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The Fed and short-term rates: Is it open market operations, open mouth operations or interest rate smoothing?

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Abstract

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 when it changes its target for the funds rate. Recently, however, several analysts have suggested that the Fed need not conduct open market operations to change the funds rate. Rather, they argue it is sufficient that the Fed indicate its desire for the funds rate. This paper notes that there is yet a third alternative, the interest-rate-smoothing hypothesis, that suggests that the Fed does not move rates per se but, rather, smooths the transition of rates to the new equilibrium required by economic shocks. This paper tests the open market and open mouth alternatives using a methodology first used by Cook and Hahn [*Journal of Monetary Economics* (1989a) 331]. Finding no evidence that either open market operations or open mouth operations can account for the close relationship between the funds rate and the funds rate target, a variety of evidence consistent with the interest-rate-smoothing hypothesis is considered. The results suggest that many changes in the Fed's funds rate target are an endogenous response to economic events and suggest that an alternative way to identify exogenous changes in policy is to identify exogenous changes in the Fed's funds rate target.

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> "Facts are stubborn things; and whatever may be our wishes, our inclinations, or the dictates of our passions, they cannot alter the state of facts and evidence." John Adams

1. Introduction

During much of its history, the Federal Reserve has implemented monetary policy by targeting short-term interest rates – since the mid-1970s, the federal funds rate. [1] The conventional view, which I call the *open market hypothesis*, is that the Fed affects short-term interest rates though open market operations. The Fed puts upward pressure on interest rates by reducing the supply of reserves through an open market sale and reduces interest rates by purchasing securities. The effect of these operations is initially reflected in the federal funds rate and subsequently in other short-term interest rates.

A number of analysts have recently suggested that open market operations may not be essential to moving short-term interest rates. Following up on an observation by McCallum (1995), Guthrie and Wright (2000) and Taylor (2001) develop models where private agents drive the interbank rate to the level desired by the monetary authority. Guthrie and Wright suggest that such *open mouth operations* might "explain the difficulties in substantiating liquidity effects in empirical work." [2] The open mouth hypothesis has also been suggested by Meulendyke (1998) and Hanes (1998), who argue that since it began announcing target changes in 1994, the Fed has not needed to use open market operations to move the federal funds rate.

Taylor (2001) notes, however, that open mouth operations only alter the timing of open market operations, thereby, loosening the temporal link between open market operations and changes in interest rates from that required by the open market hypothesis. Because of this, open mouth operations can only account for the lack of evidence of a liquidity effect using relatively high-frequency data (e.g., Hamilton, 1997; Thornton, 2001b). Assuming that the Fed must fulfill the

[1] See Meulendyke (1998), for a discussion of the evolution of the Fed's operating procedure.
[2] Guthrie and Wright (2000, p. 513).

market's expectation relatively soon, say within a reserve maintenance period, it is unlikely that the open mouth hypothesis can account for the lack of a liquidity effect using monthly or lower-frequency data (e.g., Pagan and Robertson, 1995; Thornton, 2001a). Hence, the open market and open mouth hypotheses can be viewed as specific forms of the *liquidity effect hypothesis*, which asserts that changes in short-term interest rates are due to the exogenous actions of the Fed.

There is another hypothesis that can account for the lack of evidence of a liquidity effect, which I call the *interest-rate-smoothing hypothesis*. It could also be called the *policy inertia hypothesis* because it is based on the assumptions that (1) monetary policy is implemented using a nominal interest rate target and (2) policymakers are slow to change their nominal interest rate target in response to economic shocks. The interest-rate-smoothing hypothesis, which is reflected in several models (e.g., Goodfriend, 1987, 1991; Barro, 1989), asserts that economic shocks cause movements in the equilibrium interest rate. When such shocks occur, the Fed has two options. It can either attempt to offset the effect of the shock, and thereby "smooth" the transition of rates to their new equilibrium or it can change its interest rate target. The degree of "interest rate smoothing" is determined by how quickly policymakers change the policy rate.

This paper investigates the extent to which the liquidity effect or interest rate smoothing is responsible for changes in market rates using a two-step procedure. In the first step, the open market and open mouth hypotheses are directly tested by exploiting the close relationship between the federal funds rate and the Fed's federal funds rate target using a methodology similar to that used by Cook and Hahn (1989a).

The open market and open mouth hypotheses assert the Fed moves the funds rate to the new equilibrium level determined by policymakers when the Fed changes its target for the funds rate. In contrast, the interest-rate-smoothing hypothesis asserts the Fed initially engages in endogenous open market operations to temporarily prevent the funds rate from moving to the new equilibrium level determined by market forces. Consequently, evidence that market rates are moved by exogenous changes in the funds rate target would lead to a rejection of the interest-rate-smoothing hypothesis. If, however, there is no evidence supporting either the open market or open mouth hypotheses, the interest-rate-smoothing hypothesis is a viable alternative. Consequently, I consider a variety of evidence that is consistent with the interest-rate-smoothing hypothesis and discuss other aspects of the hypothesis that make it worthy of more consideration than it has received in the monetary policy literature.

It is important to emphasize that the question being addressed is "Has the Fed changed interest rates through open market operations?" not "Can the Fed change interest rates through open 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 could affect the federal funds rate through open market operations. The fact that the Fed has the capacity to affect rates does not, ipso facto, establish that it has done so.

2. Open market, open mouth and interest-rate-smoothing hypotheses

The open market hypothesis is well known and, hence, requires little elaboration. It asserts that when the Fed changes its target for interest rates it adds or drains reserves from the banking system through open market operations depending on whether it wants to reduce or increase rates, respectively.

The open mouth hypothesis asserts the Fed does not need to conduct open market operations to move interest rates but, rather, merely announce its intentions for the federal funds rate. The open mouth and open market hypotheses are connected in two ways. First, the open mouth hypothesis is based on the assumption that the market believes that the Fed can adjust the supply of reserves to move the funds rate to its target level and can keep it there. Second, as Taylor (2001) notes, because the supply of demand for reserves determine the equilibrium funds rate, the Fed must ratify the new target though open market operations. Hence, an essential difference between the open market and the open mouth hypotheses is that the former requires the Fed to conduct open market operations immediately upon changing the funds rate target, while the latter does not – market rates move immediately upon the announcement; open market operations are conducted later.

The open mouth hypothesis requires the market to know when the target is changed. This is the key to identification. If market participants were unaware that the Fed was targeting the funds rate, open mouth operations would be impossible. In contrast, if the Fed moves the funds rate through open market operations, interest rates would respond to policy actions even if market participants were unaware that the Fed was targeting interest rates or that it had changed the target.

2.1. The interest-rate-smoothing hypothesis

In contrast to these hypotheses, the interest-rate-smoothing hypothesis asserts that some changes in the nominal interest rate target are due to shocks to the real economy or inflation expectations. The interest-rate-smoothing hypothesis is implicit in many policy models, (e.g., Goodfriend, 1987, 1991; Barro, 1989). In its extreme form, the interest-rate-smoothing hypothesis suggests that all target changes are endogenous responses to economic shocks. 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."

Of course, the Fed need not have an explicit objective of smoothing interest rates. Woodford (1999) argues that it is difficult to rationalize interest rate smoothing as an

objective in policymakers' loss function. It is sufficient that policymakers are slow to change their target rate in response to a shock, so that they automatically conduct open market operations to resist pressure on the funds rate caused by economic shocks.

This feature of the interest-rate-smoothing hypothesis was an important element of the monetarist attack on the Fed's funds rate targeting procedure in the 1960s and 1970s (e.g., Friedman, 1968). Monetarists argued that shocks that affect interest rates cause a change in the stance of monetary policy unless policymakers immediately adjust their nominal interest rate target sufficiently. The endogeneity of the stance of monetary policy to shocks to the economic environment under interest rate targeting is well established and is critical to policy evaluations based on the Taylor rule (e.g., Taylor, 1999; Clarida et al., 1999, 2000). An important question in this literature is whether policymakers have followed what McCallum (2001, p. 23) calls the "Taylor principle" – an interest rate policy rule that responds by more than point-for-point to inflation or its expectation. Failure to do so implies that policy becomes easier in response to an inflation surprise.

Of course, the Taylor principle also applies to shocks to the real rate. [3] For example, if a shock to the economy causes the real rate to rise by some amount, W, the Fed would have to increase its nominal rate target by W in order to maintain the stance of policy. If the Fed increased the target by less than W, policy would become easier; if it increased the target by more than W, policy would become tighter.

There are three important implications of policy endogeneity. First, evidence of a liquidity effect arises only when the policymakers adjust the nominal interest rate target by an amount greater than is needed to keep the stance of policy unchanged. Second, when policymakers decide to change the target, they need not conduct open market operations to move the funds rate. It will be sufficient that they no longer attempt to restrain it. Third, the change in the funds rate will occur even if the market is unaware that the funds rate target has been changed. [4] Of course, an announcement of the decision to change the target would likely expedite the process.

2.2. The funds rate and other short-term interest rates

Because open market operations directly effect the supply of reserves, they necessarily affect the federal funds rate. [5] The effect of open market operations on other short-term interest rates could come either (i) directly through the effect of open

[3] For example, in Woodford's (1999) model of policy inertia, exogenous shocks to real spending or to the natural rate of output alter the natural rate of interest and the stance of monetary policy unless the Fed adjusts the funds rate target.

[4] For example, if there were a shock to the economy that caused the equilibrium interest rate to fall, the Fed could restrain the funds rate by slowing the growth rate of reserves. Once the Fed decided to lower its funds rate target, it would be sufficient to slow the rate of decline.

[5] The reader is cautioned that this was not always the case. Before the mid-1960s the discount rate was an effective ceiling for the federal funds rate. See Thornton (2001a) for details.

market operations on the supplies of money and credit, as was thought to be the case during the 1960s and early 1970s, and/or (ii) because longer-term rates are determined (at least in part) by the markets' expectation for the federal funds rate and hence the Fed's funds rate target. [6] Given the direct effect of open market operations on reserves, it is reasonable to assume that the Fed can exercise considerable control over the federal funds rate. This is supported by the close relationship between the federal funds rate and the federal funds rate target.

The Fed's ability to directly influence other short-term rates is problematic, however. It is well known that the size of Fed open market operations are small relative to the size of the markets in which the Fed operates (e.g., Friedman, 1999; McCloskey, 2000; Thornton, 1995). Because of this, the size of open market operations required to offset economic shocks to other interest rates could be much larger than is practical, given that banks rely on reserves both to meet their reserve requirements and to conduct daily operations. Because of this, the Fed could have an incentive to adjust the funds rate target relatively quickly, especially to shocks that result in relatively large changes in other short-term rates.

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. [7] 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* (WSJ). The 3-, 6- and 12-month bill rates moved about 50-basis points for a 1-percentage-point change in the WSJ-announced target change, while the response of longer-term securities declined as the term to maturity lengthened. They interpret this as evidence that the Fed moves interest rates through open market operations.

3.1. Distinguishing between the open market and open mouth hypotheses

To distinguish between the open market hypothesis and the open mouth hypothesis, it is important to partition target changes into those the market knew had occurred and those the market was unaware had occurred. This is accomplished by comparing WSJ-announced target changes with actual target changes provided by Rudebusch (1995a,b). The Rudebusch uses a funds rate target series that is

[6] I say "at least in part" because there is little support for the simple expectations hypothesis, especially when the short-term rate is the effective federal funds rate (e.g., Simon, 1990; Hardouvelis, 1988; Roberds et al., 1996; Thornton, 2002). Consistent with these findings, Rudebusch (in press), shows that there is little predictability in interest rates beyond a one-month horizon.

[7] Subsequent work includes Bonser-Neal et al. (1998), Hardy (1998) and Thornton (1998).

constructed from the weekly *Report of Open Market Operations and Money Market Conditions*. According to this series there were 99 target changes during Cook and Hahn's sample period – 23 more than the 76 reported in the WSJ. [8]

The dates and magnitudes of federal funds rate target changes reported by the WSJ and Rudebusch (1995a,b) are presented in Table 1. There are 39 instances when the actual target change reported by Rudebusch (1995a,b) occurred on the day that the WSJ reported the change had occurred. Hence, the market was correct about the timing of Fed actions about 40% of the time. Even when the market got the timing correct, it frequently missed the magnitude. [9]

3.2. The exogeneity assumption

Cook and Hahn's conclusion that the response of Treasury rates is evidence that the Fed moved the rates through open market operations is based on their explicit assumption that WSJ-identified target changes were exogenous. [10] A more thorough analysis of these WSJ articles, however, shows that many of the target changes were endogenous. [11] The WSJ-announced target changes are based on reports from market analysts who concluded that the target had changed by observing the open market operations relative to the behavior of the federal funds rate. Market analysts relied on the following four types of signals to conclude that the Fed had changed its target for the funds rate:

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 type 1 changes are textbook examples of exogenous open market operations. The funds rate is trading at the target level and the Fed attempts to push the rate

[8] 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 was 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.

[9] It is not surprising, because the Fed was intentionally more secretive then than it is today (e.g., Goodfriend, 1986). 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, see Friedman (1981, 1982a,b) and Levin and Meulendyke (1982).

[10] See Cook and Hahn (1989a, p. 342) for a defense of this assumption.

[11] Photocopies of these articles are available upon request.

Table 1
WSJ-announced and actual target changes

Date	Δfftar$_t^{WSJ}$	Δfftar$_t^{A}$	Date	Δfftar$_t^{WSJ}$	Δfftar$_t^{A}$
09/13/74	−0.5000 (2)	−0.25000	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

Table 1 (*continued*)

Date	Δfftar$_t^{WSJ}$	Δfftar$_t^{A}$	Date	Δfftar$_t^{WSJ}$	Δfftar$_t^{A}$
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.

higher (lower) by draining (injecting) reserves. Type 2 changes are similar, except that the funds rate had already moved before the Fed took action consistent with pushing the funds rate further in the same direction. For type 3 and type 4 changes, however, the causation clearly goes from the funds rate to the funds rate target. The Fed either took actions to offset in part the movement in the funds rate or did nothing.

Each type of target change is noted in Table 1. Of the 76 WSJ target changes, there were three instances when market analysts did not state how they concluded that the target had changed. 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. Hence, nearly 50% of the WSJ-announced target changes were endogenous.

The open market hypothesis, and consequently Cook and Hahn's conclusion, is only supported if the funds rate responds significantly to type 1 changes. This conclusion would be somewhat less justified if the funds rate responds significantly to type 2 changes. Cook and Hahn's conclusion is not justified if the funds rate responds significantly only to type 3 or type 4 target changes because, in these instances, it was the change in the funds rate that caused market analysts to conclude that the Fed had changed it funds rate target.

It is important to note that it is impossible to distinguish between the open market and open mouth hypotheses using WSJ-announced target changes. The open market hypothesis is only supported if rates respond significantly to target changes that the

market was unaware had occurred. In all of these instances, however, reports that the Fed had changed the funds rate target were widely circulated. [12]

4. Results for the 1974–1979 period

The data are daily observations on changes in the effective federal funds rate, Δff, and changes in the three-month Treasury bill rate, Δtb3. There are two series on changes in the federal funds rate target, WSJ-announced changes, $\Delta\text{fftar}^{\text{WSJ}}$, and actual target changes, $\Delta\text{fftar}^{\text{A}}$, identified by Rudebusch. WSJ target changes are partitioned into those that coincided with actual target changes, $\Delta\text{fftar}_{\text{A}}^{\text{WSJ}}$, and those that did not, $\Delta\text{fftar}_{\text{NA}}^{\text{WSJ}}$. Similarly, $\Delta\text{fftar}^{\text{A}}$ is partitioned into those that coincide with WSJ-announced target changes, $\Delta\text{fftar}_{\text{WSJ}}^{\text{A}}$, and those that do not, $\Delta\text{fftar}_{\text{NWSJ}}^{\text{A}}$.

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; Sarno and Thornton, 2002). To control for the dynamic interaction between these rates, the vector error correction model

$$\Delta x_t = \Psi(L)\Delta x_{t-1} + \text{EC}_{t-1}\delta + \Delta\text{fftar}_t\beta + \varepsilon_t \tag{1}$$

is estimated, where $\Delta x_t' = (\Delta\text{ff}_t, \Delta\text{tb3}_t)$. The error correction term is denoted EC, δ denotes a 2×1 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 2×1 vector of coefficients that measures 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.

The model is estimated using WSJ target changes and actual target changes, and 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. [13] The results are insensitive to whether this observation is included or excluded, so it is included here for completeness.

One of the WSJ-reported target changes occurred on the heels of a very soft federal funds market on the last reserve settlement day of the year. Because the funds rate was uncharacteristically low on the previous market day, the decrease in the WSJ-reported target was associated with a 468-basis-point change in the funds rate. Since this could bias the results, a dummy variable that is one on this day and zero elsewhere is included in the funds rate equation. Dummy variables were also in-

[12] Neither rate would respond if the target changes were anticipated. This is not a serious problem because this requires market participants to correctly anticipate both the timing and magnitude of target changes. Moreover, the fact that the T-bill rate responds significantly to WSJ target changes indicates that these changes were not completely anticipated. Finally, 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 unanticipated than type 3 or type 4 target changes and, hence, generate a larger response of the T-bill rate.

[13] There was a very large reaction in foreign exchange markets in response to this action (e.g., Mudd, 1979; 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.

Table 2
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	0.0002	0.0250*	0.0251*
	(0.12)	(0.08)	(3.00)	(3.01)
δ	0.0156	0.0157	−0.0680*	−0.0681*
	(1.42)	(1.45)	(3.65)	(3.64)
$\Delta fftar^{WSJ}$	0.5263*	–	0.2901*	–
(76)	(7.77)		(3.09)	
$\Delta fftar_A^{WSJ}$	–	0.5739*	–	0.2584*
(38)		(6.47)		(2.60)
$\Delta fftar_{NA}^{WSJ}$	–	0.4278*	–	0.3680
(38)		(4.40)		(1.78)
Adj. R^2	0.1116	0.1123	0.4100	0.4096
s.e.	0.0937	0.0937	0.2779	0.2780
F-statistic	–	1.221	–	0.232

The estimated normalized cointegrating vector is $ff_t = 1.2762tb3_t + 1.2863$.
* Indicates statistical significance at the 5% level.

cluded for settlement Wednesdays, settlement Thursdays, the first and last days of the quarter and the first and last days of the year. [14]

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 cointegrating vector is held constant for all of the estimates reported in Tables 2–4. The standard errors are estimated using the Newey and West (1987) consistent covariance estimator.

Estimates of the model using WSJ target changes are presented in Table 2. To conserve space, only estimates of the constant term, δ and β are presented. The estimate of β for the T-bill rate, 0.526, is similar to Cook and Hahn's (1989a) estimate, 0.554. [15] 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 is the same when market analysts concluded that the Fed had changed the funds rate target whether the target was changed or not.

[14] For evidence on increased variability of the funds rate on such days, see Griffiths and Winters (1995), Spindt and Hoffmeister (1988) and Hamilton (1996, 1997).

[15] 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.

Table 3
Response to target changes classified by type

Coefficient (# of changes)	$\Delta tb3_t$	Δff_t[a]
Const.	0.0005	0.0244*
	(0.20)	(2.91)
δ	0.0156	−0.0680*
	(1.43)	(3.67)
$\Delta fftar^{WSJ}(1)$	0.5515*	−0.0408
(19)	(3.12)	(0.20)
$\Delta fftar^{WSJ}(2)$	0.6158*	0.0275
(19)	(4.56)	(0.18)
$\Delta fftar^{WSJ}$ (3)	0.4546*	0.8363*
(23)	(9.67)	(4.84)
$\Delta fftar^{WSJ}$ (4)	0.4140*	0.5358*
(12)	(2.77)	(2.38)
$\Delta fftar^{WSJ}(5)$	0.4091*	−0.2775
(3)	(2.40)	(0.72)
Adj. R^2	0.1110	0.4111
s.e.	0.0938	0.2777
F-statistic	0.435	5.230*

* Indicates statistical significance at the 5% level.
[a] Estimated normalized cointegrating vector is $ff_t = 1.2762tb3_t + 1.2863$.

Table 4
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	0.0006	0.0007	0.0257*	0.0258*	0.0258*
	(0.39)	(0.22)	(0.25)	(3.09)	(3.12)	(3.10)
δ	0.0172	0.0170	0.0173	−0.0667*	−0.0677*	−0.0671*
	(1.60)	(1.57)	(1.58)	(3.59)	(3.55)	(3.54)
$\Delta fftar^{A}$	0.4420*	–		0.2908*	–	
(99)	(5.42)			(3.09)		
$\Delta fftar^{A}_{WSJ}$	–	0.5833*		–	0.2391*	
(39)		(5.38)			(2.11)	
$\Delta fftar^{A}_{WSJ}$ (1 and 2)	–	–	0.6726*			0.0993
(20)			(3.69)			(0.53)
$\Delta fftar^{A}_{WSJ}$ (3 and 4)	–	–	0.4779*			0.4030*
(16)			(7.22)			(2.39)
$\Delta fftar^{A}_{WSJ}$ (5)			0.3660*			−0.3295
(3)			(2.17)			(0.83)
$\Delta fftar^{A}_{NWSF}$	–	0.2843*	0.2867*	–	0.3416*	0.3448*
(60)		(2.30)	(2.31)		(2.33)	(2.30)
Adj. R^2	0.0922	0.0992	0.1005	0.4101	0.4098	0.4092
s.e.	0.0948	0.0944	0.0944	0.2779	0.2780	0.2781
F-statistic	–	3.742[a]	1.015[b]	–	0.3623[a]	1.306[b]

Estimated normalized cointegrating vector is $ff_t = 1.2762tb3_t + 1.2863$.
* Indicates statistical significance at the 5% level.
[a] Test of the hypothesis $\Delta fftar^{A}_{WSJ} = \Delta fftar^{A}_{NWSJ}$.
[b] Test of the hypothesis $\Delta fftar^{A}_{WSJ}$ (3 and 4) = $\Delta fftar^{A}_{NWSJ}$ (1 and 2).

The federal funds rate also responds significantly to WSJ-announced target changes; 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.

This interpretation of the funds rate response depends on whether the target change is endogenous or exogenous. Consequently, the 76 WSJ target changes are partitioned according to type. The results are presented in Table 3. The results for the federal funds rate do not support the open market hypothesis. Specifically, the funds rate responds significantly only to endogenous target 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 and, therefore, is evidence of the liquidity effect. Indeed, consistent with market analysts' observations, the coefficient for type 3 changes is larger than for type 4 changes; although, the difference is not statistically significant.

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, including the three target 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. [16]

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 also supported by estimates of the response to the 99 actual target changes presented in Table 4. 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 the response to the 39 reported changes.

Moreover, the response of the T-bill rate to the 60 actual target changes is fragile. [17] This is illustrated in Fig. 1, which shows Δtb3 plotted against $\Delta \text{fftar}^{A}_{WSJ}$ and $\Delta \text{fftar}^{A}_{NWSJ}$, in Panels A and B, respectively. Panel A shows a fairly strong positive

[16] 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; Thornton, 1989), changes in the discount rate (e.g., Thornton, 1994, 1998; Roley and Troll, 1984; Smirlock and Yawitz, 1985; Cook and Hahn, 1988; Batten and Thornton, 1984, 1985), the employment report (e.g., Hardouvelis, 1987; Cook and Korn, 1991) and other special announcements (Cook and Hahn, 1988). What is often not known, and is difficult to determine, is precisely why markets react to this information (e.g., Thornton, 1998).

[17] This equation was also estimated with two leads and two lags of the 60 target changes to account for the possibility that not all target changes occurred on the day noted by Rudebusch. None of the coefficients on the leads or lags were statistically significant.

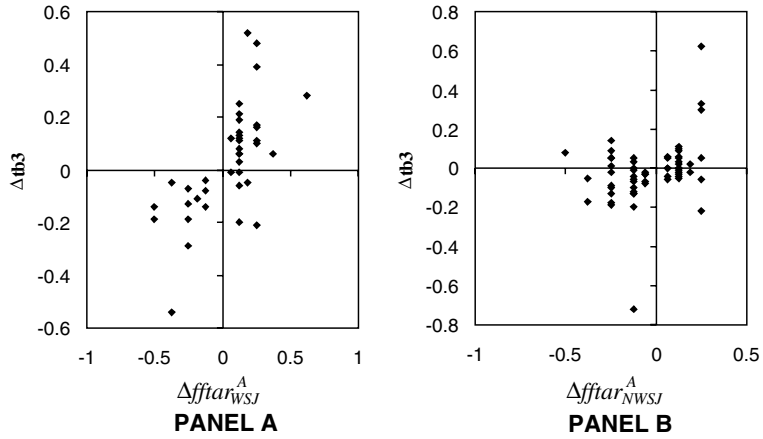

Fig. 1.

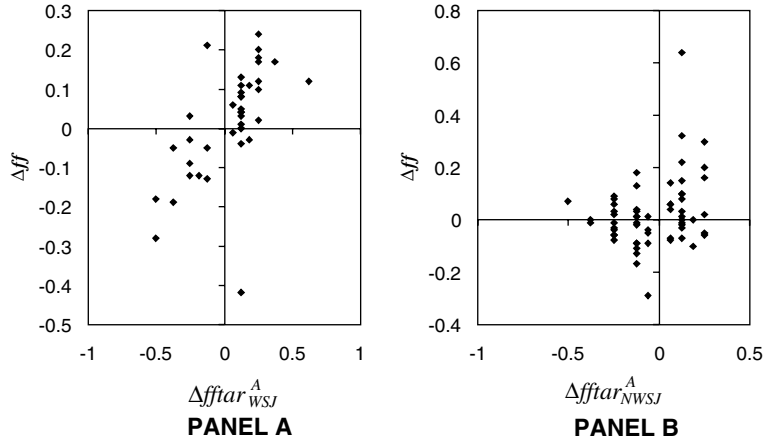

Fig. 2.

relationship between changes in the target and changes in the T-bill rate. Panel B, however, shows that the relationship between Δtb3 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. [18]

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. Fig. 2 shows Δff plotted against $\Delta fftar^{A}_{WSJ}$ and$\Delta fftar^{A}_{NWSJ}$ in Panels A and B,

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

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. 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.

It is important to note, however, that 16 of the 39 target changes that coincided with WSJ announcements were type 3 and 4 changes. Hence, the statistically significant relationship between Δff and $\Delta fftar^{A}_{WSJ}$ could be a consequence of reverse causation. To test this possibility, the 39 changes were partitioned into type 1 and 2, type 3 and 4 and type 5 target changes. The results, reported in Table 4, show that only the type 3 and 4 target changes are statistically significant. The response of the funds rate to type 1 and 2 target changes is both small and statistically insignificant.

The lack of a statistically significant relationship between funds rate changes and changes in the funds rate target, except in those instances where the relationship is due to reverse causation, suggests that the Fed did not implement monetary policy with open market operations during this period. Hence, the evidence does not support Cook and Hahn's conclusion that the significant response of Treasury rates to WSJ-reported target changes is evidence of a liquidity effect. Rather, the response of the T-bill rate is an announcement effect.

The evidence for the open mouth hypothesis is less clear. It was widely known that the Fed was targeting the funds rate and considerable resources were devoted to "Fed watching." Despite the evidence that market analysts frequently missed the timing and/or magnitude of funds rate target changes, it is reasonable to assume that they should have been able to determine that the target had changed within a few days of the change. [19]

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 after the Fed switched from its nonborrowed reserve operation procedure in October 1982. Sometime between October 1982 and the late 1980s the Fed began explicitly targeting the federal funds rate, but the market was unaware of it.

It is useful to briefly review the chronology of the events. After explicitly targeting the federal funds rate for a number of years, in October 1979 the Fed switched to targeting M1 using a nonborrowed reserves operating procedure in order to reduce

[19] If open mouth operations account for the relationship between the funds rate and the funds rate target, the deviations of the funds rate from the target should be larger a few days after a target change that the market was unaware had occurred. 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, however, is only slightly larger than for the entire sample period, 0.15 and 0.13, respectively. Likewise, the average absolute spread between the funds rate and target (10 basis points) was only 1 basis point higher. (The results are nearly identical if two days are used.)

inflation (Meulendyke, 1998). When the relationship between M1 and nominal GNP broke down in the early 1980s, the Federal Open Market Committee (FOMC) abandoned M1 targeting and began targeting borrowed reserves (Wallich, 1984; Strongin, 1995; and Meulendyke, 1998). Sometime later, the Fed switched back to an explicit funds rate targeting procedure. However, 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 to an explicit funds rate targeting procedure. Consequently, exactly when the Fed began explicitly targeting the federal funds rate is controversial. Thornton (1988) presents evidence that the Fed was explicitly targeting the funds rate as early as 1984. This dating is consistent with Greenspan's (1997) recent acknowledgement that, "increasingly since 1982 we have been setting the funds rate directly in response to a wide variety of factors and forecasts." [20] Meulendyke (1998) suggests, however, the switch occurred later, noting that the "informal move away from borrowing reserves operating procedure was speeded by the stock market break on October 19, 1987," when the FOMC found that "a stable relationship between the amount of borrowing and the fund rate did not reemerge." [21]

Evidence that the Fed was targeting the funds rate before the late 1980s comes from the fact that funds rate target data are available from the early 1980s and the fact the funds rate remained very close to the funds rate target from the early to late 1980s. For example, from March 1, 1984 through September 29, 1989, 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, and on 44% of the days the funds rate deviated from the funds rate target by fewer than 10-basis points. [22] The relationship was closer during the period from September 13, 1974 through October 5, 1979, when the average absolute spread was 9 basis points, the standard deviation was 13 basis points, and on 72% of the days the funds rate deviated from the funds rate target by fewer than 10 basis points. The relationship between these rates in the early 1980s is more similar to that for the period October 2, 1989 to December 31, 1997, when the mean absolute spread was 11 basis points, the standard deviation was 19 basis points, and the funds rate deviated from the funds rate target by fewer than 10 basis points on 67% of the days.

5.1. When did the market know that the Fed was targeting the funds rate?

While not conclusive, the evidence noted above strongly suggests that the Fed was explicitly targeting the funds rate before 1990. The critical question for identifying the open mouth hypothesis is when did the market become aware that the Fed was targeting the funds rate? If market participants were unaware that the Fed was targeting the fund rate, the open mouth hypothesis cannot account for the close

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

[21] Meulendyke (1998, p. 55).

[22] For a few days following the stock market crash in 1987 – 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.

Table 5
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.	−0.0008	−0.0288*
	(0.86)	(4.17)
δ	0.0082	−0.1945*
	(1.92)	(4.16)
$\Delta fftar^{A}_{B91}$	0.0971*	0.2329
(82)	(1.98)	(1.60)
$\Delta fftar^{A}_{A90}$	0.3125*	0.3721
(26)	(5.69)	(1.36)
Adj. R^2	0.0506	0.2498
s.e.	0.0588	0.3264
LR test	8.544*	0.206

Estimated normalized cointegrating vector is $ff_t = 1.1415tb3_t + 0.3027$.
* Indicates statistical significance at the 5% level.

relationship between the funds rate and the funds rate target. Answering this question is complicated by the fact that 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* – "the middle of the federal funds rate trading area that is expected to be consistent with the borrowing assumption." [23] This language suggests that as late as 1991, the Fed was reluctant to acknowledge that it was explicitly targeting the federal funds rate.

Poole et al. (2002) have recently undertaken an extensive investigation of WSJ reports for days surrounding both FOMC meetings and funds rate target changes since the early 1980s. They conclude that there is little indication that the market was aware that the Fed was targeting the federal funds rate before 1989 and that the market was not consistently aware of target changes until after 1990. [24]

If market analysts were aware that the Fed was targeting the funds rate, it is reasonable to assume that they would be able to identify some of the target changes on the day they were made, as they did during the 1970s. If this is the case, the T-bill rate should respond to target changes fairly soon after the market became aware that the Fed was targeting the funds rate.

To test whether the market was aware that the Fed was targeting the funds rate before the late 1980s, Eq. (1) was estimated partitioning target changes into those that occurred before 1991 and after 1990 – the date identified by Poole et al. (2002). The results, presented in Table 5, show that the response of the T-bill rate was small and only marginally significant before 1991; however, it was more than three times larger and highly significant after 1990. Hence, consistent with the

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

[24] This date is similar to that obtained using an econometric procedure. These results are available in a longer version of this paper, which is available from the author upon request.

findings of Poole et al. (2002), these results suggest that the market was unaware that the Fed was targeting the funds rate until after 1990. If the market was unaware that the Fed was targeting the funds rate, the close relationship between the funds rate and the funds rate target during the pre-1991 period could not be due to open mouth operations. The results in Table 5 also suggest that the close relationship between these rates was not due to open market operations because the federal funds rate does not respond significantly to target changes during the entire 1984–1997 period. Hence, the evidence for 1974–1979 and the 1980s does not support either the open market hypothesis or the open mouth hypothesis.

6. The interest-rate-smoothing hypothesis

The interest-rate-smoothing hypothesis asserts the Fed does not move rates per se, but rather changes its target for the nominal interest rate in response to economic shocks. This section reviews evidence that is consistent with the interest-rate-smoothing hypothesis.

6.1. The relationship between interest rates and narrow money and reserve aggregates

The liquidity effect hypothesis suggests there should be a strong negative relationship between interest rates and narrow monetary and reserve aggregates that are most closely linked to open market operations. The interest rate smoothing hypothesis, however, suggests that the relationship between interest rates and such aggregates should be positive. Consistent with the latter hypothesis, the historical relationship between interest rates and such monetary aggregates is positive (e.g., Pagan and Robertson, 1995; Thornton, 2001a).

The exception is nonborrowed reserves. Thornton (2001a) has shown, however, that the strong negative contemporaneous correlation between nonborrowed reserves and short-term interest rates is a consequence of the fact that the Fed has an incentive to offset changes in borrowing when it is targeting the federal funds rate and has done so historically. [25] Even when nonborrowed reserves is used, the size of the estimated liquidity effect is small. Indeed, Pagan and Robertson (1995) conclude that "most of the factors historically driving the federal funds rate do not seem to be due to the Fed..." [26]

[25] The negative relationship between nonborrowed reserves and interest rates stems from the fact that when interest rates rise relative to the discount rate, banks borrow more from the discount window. Because the equilibrium federal funds rate is determined by the supply and demand for total reserves, the Fed acts quickly to offset changes in borrowing. See Thornton (2001a) for a more complete description of this process and Thornton (2001a,b) for evidence.

[26] Pagan and Robertson (1995, p. 52).

6.2. Policy inertia

The interest-rate-smoothing hypothesis is also consistent with observations that the Fed has historically targeted nominal interest rates and has been slow to adjust its interest rate target. [27] 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 target change." [28]

If policymakers are slow to respond to shocks to the economy (for whatever reason), one might expect such shocks to be reflected in a 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 interest rates per se, since, as Goodfriend suggests, both events are driven by the same cause. It is merely a consequence of the fact that private economic agents respond more quickly than policymakers to economic shocks.

6.3. Temporal ordering

The interest-rate-smoothing hypothesis also implies that changes in market interest rates will precede changes in the funds rate target. A test of temporal ordering, called Granger causality test, strongly supports this implication. [29] Of course, the temporal ordering between the funds rate target and market rates is also implied by the expectations hypothesis. Support for the expectations hypothesis is generally weak, however, and is particularly weak when the short-term rate is the effective federal funds rate and the long-term rate is a short-term T-bill rate (e.g., Hardouvelis, 1988; Simon, 1990; Roberds et al., 1996; Thornton, 2002). In the absence of evidence that differentiates between these alternative explanations, the interest-rate-smoothing hypothesis is as plausible an explanation as the expectations hypothesis for the observed temporal ordering.

6.4. The 1989 experience

The interest-rate-smoothing hypothesis is also consistent with an experience when the Fed seemed particularly slow to change its funds rate target. 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%. Given the high inflation rate and the FOMC objective of reducing the trend rate of inflation, 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

[27] Several reasons for the slow response of policymakers have been suggested. See Cobham (2001) for a summary of these arguments.

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

[29] The results of these tests are not presented here to conserve space, but they will be provided upon request.

commitment to the fight against inflation. . .'' [30] The increase in the discount rate was accompanied by a 18.75-basis-point increase in the target for the federal funds rate, which came on the heels of two 25-basis-point increases on February 14 and 23. The Fed further indicated its desire for a restrictive monetary policy by raising the funds rate target modestly by 6.25 basis points on May 4.

Despite increases in the discount rate and the funds rate target, short-term interest rates began to decline. The T-bill rate declined by about 85 basis points between its peak in March and June 5 – the day before the first of three 25-basis-point cuts in the funds rate target. A second 25-basis-point target reduction occurred on July 7 and a third on July 27. An additional 6.25-basis-point cut occurred on August 10. The Fed cut the funds rate target even though its outlook for the economy and inflation was essentially unchanged. [31] Indeed, CPI inflation in 1989 was about 75 basis points higher than in 1988.

Consistent with the interest-rate-smoothing hypothesis, total reserves decreased by $0.89 billion during the period from February to May. This is the largest three-month decline in total reserves in the entire period from January 1959 to March 1995. [32] This is remarkable because consecutive monthly decreases in reserves are uncommon owing to the need to increase the monetary base to meet the growing demand for currency. The effect of these actions on banks was direct and substantial. M1 – which had been growing at about a 3.5% rate during the previous year – declined by $11 billion between February and June 1989. [33]

The Fed's effort to maintain the funds rate appears to have been 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. Hence, consistent with the conventional open market view of monetary policy, the Fed appears to exert considerable control over the federal funds rate. By mid-May, however, the funds rate was trading below the target and the market began to revise its expectations for the funds rate for June and beyond (see Poole et al., 2002, the appendix, for details).

[30] Board of Governors of the Federal Reserve System (1989, p. 67).

[31] 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%; March 22 meeting, 2.9% and 4.7%; May 10 meeting, 2.8% and 4.7%; June 28 meeting, 2.2% and 4.5%; and the August 16 meeting, 2.4% and 4.3%.

[32] 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.

[33] It appears that the move to reduce the funds rate target was initially driven by concerns about slow money growth. At the June 5, 1989, conference call, Chairman Greenspan noted that his two reasons for lowering the funds rate were ''(1) the money supply data and (2) evidence that is emerging that the commodity price inflation is beginning to subdue.'' (Transcripts of conference call on June 5, 1989, p. 3.) Moreover, at the July 5–6, 1989, FOMC meeting, the Chairman noted that ''I wouldn't be particularly concerned were it not for the fact that, at this stage, I do think the money supply data – even though projected with some optimism to strengthen – are really quite restrained.'' (Transcript of the FOMC of July 5–6, 1989, p. 48.)

6.5. The frequency of federal funds rate target changes

Finally, changes in the funds rate target have often been more frequent than would be suggested if they represented exogenous monetary policy actions. Target changes were especially frequent during the 1974–1979 period, when the Fed adjusted the funds rate target 99 times – an average of about once every 2.5 weeks. The median number of days between target changes during this period was 6.

Prior to 1994, most of the target changes were made during intermeeting periods. The Desk initiated many of these, presumably with the advice and consent of the Chairman. Indeed, the Fed has acknowledged that some of the target changes during the 1980s were a response to shifts in demand (e.g., Thornton and Wheelock, 2000, p. 6).

7. Discussion

This paper investigates whether relationships between the federal funds rate and the Fed's federal funds rate target can be accounted for by open market operations or open mouth operations by estimating the response of the three-month T-bill rate and the effective federal funds rate to changes in the funds rate target. For the period from 1974 to 1979 and during the 1980s, there is no evidence that the Fed moved the funds rate using either open market or open mouth operations.

Moreover, a more detailed analysis of Cook and Hahn's (1989a) data reveals that many of the funds rate target changes they identified were due to the endogenous movement of the funds rate and not to open market operations. Hence, their conclusion that the estimated response of Treasury rates to WSJ-identified target changes is evidence of the liquidity effect is not supported by the market's reaction to such changes. What Cook and Hahn identified is an announcement effect, not altogether different from that long associated with changes in the Fed's discount rate.

The lack of support for the open market or open mouth hypotheses is consistent with the interest-rate-smoothing hypothesis, which asserts that many, if not most changes in the policy rate are endogenous responses to economic shocks rather than exogenous policy actions. While many policy discussions assume that changes in the policy rate represent exogenous policy actions, modern analyses of monetary policy, including the Taylor rule, explicitly account for the endogenous behavior of the policy rate.

The interest-rate-smoothing hypothesis is consistent with the observation that the Fed appears to be slow to adjust its funds rate, as well as a number of empirical facts, such as (1) the inability of researchers to find a significant liquidity effect using narrow money and reserve aggregates, (2) the strong tendency of the funds rate target to follow changes in market rates and (3) the fact that during some periods target changes were far more frequent than rational monetary policy would suggest is necessary. It is also supported by the behavior of the funds rate target and reserves during the early part of 1989, when the Fed was particularly slow to adjust the funds rate target.

The extent to which changes in the funds rate target are exogenous policy actions or endogenous responses to exogenous economic shocks goes to the heart of monetary policy identification. Recent attempts at identification in the context of the Taylor rule (e.g., Taylor, 1999; Clarida et al., 1999, 2000) are useful. To date, however, analysts have only considered the endogenous response of the policy rate to changes in inflation or inflation expectations, and not to shocks to the real rate.

Additional evidence might be obtained by attempting to directly distinguish between endogenous and exogenous changes in the Fed's funds rate target, perhaps through a detailed analysis of Fed documents to identify target changes that were reactions to specific economic shocks and those that were not. Independent information about the stance of monetary policy might also be obtained by a thorough analysis of monetary and reserve aggregates. In the 1970s policymakers were criticized for confusing rising interest rates with tighter monetary policy, suggesting that more attention be paid to the behavior of monetary aggregates. While financial innovations and deregulation of the 1980s and the introduction of sweep programs in 1994 have made analyzing the behavior of monetary and reserve aggregates difficult, a careful and detailed analysis of such aggregates may yield information that is useful for distinguishing between endogenous and exogenous policy actions. [34] In any event, the evidence presented here suggests that changes in the policy rate may have a significant endogenous component, so that identifying exogenous monetary policy shocks may be more difficult than is often thought to be the case.

References

Barro, R.J., 1989. Interest rate targeting. Journal of Monetary Economics (January), 3–30.

Batten, D.S., Thornton, D.L., 1984. Discount rate changes and the foreign exchange market. Journal of International Money and Finance (December), 279–292.

Batten, D.S., Thornton, D.L., 1985. The discount rate, interest rates and foreign exchange rates: An analysis with daily data, Federal Reserve Bank of St. Louis Review (February), 22–30.

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

Bonser-Neal, C., Roley, V.V., Sellon Jr., G.H., 1998. Monetary policy actions, intervention, and exchange rates: A reexamination of the empirical relationships using federal funds rate target data. Journal of Business (April), 147–177.

Clarida, R., Gali, J., Gertler, M., 1999. The science of monetary policy: A new Keynesian perspective. Journal of Economic Literature (December), 1661–1707.

Clarida, R., Gali, J., Gertler, M., 2000. Monetary policy rules and macroeconomic stability: Evidence and some theory. Quarterly Journal of Economics (February), 147–180.

Cobham, D., 2001. Interest rate smoothing: Some direct evidence from the UK unpublished manuscript, University of St. Andrews.

Cook, T., Hahn, T., 1989a. The effect of changes in the federal funds rate target on market interest rates in the 1970s. Journal of Monetary Economics (November), 331–351.

Cook, T., Hahn, T., 1989b. 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.

Cook, T., Hahn, T., 1988. The information content of discount rate announcements and their effect on market interest rates. Journal of Money, Credit and Banking (May), 167–180.

[34] For a recent attempt to include monetary aggregates in assessing policy, see Leeper and Zha (2001).

Cook, T., Korn, S., 1991. The reaction of interest rates to the employment report: The role of policy anticipations. Federal Reserve Bank of Richmond Economic Review (September/October), 3–12.
Friedman, B.M., 1999. The future of monetary policy: The Central Bank as an army with only a signal corps. International Finance (November), 321–338.
Friedman, M., 1968. The role of monetary policy. American Economic Review (March), 1–17.
Friedman, M., 1981. Churning at the Fed. Newsweek (August 31), 43.
Friedman, M., 1982a. Monetary policy: Theory and practice. Journal of Money, Credit and Banking (February), 98–118.
Friedman, M., 1982b. Monetary policy: Theory and practice, a reply. Journal of Money, Credit and Banking (August), 404–406.
Goodfriend, M., 1986. Monetary mystique: Secrecy and central banking. Journal of Monetary Economics (January), 63–92.
Goodfriend, M., 1987. Interest rate smoothing and price level trend-stationarity. Journal of Monetary Economics (May), 335–348.
Goodfriend, M., 1991. Interest Rates and the Conduct of Monetary Policy. Carnegie-Rochester Conference Series on Public Policy (Spring), 7–30.
Greenspan, A., 1997. Remarks by Chairman Greenspan at the 15th Anniversary Conference of the Center for Economic Policy Research at Stanford University, September 5.
Griffiths, M.D., Winters, D.B., 1995. Day-of-the-week effects federal funds rates: Further empirical findings. Journal of Banking and Finance (October), 1265–1284.
Guthrie, G., Wright, J., 2000. Market implemented monetary policy with open mouth operations. Journal of Monetary Economics (October), 489–516.
Hamilton, J.D., 1996. The Daily Market for Federal Funds. Journal of Political Economy (February), 26–56.
Hamilton, J.D., 1997. Measuring the liquidity effect. American Economic Review (March), 80–97.
Hanes, C., 1998. Reserves, Fed funds and Repo: How the Federal Reserve controls interest rates under federal funds rate targeting, unpublished manuscript.
Hardouvelis, G.A., 1987. Macroeconomic Information and Stock Prices. Journal of Economics and Business (May), 131–140.
Hardouvelis, G.A., 1988. The predictive power of the term structure during recent monetary regimes. Journal of Finance (June), 339–356.
Hardy, D.S., 1998. Anticipation and surprises in Central Bank interest rate policy. International Monetary Fund Staff Papers (December), 647–671.
Leeper, E.M., Zha, T., 2001. Assessing simple policy rules: A view from a complete macroeconomic model. Federal Reserve Bank of St. Louis Review (July/August), 83–110.
Levin, F.J., Meulendyke, A.-M., 1982. Monetary Policy: Theory and Practice, A Comment. Journal of Money, Credit and Banking (August), 399–403.
McCallum, B.T., 1995. New Zealand's monetary policy arrangements: Some critical issues. Reserve Bank of New Zealand Discussion Paper no. G95/4.
McCallum, B.T., 2001. Monetary policy analysis in models without money. Federal Reserve Bank of St. Louis Review (July/August), 145–160.
McCloskey, D.N., 2000. Alan greenspan doesn't influence interest rates. Eastern Economic Journal (Winter), 99–101.
Meulendyke, A.-M., 1998. U.S. Monetary Policy and Financial Markets. Federal Reserve Bank of New York.
Mudd, D.R., 1979. Did discount rate changes affect the foreign exchange value of the dollar during 1978? Federal Reserve Bank of St. Louis Review (April), 20–26.
Newey, W., West, K., 1987. A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica (May), 703–708.
Pagan, A.R., Robertson, J.C., 1995. Resolving the liquidity effect. Federal Reserve Bank of St. Louis Review (May/June), 33–54.
Poole, W., Rasche, R.H., Thornton, D.L., 2002. Market Anticipations of Monetary Policy Actions, Federal Reserve Bank of St. Louis Review (July/August), 65–94.

Roberds, W., Runkle, D., Whiteman, C.H., 1996. A daily view of yield spreads and short-term interest rate movements. Journal of Money, Credit and Banking (February), 34–53.
Roley, V.V., Troll, R., 1984. The impact of discount rate changes on market interest rates. Federal Reserve Bank of Kansas City Economic Review (January), 27–39.
Rudebusch, G.D., 1995a. Federal Reserve interest rate targeting, rational expectations, and the term structure. Journal of Monetary Economics (April), 245–274.
Rudebusch, G.D., 1995b. Erratum. Journal of Monetary Economics (December), 679.
Rudebusch, G.D., in press. Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia, January. Journal of Monetary Economics.
Sanro, L., Thornton, D.L., 2002. The dynamic relationship between the federal funds rate and the treasury bill rate: An empirical investigation. Journal of Banking and Finance.
Simon, D.P., 1990. Expectations and the treasury bill-federal funds rate spread over recent monetary policy regimes. Journal of Finance (June), 467–477.
Smirlock, M., Yawitz, J., 1985. Asset returns, discount rate changes, and market efficiency. Journal of Finance (September), 1141–1158.
Spindt, P.A., Hoffmeister, J.R., 1988. The microeconomics of the federal funds market: implications for day-of-the-week effects in funds rate variability. Journal of Financial and Quantitative Analysis (December), 401–416.
Stock, J.H., Watson, M.W., 1988. Testing for common trends. Journal of the American Statistical Association (December), 1097–1107.
Strongin, S., 1995. The identification of monetary policy disturbances: Explaining the liquidity puzzle. Journal of Monetary Economics (August), 463–497.
Taylor, J.B., 1999. A Historical Analysis of Monetary Policy Rules. In: Taylor, J.B. (Ed.), Monetary Policy Rules. University of Chicago Press, Chicago, Illinois, pp. 155–162.
Taylor, J.B., 2001. Expectations, open market operations, and changes in the federal funds rate, Federal Reserve Bank of St. Louis Review (July/August), 33–47.
Thornton, D.L., 1988. The borrowed-reserves operating procedure: Theory and evidence, Federal Reserve Bank of St. Louis Review (January/February), 30–54.
Thornton, D.L., 1989. The effect of unanticipated money on the money and foreign exchange markets. Journal of International Money and Finance (December), 573–588.
Thornton, D.L., 1994. Why do T-bill rates react to discount rate changes. Journal of Money, Credit and Banking (November), 839–850.
Thornton, D.L., 1995. Does the Fed control short-term interest rates? Federal Reserve Bank of St. Louis, Monetary Trends (December).
Thornton, D.L., 1998. The information content of discount rate announcements: What is behind the announcement effect? Journal of Banking and Finance (January), 83–108.
Thornton, D.L., 2001a. The Federal Reserve's Operating Procedure, Nonborrowed Reserves, Borrowed Reserves and the Liquidity Effect. Journal of Banking and Finance (September), 1717–1739.
Thornton, D.L., 2001b. Identifying the liquidity effect at the daily frequency. Federal Reserve Bank of St. Louis Review (July/August), 59–78.
Thornton, D.L., 2002. The conventional test of the expectations hypothesis: Resolving the anomalies at the very short end of the term structure, unpublished manuscript, Federal Reserve Bank of St. Louis.
Thornton, D.L., Wheelock, D.C., 2000. A history of the asymmetric policy directive. Federal Reserve Bank of St. Louis Review (September/October), 1–16.
Wallich, H.C., 1984. Recent techniques of monetary policy. Federal Reserve Bank of Kansas City Economic Review (May), 21–30.
Woodford, M., 1999. Optimal Monetary Policy Inertia. The Manchester School (Suppl.), 1–35.