05/10/77	0.1250*** (2)	0.0000
01/03/75	-0.2500 (1)	-0.5000	05/18/77	0.0000	0.1250
01/06/75	-0.2500* (4)	0.0000	05/19/77	0.1250* (4)	0.0000
01/07/75	-0.2500** (3)	0.0000	07/27/77	0.0000	0.1250
01/10/75	0.0000	-0.2500	07/28/77	0.2500 (3)	0.1250
01/14/75	-0.2500** (5)	0.0000	08/01/77	0.0000	0.1250
01/17/75	0.0000	-0.1250	08/09/77	0.1250 (1)	0.1250
01/24/75	0.0000	-0.2500	08/12/77	0.1250 (1)	0.1250
01/31/75	-0.5000 (2)	-0.3750	09/09/77	0.1250 (2)	0.1250
02/07/75	0.0000	-0.2500	09/21/77	0.0000	0.1250
02/13/75	-0.2500*** (1)	0.0000	09/22/77	0.1250* (3)	0.0000
02/14/75	-0.2500*** (2)	0.0000	09/30/77	0.1250 (3)	0.1250
02/21/75	-0.2500 (1)	-0.2500	10/03/77	0.0000	0.0625
03/07/75	0.0000	-0.2500	10/07/77	0.1250 (1)	0.0625
03/21/75	0.0000	-0.2500	10/28/77	0.0000	0.0625
03/26/75	-0.2500*** (2)	0.0000	10/31/77	0.1250* (1)	0.0000
05/02/75	0.0000	-0.2500	11/04/77	0.0000	-0.0625
05/08/75	-0.2500 (1)	-0.1250	01/09/78	0.2500 (2)	0.2500
06/06/75	0.0000	0.1250	04/19/78	0.2500 (1)	0.2500
06/18/75	0.0000	0.2500	04/26/78	0.0000	0.1250
06/20/75	0.5000 (2)	0.2500	04/27/78	0.2500 (3)	0.1250
06/27/75	0.0000	0.2500	05/17/78	0.0000	0.2500
07/16/75	0.1250*** (3)	0.0000	05/18/78	0.2500* (1)	0.0000
07/18/75	0.0000	0.1875	06/21/78	0.2500 (3)	0.2500
07/21/75	0.1250* (2)	0.0000	07/19/78	0.0000	0.1250
07/22/75	0.1250** (1)	0.0000	07/20/78	0.1250* (5)	0.0000
09/19/75	0.0000	0.1875	08/16/78	0.1250 (4)	0.1250
09/26/75	0.0000	-0.1250	08/18/78	0.1250 (1)	0.1250
10/03/75	-0.1250 (2)	-0.2500	08/25/78	0.0000	0.1250
10/10/75	0.0000	-0.2500	08/28/78	0.1250* (3)	0.0000
10/21/75	-0.3750*** (2)	0.0000	09/08/78	0.1250 (1)	0.1250
10/24/75	0.0000	-0.1250	09/20/78	0.1250 (1)	0.1250
10/31/75	0.0000	-0.1250	09/22/78	0.0000	0.1250
11/07/75	-0.1250 (4)	-0.2500	09/25/78	0.1250* (3)	0.0000
11/12/75	-0.1250** (2)	0.0000	09/28/78	0.1250 (4)	0.1250
12/26/75	0.0000	-0.1250	10/18/78	0.1250 (2)	0.2500
01/02/76	0.0000	-0.1250	10/20/78	0.1250** (4)	0.0000
01/06/76	-0.1250** (1)	0.0000	10/26/78	0.1250*** (4)	0.0000
01/09/76	0.0000	-0.1250	10/31/78	0.3750 (4)	0.6250
01/12/76	0.0000	-0.1250	11/01/78	0.2500* (3)	0.0000
02/27/76	0.2500 (4)	0.0625	11/21/78	0.0000	0.2500
03/10/76	0.0000	-0.0625	11/28/78	0.1250*** (3)	0.0000
03/30/76	-0.1250*** (1)	0.0000	12/19/78	0.1250 (1)	0.1875
04/21/76	0.0000	0.1250	01/15/79	0.1250*** (4)	0.0000
04/23/76	0.1250** (3)	0.0000	04/27/79	0.1880 (2)	0.1875
04/30/76	0.0000	0.1250	07/20/79	0.3750 (3)	0.2500
05/05/76	0.1250*** (3)	0.0000	07/27/79	0.0000	0.1250
05/11/76	0.0000	0.1250	08/15/79	0.3750 (2)	0.3750
05/12/76	0.1250* (3)	0.0000	08/24/79	0.2500 (3)	0.2500
05/14/76	0.1250 (4)	0.1250	08/31/79	0.0000	0.1250
05/19/76	0.1250 (3)	0.1250	09/04/79	0.1250* (3)	0.0000
05/21/76	0.0000	0.0625	09/19/79	0.1250 (1)	0.1250

Asterisk indicates the number of days after the last actual target Change, where
* 1 day after, ** 2 days after, *** 3 or more days after
(n) indicates the type of the *WSJ* target change.

Table 2: Descriptive Statistics					
Statistic	Mean	Std. Dev.	Min.	Max.	No. Obs.
$\Delta fftar^{WSJ}$	0.0206	0.2260	-0.5000	0.5000	76
$\Delta fftar_{A}^{WSJ}$	0.0497	0.2566	-0.5000	0.5000	38
$\Delta fftar_{NA}^{WSJ}$	-0.0101	0.1872	-0.3725	0.2500	38
$\Delta fftar^{A}$	-0.0025	0.2145	-0.5000	0.6250	99
$\Delta fftar_{WSJ}^{A}$	0.0433	0.2463	-.5000	0.6250	39
$\Delta fftar_{NWSJ}^{A}$	-0.0323	0.1871	-.5000	0.2500	60

Table 3: The Market's Response to WSJ Funds Rate Target Changes, September 13, 1974 – October 5, 1979

Coefficient (# of changes)	$\Delta tb3_t$		Δff_t	
Const.	0.0003 (0.12)	0.0002 (0.08)	0.0213* (2.81)	0.0214* (2.82)
δ	0.0156 (1.42)	0.0157 (1.45)	-0.0711* (3.46)	-0.0712* (3.46)
$\Delta fftar^{WSJ}$ (76)	0.5263* (7.77)	--	0.3031* (3.21)	--
$\Delta fftar_A^{WSJ}$ (38)	--	0.5739* (6.47)	--	0.2778* (2.88)
$\Delta fftar_{NA}^{WSJ}$ (38)	--	0.4278* (4.40)	--	.3583 (1.73)
Adj, R^2	0.1116	0.1123	0.3825	0.3821
s.e.	0.0937	0.0937	0.2843	0.2844
F-statistic	--	1.221	--	0.128

The estimated normalized cointegrating vector is $ff_t = 1.2762 tb3_t + 1.2863$.

* Indicates statistical significance at the 5 percent level.

Table 4: Response to Target Changes Classified by Type		
Coefficient (# of changes)	$\Delta tb3_t$	Δff_t [1/]
Const.	0.0005 (0.20)	0.0207* (2.72)
δ	0.0156 (1.43)	-0.0720* (3.49)
$\Delta fftar^{WSJ}(1)$ (19)	0.5515* (3.12)	-0.0144 (0.0813)
$\Delta fftar^{WSJ}(2)$ (19)	0.6158* (4.56)	0.0344 (0.22)
$\Delta fftar^{WSJ}(3)$ (23)	0.4546* (9.67)	0.8488* (4.97)
$\Delta fftar^{WSJ}(4)$ (12)	0.4140* (2.77)	0.5405* (2.37)
$\Delta fftar^{WSJ}(5)$ (3)	0.4091* (2.40)	-0.3067 (0.78)
Adj R^2	0.1110	0.3836
s.e.	0.0938	0.2841
F-statistic	0.4346	5.6113*

1/ Estimated normalized cointegrating vector is $ff_t = 1.2762 tb3_t + 1.2863$.

* Indicates statistical significance at the 5 percent level.

Table 5: The Market's Reaction to Actual Funds Rate Target Changes: September 13, 1974-October 5, 1979				
Coefficient (# of changes)	$\Delta tb3_t$		Δff_t	
Const.	0.0010 (0.39)	0.0006 (0.23)	0.0221* (2.92)	0.0223* (2.96)
δ	0.0172 (1. 60)	0.0171 (1.59)	-0.0700* (3.39)	-0.070* (3.39)
$\Delta fftar^A$ (99)	0.4420* (5.42)	--	0.3191* (3.67)	--
$\Delta fftar^A_{WSJ}$ (39)	--	0.5833* (5.37)	--	0.2657* (2.58)
$\Delta fftar^A_{NWSJ}$ (60)	--	0.2843* (2.40)	--	0.3787* (2.55)
Adj. R^2	0.0922	0.0992	0.3830	0.3826
s.e.	0.0948	0.0944	0.2842	0.2843
F-statistic	--	3.742*	--	0.3864

Estimated normalized cointegrating vector is $ff_t = 1.2762tb3_t + 1.2863$.

* Indicates statistical significance at the 5 percent level.

Table 6: The Market's Reaction to Actual Funds Rate Target Changes: March 1, 1984 – December 31, 1997				
Coefficient (# of changes)	$\Delta tb3_t$		Δff_t	
Const.	-0.0009 (0.87)	-0.0008 (0.85)	-0.0014 (0.25)	-0.0014 (0.24)
δ	0.0089* (2.31)	0.0086* (2.25)	-0.2126* (4.14)	-0.2122* (4.14)
$\Delta fftar^{A}_{B88}$ (60)	0.0244 (0.48)	--	0.1391 (0.67)	--
$\Delta fftar^{A}_{A88}$ (48)	0.3032* (6.65)	--	0.3144 (1.45)	--
$\Delta fftar^{A}_{B90}$ (82)	--	0.0596 (1.32)	--	0.0743 (0.42)
$\Delta fftar^{A}_{A90}$ (26)	--	0.3363* (5.81)	--	0.4752 (1.76)
Adj. R^2	0.0528	0.0519	0.1964	0.1969
s.e.	0.0587	0.0587	0.3379	0.3378
LR test	47.492*	44.244*	0.570	2.828

1/ Estimated normalized cointegrating vector is $ff_t = 1.1415 tb3_t + 0.3027$.

* Indicates statistical significance at the 5 percent level.

Table 7: Tests of Granger Causality Between *tb3* and *fftar*						
	Sample Period					
	9/13/74-10/5/79		3/1/84-9/29/89		10/2/89-12/31/97	
Lag Length	F1	F2	F1	F2	F1	F2
2	27.84*	1.36	502.85*	2.30	29.71*	1.30
4	14.50*	3.04*	259.16*	1.30	15.51*	1.18
6	7.44*	5.98*	177.72*	1.22	10.81*	0.76
8	5.86*	5.44*	136.29*	0.86	8.33*	0.57
10	4.72*	4.81*	101.00*	0.95	6.99*	1.28

F1=*tb3* does not Granger cause *fftar*.
F2= *fftar* does not Granger cause *tb3*.
* Indicates statistical significance at the 5 percent level.

Figure 1: Federal Funds Rate and Target

(September 13, 1974 - October 5, 1979)

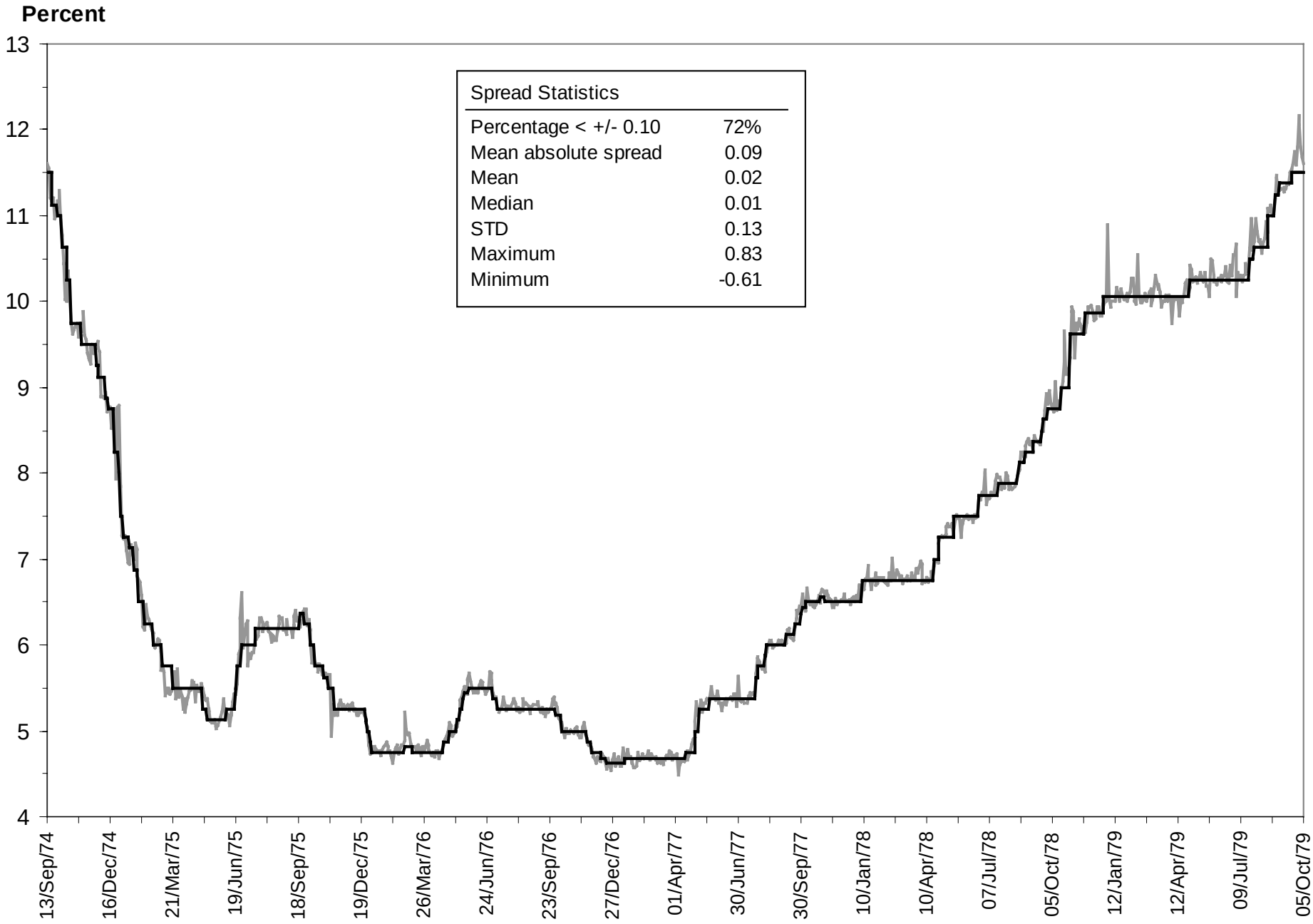


Figure 2: Federal Funds Rate and Target

(March 1, 1984 - September 29, 1989)

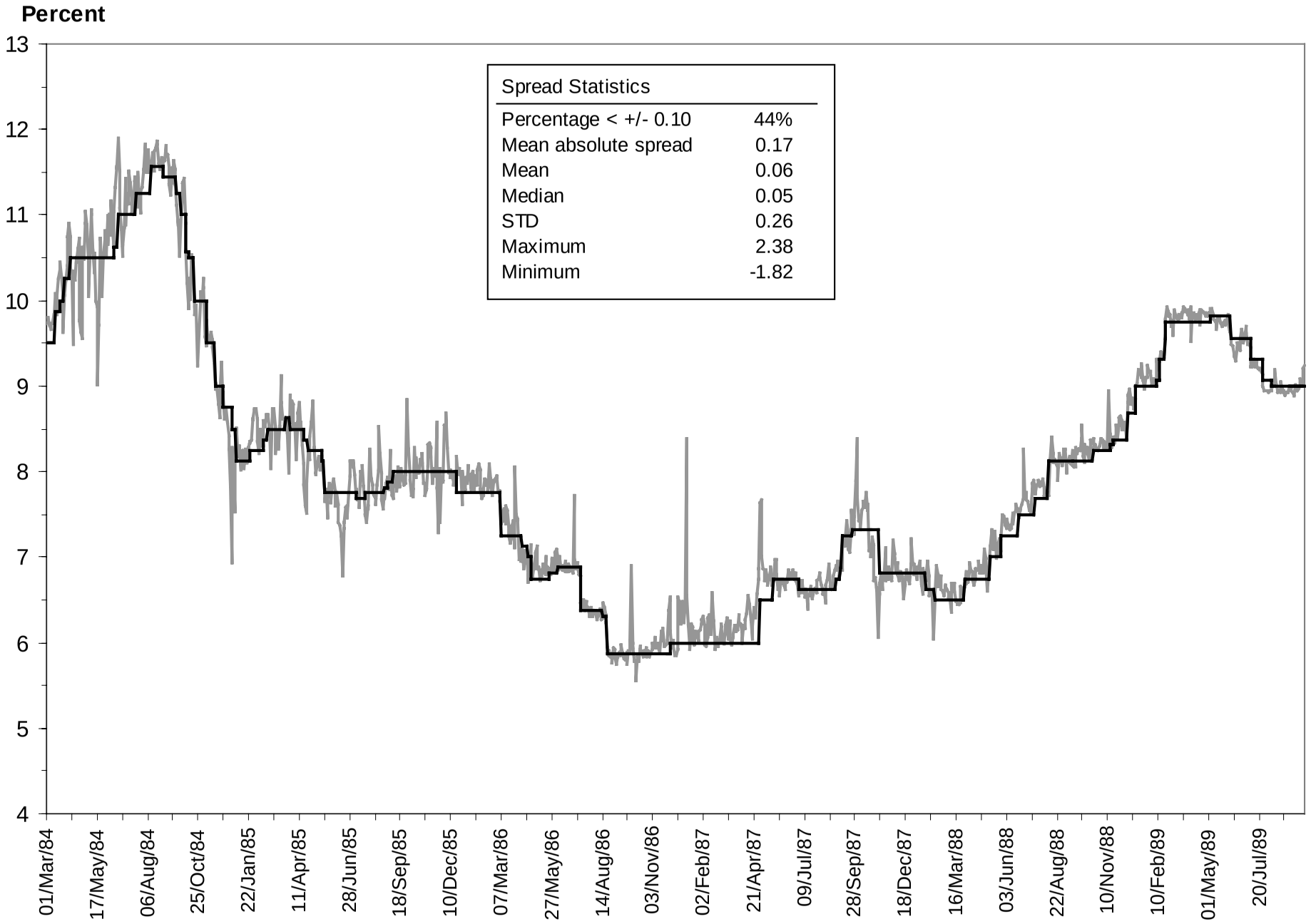


Figure 3: Federal Funds Rate and Target

(October 2, 1989 - December 31, 1997)

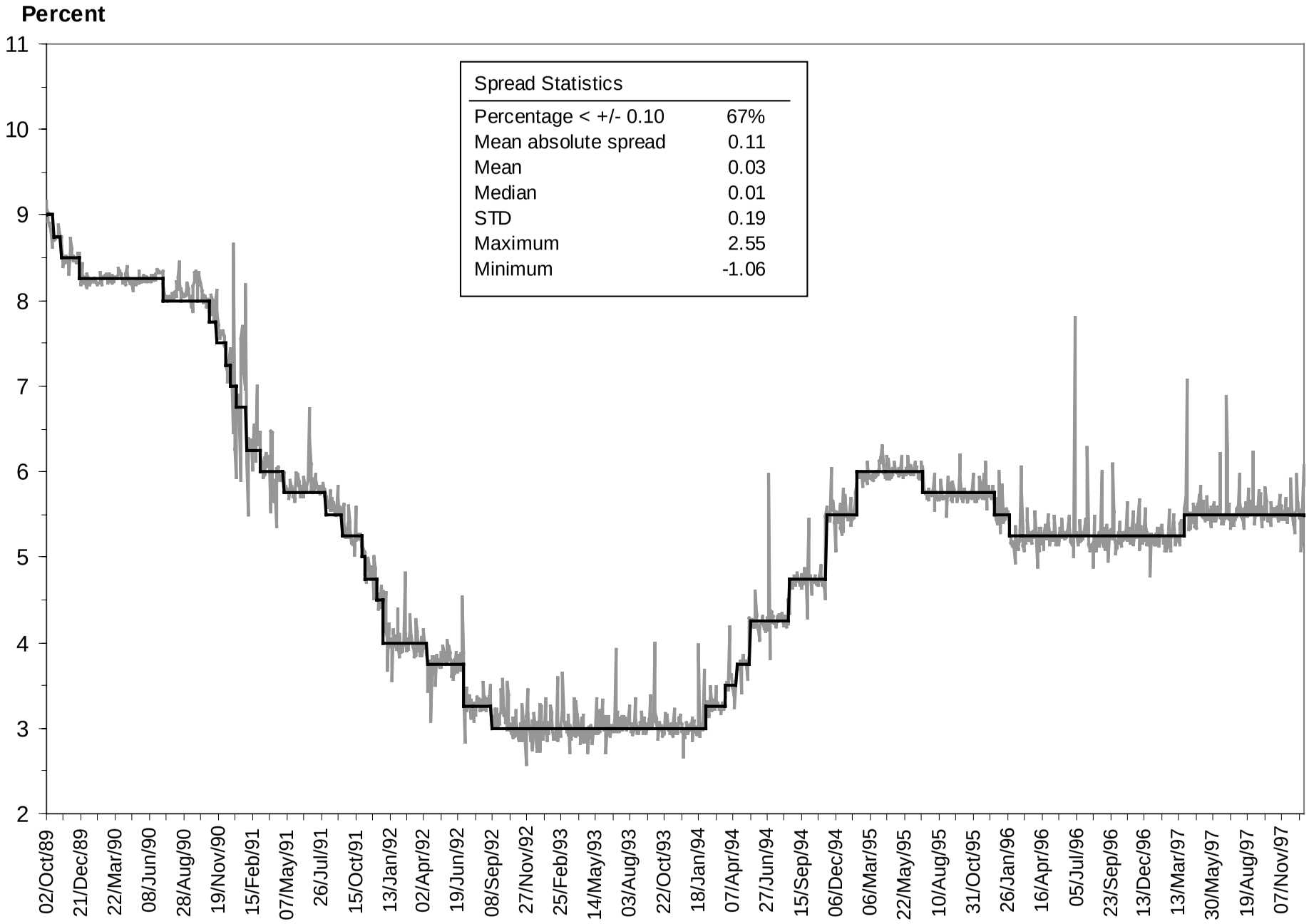
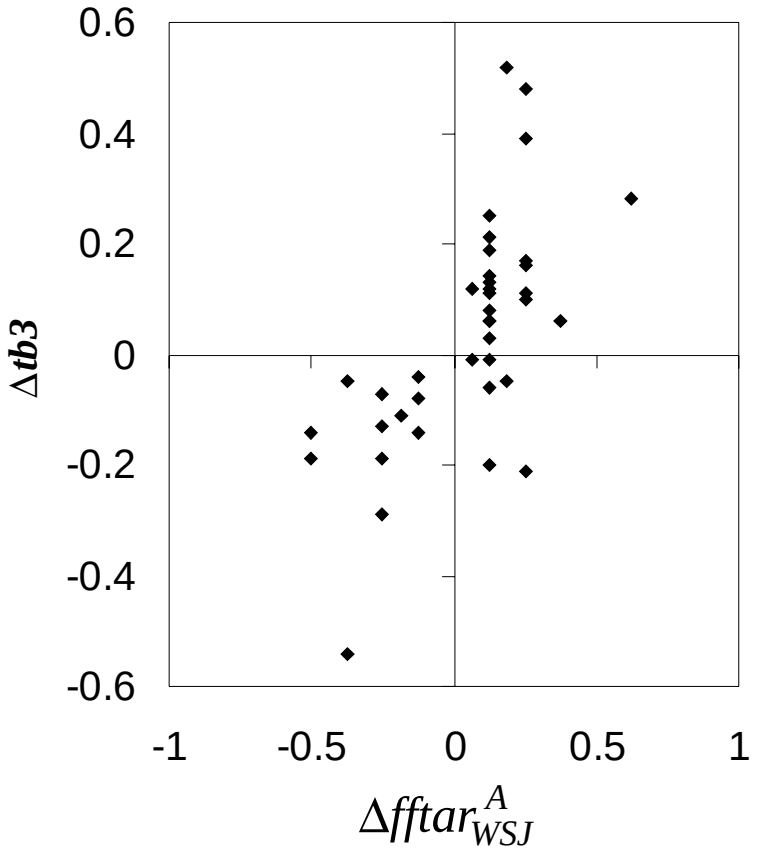
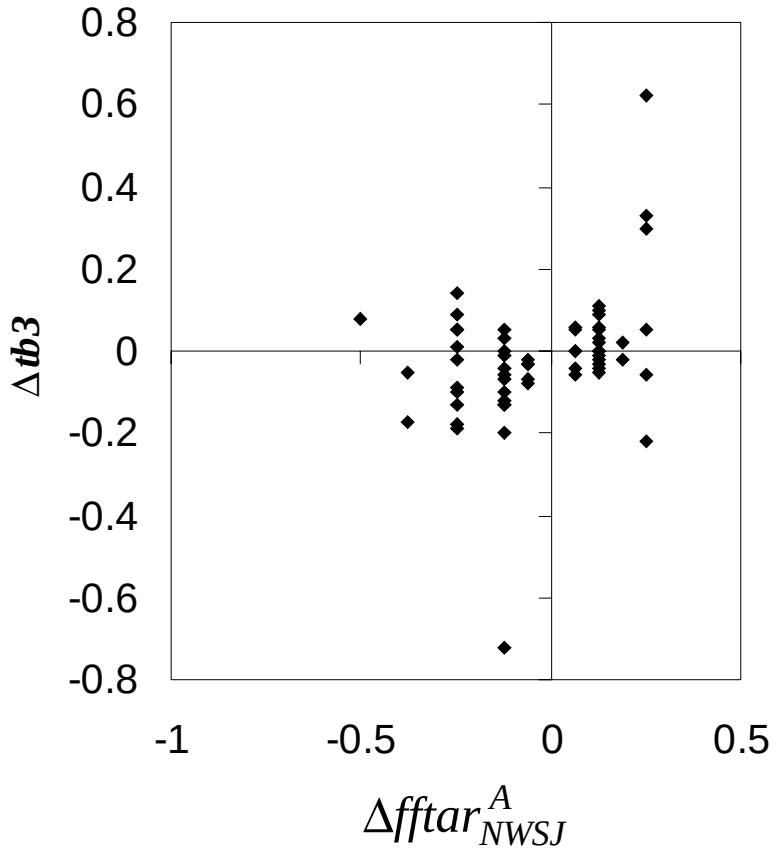


Figure 4

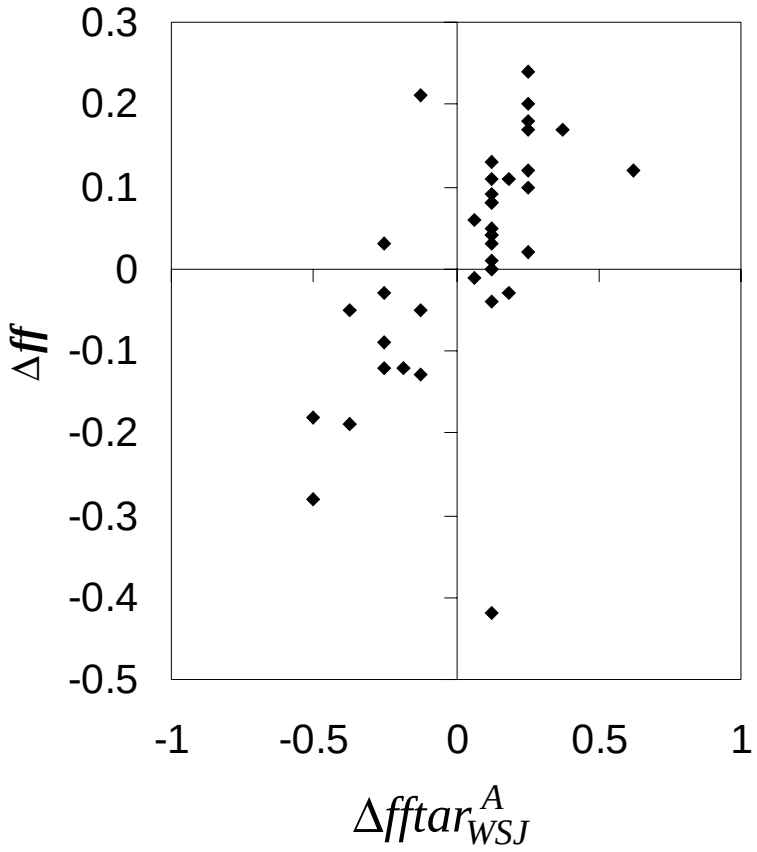


PANEL A

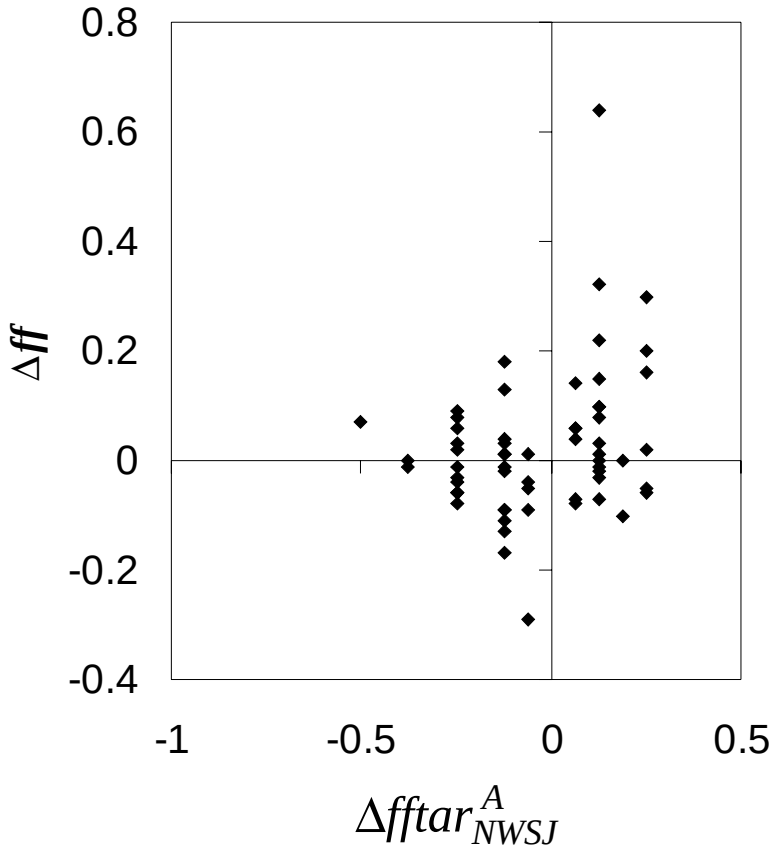


PANEL B

Figure 5



PANEL A



PANEL B

Figure 6