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Abstract

It is common practice to estimate the response of asset prices to monetary policy actions using market-based measures of monetary policy shocks, such as the federal funds futures rate. I show that because interest rates and market-based measures of monetary policy shocks respond simultaneously to all news and not simply news about monetary policy actions, market-based measures of monetary policy shocks yield biased estimates of the response of interest rates to monetary policy actions. I propose a methodology that corrects for this "joint-response bias." The results indicate that the response of Treasury yields to monetary policy actions is considerably weaker than previously estimated. In particular, there is no statistically significant response of longer-term Treasury yields before February 2000 and no statistically significant response of any Treasury rate after.

JEL Classification: E40, E52
Key words: monetary policy shocks, identification, simultaneity, federal funds target

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Monetary policymakers and financial market participants are interested in knowing how market interest rates respond to Federal Reserve actions. Cook and Hahn (1989) were the first to estimate the response of interest rates to changes in the Fed's short-term interest rate target. They estimated the response of Treasury yields to changes in the Fed's target for the federal funds rate using an event-study methodology. Specifically, they estimated regressions of the daily change in various Treasury yield on the change in the funds rate target. They found that Treasury rates across the maturity spectrum responded strongly and significantly to changes in the Fed's funds rate target during the period 1973-1979.

Using Cook and Hahn's event-study methodology for the period June 6, 1989, through February 2, 2000, Kuttner (2001) found a uniformly smaller response of Treasury rates to funds rate target changes. Noting that rates, especially longer-term rates, should respond only to unanticipated target changes, he suggested that the relative failure of Cook and Hahn's methodology to identify large and statistically significant responses in the latter period was likely a consequence of their failure to differentiate between expected and unexpected target changes.

Following Rudebusch's (1998) suggestion that the federal funds futures rates provide a natural forecast of the Federal Open Market Committee's (FOMC's) target for the federal funds rate, Kuttner (2001) used the federal funds futures rate to decompose target changes into their expected and unexpected components. Since then, it has become common practice to estimate the response on interest rates and other asset prices to unanticipated monetary policy actions using market-based measures of unanticipated monetary policy actions—federal funds futures rates, eurodollar deposit rates, the 3-month T-bill rate, and eurodollar futures rates (e.g., Hamilton, 2008; Gürkaynak, Sack, and Swanson, 2007; Faust, Swanson, and Wright, 2004; Bomfim, 2003; Poole and Rasche, 2000; Poole, Rasche, and Thornton, 2002; and Cochrane and Piazzesi, 2002).

However, if interest rates and the market-based measures of monetary policy shocks respond to all news—and not only news about monetary policy actions—it is easy to show that market-based policy shock measures will not separately identify the response to monetary policy actions from the response to other news. Hence, estimates of the response of interest rate to monetary policy actions will be biased. Indeed, this methodology could indicate that interest rates respond significantly to monetary actions that are fully anticipated.

I propose a methodology that accounts for the bias associated with the joint response of interest rates and market-based monetary policy shock measures to news from a variety of sources. Specifically, Kuttner's (2001) market-based monetary policy surprise measure is calculated for every day, not only for days when the FOMC changed the funds rate target. The marginal effect of surprise monetary policy actions is then identified by regressing daily changes in Treasury rates on this measure for every day during the sample period and for days when the target was changed. The market-based measure of monetary policy shocks on all days is effectively a latent variable that accounts for the joint response of interest rates and the market-based monetary policy shock measure to unobservable news.

When the joint-response bias is accounted for, the response of Treasury rates on securities with maturities of less than 5 years is considerably smaller than previously thought, and there is no statistically significant response of Treasury yields on securities with maturities of 5 years or longer before February 2000. Moreover, after February 2000 none of the Treasury rates respond significantly to unanticipated monetary policy actions.

The remainder of the paper is divided into five sections. Section 2 analyses the response of interest rates to news. Cook and Hahn's (1989) event-study methodology and Kuttner's critique and refinement of this methodology are presented in Section 3. Section 4 shows why market-based monetary policy shock measures yield biased estimates of the response of interest rates to monetary policy shocks. Section 5 presents a latent-variable methodology and compares the results using this and Kuttner's methodology. The conclusions are presented in Section 6.

2. The Response of Interest Rates to News

There have been any number of empirical investigations of the response of interest rates (or other assets prices) to headline news (e.g., Remolona and Fleming, 1999; Fleming and Remolona, 1999; and Bartolini, 2008). Because the FOMC has been targeting the federal funds rate, much of this research has focused on news about monetary policy (e.g., Gürkaynak, et al., 2005, Bernanke and Kuttner, 2005). While all of the attention in economic research has focused on headline news events, interest rates and other asset prices respond to information from myriad of sources. Because this information is not easily identified, it is difficult if not impossible to associate a given response with a particular piece of information or news.

This section analyzes the relationship between Kuttner's (2001) market-based monetary policy shock measure and changes in Treasury rates on all days.[1] Kuttner's

[1] Piazzesi and Swanson (2008) argue that federal funds futures rate measures of financial markets' expectations of monetary policy may be biased because of a risk premium. They find, however, that Kuttner's (2001) measure appears to be relatively robust to risk premia in federal funds futures contracts,

(2001) market-based monetary shock measure is primarily based on the spot or current-month federal funds futures rate. The federal funds futures rate is the rate on a derivative contract whose value depends on the average level of the effective federal funds rate in the month of the contract. Consequently, the market's expectation for the average of effective funds rate over the month on the t^{th} day of the month is given by

(1) $$fff_t^0 = m^{-1}\left\{\left[\sum_{k=1}^{t-1} ff_k / (t-1)\right] + E_t\left[\sum_{k=t}^{m} ff_k / (m-t+1)\right]\right\},$$

where fff_t^0 denotes the rate on the current-month federal funds futures contract, ff denotes the effective (overnight) federal funds rate and m denotes the number of days in the month. That is, the futures rate is simply a weighted average of the observed funds rate up to day t and the market's expectation of the funds rate over the remainder of the month. If the market expects the FOMC to change its target on day t, but not again during the month, then $fff_t^0 - fff_{t-1}^0$ would be zero. Hence, a natural way to estimate the monetary policy surprise is

(2) $$\Delta ff_t^{*u} = \frac{m}{m-t}(fff_t^0 - fff_{t-1}^0).$$

Aware that this measure could not be calculated on the first day of the month Kuttner replaced fff_{t-1}^0 with the 1-month ahead federal funds futures rate on the last day of the previous month. He also noted that there were problems with this measure on the last few days of the month, so he used

(3) $$\Delta ff_t^{*u} = (fff_t^1 - fff_{t-1}^1),$$

noting that "The difference-based measure may largely 'difference out' risk premia that are moving primarily at lower, business-cycle frequencies" (Piazzesi and Swanson, 2008, p. 690).

where fff_t^1 denotes the rate on the 1-month ahead federal funds futures contract, on the last three days of the month.[2]

Kuttner (2001) only calculated Δff_t^{*u} on days when the FOMC changed its target for the funds rate and partitioned target changes into expected and unexpected target. Specifically,

$$(4) \qquad \Delta ff_t^{*e} = \Delta ff_t^{*} - \Delta ff_t^{*u} = \Delta ff_t^{*} - \frac{m}{m-t}(fff_t^0 - fff_{t-1}^0),$$

where Δff_t^{*} denotes the change in the funds rate target and Δff_t^{*e} denotes the expected target change.

It is clear that Δff_t^{*u} can be calculated for any day of the month; however, unexpected target changes can only be calculated on days when the target is changed. Table 1 presents the correlation between Kuttner's policy shock measure and changes in the 3- and 6-month T-bill rates, denoted as (tb3) and (tb6), and the 1-, 3-, 5-, 7-, 10-, and 20-year Treasury bond yields, denoted as t1, t3, t5, t7, t10, and t20, respectively, over rates over the sample period is June 6, 1989 through June 29, 2007. The sample period ends on June 29, 2007 to prevent contamination of the results by the recent turmoil in financial markets.

Table 1 presents the correlation between Kuttner's shock measure and changes in the Treasury rates over the sample period. The days are partitioned into days with and without headline news. Headline news days are days when the target is changed, FOMC minutes are released, an FOMC meeting occurs, or a major economic announcement is made (see the Appendix A for the list of headline news events). If the market does not

[2] Poole and Rasche (2000) used equation (9) exclusively as their measure of the monetary policy shock. The results presented here are qualitatively the same when Poole and Rasche's (2000) measure is used.

respond to ambient news, the correlation between the market-based monetary policy shock measure and changes in Treasury rates should be relatively small on days when there is no headline news and much smaller than on headline news days.

The top panel of Table 1 shows the correlations on days with no headline news. The bottom panel presents the correlations on headline news days. The top panel shows that the market-based monetary shock measure is highly positively correlated with changes in the T-bill rates on days with no headline news. The correlation is smaller for longer-term rates but statistically significant for all rates. With few exceptions, the correlation is slightly higher on headline news days; however, differences in correlations on headline news days and other days are small. Not surprisingly, daily changes in Treasury rates are highly correlated with each other and the correlation declines as the difference in the maturity increases. The correlation among Treasury rates is slightly higher on headline news days, but again the differences are small. The correlations show that Kuttner's policy shock measure and Treasury rate move more strongly together even on days when the information that moves the markets is not easily identified.

While the analysis presented in this paper focuses on Kuttner's federal funds futures rate policy shock measure, the analysis applies to all of the market-based measures of monetary policy shocks that have been used in the literature.

2.1 Why Does The Federal Funds Futures Rate Respond to Ambient News?

Table 1 demonstrates that the federal funds futures rate and other rates respond to a variety of information and not simply news about monetary policy. To see why, it is useful to consider three conditions that would have to exist for the federal funds futures market to respond only to monetary policy news.

First, the market would have to aware that the FOMC was targeting the funds. If the market was unaware that the FOMC was targeting the funds rate, there would be no particular reason for the market to focus solely on FOMC policy actions. There is ample evidence that there was uncertainty about the extent to which the FOMC was targeting the funds rate during at least the early-to-late 1980s. Thornton (2006a) shows that even though the FOMC began "targeting" the federal funds rate in September 1982, officially the FOMC was targeting borrowed reserves.[3] Thornton (2006a) notes that although the FOMC had dropped all "pretense of targeting borrowed reserve" in its policy deliberations by late 1989, the FOMC was officially targeting borrowed reserves as late as 1993.

Uncertainty about whether the FOMC was targeting the funds rate is supported by Poole, Rasche, and Thornton (2002). They reviewed the "*Credit Market*" column of the *Wall Street Journal* two days before and after each FOMC meeting beginning in late 1987. They found that "there is little indication that the market was aware that the Fed was setting an explicit objective for the federal funds rate before 1989"[4] Moreover, they show that there were several occasions when the market was unaware that the target had changed as late as October 1991.

Second, market participants would have to know the level FOMC's funds rate target. If there is uncertainty about the level of the funds rate target or the precision with which the FOMC is targeting the funds rate, the futures rate might respond to information that it believes would affect the average level of the funds rate. Thornton (2006a) shows that the FOMC was ambiguous about the extent to which it was targeting the funds rate.

[3] Thornton (2006a) cites several reasons for the FOMC preference to be seen as targeting borrowed reserves rather than the funds rate.
[4] Poole, Rasche, and Thornton (2002), pp. 73-74.

Indeed, Chairman Greenspan maintained that the FOMC was not targeting the funds rate at a precise level, as was done in the mid- to late-1970s. The ambiguity is apparent in the FOMC's statement at the February 1994 meeting, when it began the practice of announcing policy actions. The announcement made no mention of the funds rate, let alone the funds rate target. It merely read, "the Federal Open Market Committee decided to increase slightly the degree of pressure on reserve positions. The action is expected to be associated with a small increase in *short-term money market interest rates*."[5] Moreover, before February 1994, the market had to infer whether the FOMC had taken a policy action from signals that the Trading Desk of the Federal Reserve Bank of New York provided in conducting daily open market operations (e.g., Feinman, 1993).[6]

Over time the FOMC became increasingly open about the fact that it was targeting the funds rate and more specific about the level of the target. When it reduced the target by 25 basis points in July 1995, the FOMC's statement read, "the Federal Open Market Committee decided to decrease slightly the degree of pressure on bank reserve positions"…"today's action will be reflected in a 25 basis point decline in the federal funds rate *from about* 6 percent *to about* 5-3/4 percent."[7] The FOMC did not officially announce it was targeting the funds rate until December 21, 1999, when it announced that "The Federal Open Market Committee made no change today in its target for the federal funds rate."[8] When the FOMC increased the target by 25 basis points at its February 2, 2000, meeting the ambiguity was gone: The statement read: "The Federal Open Market

[5] Board of Governors (1994), emphasis added.
[6] The classic case of misinterpreting the Desk's signal occurred the day before Thanksgiving 1989 when market analyst misinterpreted the Desk's action as a signal the Fed had eased policy.
[7] Board of Governors (1995), emphasis added.
[8] Board of Governors (1999).

Committee voted today to raise its target for the federal funds rate by 25 basis points to 5-3/4 percent."

The third condition is there should be no uncertainty about the magnitude and timing of the next target change. If the market is uncertain about when and how much the FOMC might change the target next, it is reasonable to assume that the federal funds futures rate will respond to news that might cause the FOMC to adjust its target. The evidence is that there has been considerable uncertainty about the next target change. Poole, Rasche, and Thornton (2002) found that of the 24 (of 62) target changes that the market was aware had occurred between August 1987 and February 1994, only 6 were anticipated. Moreover, they found that only 10 of the 24 target changes over the period February 5, 1994, through July 31, 2001, were unanticipated, and that "on seven of these occasions the market anticipated the change two or more weeks in advance." The remaining 17 target changes were either unanticipated or anticipated only a few days in advance of the FOMC's action. While most target changes since February 1994 have occurred at regularly scheduled FOMC meetings, intermeeting changes are never ruled out.

Uncertainty about whether the FOMC was targeting the funds rate, the level of the funds rate target, the timing and magnitude of the next target changes are reflected in the behavior of the funds rate relative to the target. Figure 1 shows the difference between the effective funds rate and the FOMC's funds rate target daily over the period June 6, 1989 through June 29, 2007. Figure 2 shows the absolute value of the monthly average difference between the effective federal funds rate from the FOMC's target from July, 1989, to June, 2007. Consistent with the above analyses, the differences tended to be much larger before about 2000. The differences become very small in the early 2000s. By then the market knew the precise level of the FOMC's funds rate target and the Fed was frequently signaling the magnitude and timing of the next target change. Given the large differences between the funds rate and the target before 2000, it is not surprising that Table 1 shows that the federal funds futures market responded to news from a variety of sources and not simply news about monetary policy or monetary policy actions.

3. Estimating the Response of Interest Rates to Monetary Policy Actions

Cook and Hahn (1989) estimated the response of Treasury rates to monetary policy actions by estimating the equation

(1) $$\Delta i_t = \alpha + \beta \Delta ff_t^* + \varepsilon_t ,$$

where ff_t^* denotes the Fed's target for the federal funds rate and i_t denotes a one of eight Treasury rates used above.[9] They found that the estimate of β was very close to 0.50 for the 3-, 6-, and 12-month T-bill rates and that the estimates of β then declined monotonically to 0.098 for the 20-year bond yield as the term to maturity increased. Estimates of β were highly statistically significant for all rates and estimates of R^2 ranged from 59 to 29 percent.

Kuttner (2001) estimated equation (1) over the period June 6, 1989, through February 2, 2000 and found that the reactions of interest rates to a change in the funds rate target were "uniformly smaller and less significant than those for the 1975-1979 sample period." Moreover, there was no statistically significant response for long-term yields. Rejecting as "implausible" that his result was due to market being unaware that

[9] Cook and Hahn (1989) did not use the actual change in the funds target because the magnitude and timing of these changes were unknown. Rather, they determined when the funds rate target had changed from press reports in the *Wall Street Journal*. To see other problems associated with Cook and Hahn's analysis, see Thornton (2004).

the Fed was targeting the funds rate "because of the Fed's greater transparency," Kuttner (2001) suggested that "a more likely explanation is that target rate changes have been more widely anticipated in recent years." Specifically, he suggested that Cook and Hahn's event-study methodology's failed to distinguish between anticipated and unanticipated target changes. This produced "noise" which resulted in "an attenuated estimate of interest rates' response to policy surprises."[10] He suggested that the bias could be eliminated by using the federal funds futures rate to proxy for the unexpected component of the target change. Specifically, Kuttner suggested that the response of interest rates to a monetary policy shock could be determined by estimating

(2) $$\Delta i_t = \alpha + \beta \Delta ff_t^{*u} + \omega_t ,$$

on days when the FOMC's changed it target for the funds rate.

4. The Joint-Response Bias

If the federal funds futures rate responds to news from a variety of sources and not solely news about changes in the funds rate target, estimates of β from equation (2) will be biased. To see why, assume that

(3) $$\Delta fff_t = \lambda N_t + \delta(\Delta ff_t^* \neq 0) + \nu_t$$

and

(4) $$\Delta i_t = \mu N_t + \theta(\Delta ff_t^* \neq 0) + \omega_t ,$$

where N_t denotes the news that affects the market every day other than changes in the FOMC's target for the federal funds rate, and ν_t and ω_t (both *i.i.d.*) denote idiosyncratic shocks to the federal funds futures rate and Treasury rates, respectively. The coefficients λ and μ denote the response of the federal funds futures rate and Treasury rates,

[10] Kuttner (2001), p. 527

respectively, to news other than a monetary policy action, and δ and θ denote the response of the futures rate and Treasury rates, respectively, to monetary policy actions. If policy actions are fully anticipated, then $\theta = \delta = 0$. Of course, these coefficients are also zero on days when there is no monetary policy action.

Substituting equation (3) into equation (2) yields

(5) $$\Delta i_t = \alpha + \beta(\lambda N_t + \delta(\Delta ff_t^* \neq 0) + \nu_t) + \varepsilon_t .$$

It is easy to show that

(6) $$P\lim \hat{\beta} = \frac{\mu\lambda\sigma_N^2 + \theta\delta\sigma_{\Delta ff^*}^2}{\lambda^2\sigma_N^2 + \delta^2\sigma_{\Delta ff^*}^2},$$

where σ_N^2 and σ_{TC}^2 denote the variance of news and monetary policy actions, respectively.

Equation (6) shows that the estimate of β from equation (2) is the sum of the response of market rates to surprise monetary policy actions and the response to other news. Note that the estimate of β could be nonzero even when target changes are fully anticipated, i.e., $\theta = \delta = 0$.[11] Equation (2) correctly identifies the response of the interest rate to a monetary policy surprise if and only if $\lambda = 0$, i.e., the market-based measure of monetary policy surprises responds only to monetary policy actions. In this instance, $P\lim \hat{\beta} = \delta / \theta$—the relative response of the interest rate and the futures rate to a change in the funds rate target. The estimate of β is less than 1.0 when the reaction of the interest rate is smaller than the reaction of the federal funds futures rate.[12]

[11] Analysts do not observe this because equation (2) is typically estimated using only days when there is a change in the FOMC's funds rate target.
[12] Estimates from Equation 1 could also suffer from simultaneous equation bias. For example, for a period during the early 1990s the funds rate target was changed shortly after the Bureau of Labor Statistics'

Gürkaynak, Sack, and Swanson (2005) propose a method for dealing with the joint-response bias. Specifically, they note that if data are measured over a time interval that is sufficiently small, it is "much less likely that any other significant events took place within this narrow window that might have influenced asset prices."[13] Using extremely high-frequency data significantly reduces, if not eliminates, the joint-response bias; however, the estimated response using ultrahigh-frequency data might overstate the effect of Fed actions on interest rates on the day. For example, Gürkaynak, Sack, and Swanson (2005) note that

> The Federal Reserve's announcement following its January 28, 2004, policy meeting led to one of the largest reactions in the Treasury market on record, with two- and five-year yields jumping 20 and 25 basis points (bp) respectively in the half-hour surrounding the announcement—the largest movements around any Federal Open Market Committee (FOMC) announcement over the fourteen years for which we have data.

Although the immediate reaction to these announcements was exceptional, the changes in these rates over the day were much less remarkable. The daily changes in these rates were 17 and 15 basis points, respectively. Daily changes in other Treasury rates were even smaller; for example, the 10- and 20-year yields changed by 11 and 10 basis points, respectively. Moreover, these daily changes are not particularly unusual: There are 267 days (6 percent of the days) in the sample used in this study when the daily change in the 10-year Treasury yield was 11 basis points or larger and 135 days when the 5-year yield changed by 15 basis points or more. Consequently, using very high-frequency data may give a

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release of the employment report. This ignited speculation that FOMC was responding to the employment report. Rigobon and Sack (2004) attempt to account for textbook simultaneous equation bias using a statistical procedure that exploits heteroskedasticity on days when there is known shift in the variance of one of the shocks; specifically, days of FOMC meetings and the Chairman's semiannual testimony to Congress. They find little evidence of simultaneous equation bias using Kuttner's measures of monetary policy shocks.

[13] Gürkaynak, Sack, and Swanson (2007), p. 60.

distorted picture of the extent to which interest rates respond to monetary policy shocks. Moreover, most this literature has used daily data, which is more readily available.

5. Correcting for the Joint-Response Bias

The joint-response bias stems from the fact that interest rates and market-based monetary policy shock measures respond to all information relevant for the determination of interest rates. Hence, it is necessary to account for this joint response in order to identify the effect of surprise monetary policy actions on interest rates. This can be done by using the market-based measure of a monetary policy shocks as a latent variable that accounts for the markets' reaction to unobservable news. Specifically, estimate

(11) $$\Delta i_t = \alpha' + \alpha''(TC_t) + \beta^n \Delta ff_t^{*u} + \beta^{mps} \Delta ff_t^{*u}(TC_t) + \varepsilon_t \,,$$

where TC_t denotes a dummy variable that is 1.0 on days when the FOMC changed the funds rate target and zero otherwise, and where β^n reflects the joint response of interest rates and market-based measures of monetary policy shocks to ambient news, and β^{mps} reflects the marginal effect associated with a surprise monetary policy action. If β^{mps} is not significantly different from zero, the market's reaction to a surprise monetary policy actions is no different from its reaction to other news—surprise monetary policy actions have no unique effect on interest rates.

5.1 The Response of Treasury Rates to Monetary Policy Shocks

To determine the extent of the joint-response bias, Kuttner's (2001) equation is estimated over his sample period (June 6, 1989 - February 2, 2000). That is,

(12) $$\Delta i_t = \alpha + \beta_1 \Delta ff_t^{*u} + \beta_2(\Delta ff_t^{*} - \Delta ff_t^{*u}) + \varepsilon_t$$

is estimated for each of eight Treasury rates.[14] The estimates of equation (12), presented in Table 2, are similar to those reported by Kuttner (2001).[15] None of the estimates of β_2 is statistically significant, indicating that anticipated policy actions are already reflected in rates. In contrast, all of the estimates of β_1 are positive and statistically significant, indicating that surprise monetary policy actions have a strong positive effect on interest rates across the term structure. The estimated response of the T-bill rates for maturities of 1 and 3 years is similar. The magnitude of the response of longer-term yields is smaller and declines monotonically as the term to maturity increases.

To examine the extent of the joint-response bias associated with estimate of β_1 from equation (12), estimates of equation (11) are presented in Table 3. The estimates are remarkably similar to Cook and Hahn's (1989). In every instance, however, the response of the monetary policy shock from equation (12) appears to overestimate the market's response to a monetary policy action. Moreover, for maturities longer than 3 years the estimated responses are not statistically significant. Monetary policy shocks appear to have had no statistically significant effect at the long end of the yield curve during this period.[16]

[14] The Kuttner shocks on days when the funds rate target changed used here differ on a few occasions from those used by Kuttner (2001). The differences are twofold. First, the dates of target changes are from Thornton (2006a), which differ from Kuttner's on three days. There were also six days when the values are different, apparently because of differences in the futures rates used here and those used by Kuttner (2001). Appendix B shows the Kuttner shocks used here and Kuttner's (2001) shocks. In any event, these small differences are not important for the qualitative results presented here.

[15] The covariance matrix for this and all other equations reported here were obtained using a heteroskedasticity and autocorrelation consistent estimator.

[16] Several analysts (e.g., Rudebusch, 1998; Bernanke and Kuttner, 2005; and Gürkaynak, et al., 2007) noted that in the early 1990s several target changes occurred shortly after the Bureau of Labor Statistics' release of the employment report, igniting speculation that FOMC was responding to the employment report. As a robustness check, Equation (11) was estimated partition Δff_t^{*u} by days when the target was changed, all other headline news days and non-headline news days. The estimates of β^{mps} are very similar to those reported in Table 3 and, hence, are not reported here.

5.2 The Response to Monetary Shocks Since 2000

By 2000 the FOMC was precise about its funds rate target, and Chairman Greenspan often signaled that the target would change well in advance of the action. Under such circumstances, the analysis in Section 4 suggests that the difference in the estimates of the market's response to monetary policy shocks from equations (11) and (12) might be smaller. To investigate this possibility, these equations are estimated for the period February 3, 2000, through June 29, 2007. The estimates of equation (12), presented in Table 4, suggest a marked decline in the response to monetary policy shocks. The estimates of the response of Treasury rates of with maturities of 3 months to 1 year are about half as large as those from the previous sample period. Moreover, none of the estimated responses for rates with maturities longer than a year is statistically significant.

As before, estimates of equation (11), presented in Table 5, show that the estimates of the response of Treasury rates to monetary policy shocks from Kuttner's (2001) equation are essentially the sum of the responses to ambient news and to monetary policy surprises. Over this sample period, however, none of the estimates of β^{mps} is statistically significant at the 5 percent significance level, suggesting that surprise monetary policy actions had no effect on the Treasury yields.

The lack of a statistically significant response might simply reflect the lack of surprise policy actions during this period. Table 6 presents the Kuttner shocks on days when the funds rate target was changed since January 2000. With few exceptions, the Kuttner shocks are relatively small. The major exceptions were the three intermeeting target changes that occurred on January 3, April 18, and September 17, 2001. In these instances, the timing, and perhaps the magnitude of the change, surprised the market. The other major exception occurred on November 6, 2002, when the market was expecting a 25 basis point reduction in the target rate and the FOMC reduced the target by 50 basis points. The lack of surprise changes in the funds rate is particularly pronounced after mid-2004. Beginning with the target change on June 30, 2004 there are no Kuttner shocks larger than 2 basis points in absolute value. This finding is not surprising because beginning in May 2004, the FOMC adopted the "measured pace" language in its statement. The measured pace language was widely regarded as indicating that the FOMC would increase its funds rate target by 25 basis points at its next meeting. The FOMC fulfilled this expectation at each of the next 14 meetings.[17] This language was modified at the December 2005 meeting and discontinued at the January 2006 meeting. Three target changes were made after January 2006, all of which were signaled well in advance of the action.

To see whether the lack of surprise actions might explain the lack of a statistically significant response, equation (11) was estimated for the period February 3, 2000, through December 31, 2003, when relatively large monetary policy shocks were more numerous. The results are qualitatively the same as those presented in Table 5 and, hence, not presented here. In particular, the marginal effect of monetary policy shocks is positive but statistically insignificant for maturities of a year or less and negative and not statistically insignificant for maturities longer than 1 year. The fact that 7 of the 16 monetary policy shocks during this period were 10 basis points or larger suggests that the lack of a statistically significant response of Treasury rates may not be due solely to a lack of surprise policy actions; rather, it might reflect a fundamental change in the relationship between the federal funds rate and other interest rates (e.g., Thornton, 2009).

[17] See Thornton (2006b) for a discussion of the "measured pace" language.

6. Conclusion

Following Kuttner's (2001) use of the federal funds futures rate to measure monetary policy shocks, it has become common to investigate the response of asset prices to unanticipated monetary policy actions using market-based measures of monetary policy shocks. This methodology is shown to yield biased estimates of the response of asset prices to monetary policy shocks when market-based measures of monetary policy shocks respond to news other than the policy action being investigated.

This bias can be accounted for by estimating the equation for all days in the sample and not merely days when there is a policy actions. In so doing, the market-based monetary policy shock measure is effectively a latent variable that accounts for the relationship between the asset price and the market-based monetary policy shock measure. A comparison of the results using this latent-variable, event-study methodology with Kuttner's (2001) event-study methodology shows that the latter methodology consistently overestimates the response of Treasury yields to monetary policy shocks. For the sample period June 6, 1989, through February 2, 2000, Kuttner's methodology yields estimates of the response of Treasury rates on assets with maturities of 1 year or less that are about 40 percent too large. For maturities between 1 and 5 years, the overestimate is much larger. For maturities of 5 years and longer, there is no statistically significant response to monetary policy shocks.

Over the period 2000-20007 there is no statistically significant response of Treasury rates to monetary policy shocks. Although the evidence is inconclusive, the lack of a statistically significant response after February 3, 2000, does not appear to be due solely to the greater predictability of funds rate target changes.

References

Bartolini, L., L. Goldberg, and A. Sacarny. (2008). "How Economic News Moves Markets," *Current Issues in Economics and Finance*, Federal Reserve Bank of New York, *14*(6), 1-7.

Bernanke, B.S., and K.N. Kuttner. (2005) "What Explains the Stock Market Reaction to Federal Reserve Policy?" *Journal of Finance, 60*, 1221-57.

Board of Governors of the Federal Reserve, *Press Release*, February 4, 1994.

Board of Governors of the Federal Reserve, *Press Release*, July 6, 1995.

Board of Governors of the Federal Reserve, *Press Release*, December 21, 1999.

Bomfim, A. (2003) "Pre-Announcement Effects, News Effects, and Volatility: Monetary Policy and the Stock Market," *Journal of Banking and Finance*, *27*, 133-51.

Cochrane, J.H., and M. Piazzesi. (2002) "The Fed and Interest Rates: A High-Frequency Identification," *American Economic Review*, *92*, 90-101.

Cook, T., and T. Hahn. (1989). "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s," *Journal of Monetary Economics*, *24*(3), pp. 331-51.

Faust, J., E.T. Swanson, and J.H. Wright. (2004) "Indentifying VARs Based on High Frequency Futures Data," *Journal of Monetary Economics*, *51*, 1007-131.

Feinman, J.N. (1993). "Estimating the Open Market Desk's Daily Reaction Function," *Journal of Money, Credit and Banking*, *25*, 231-47.

Fleming, M.J., and E.M. Remolona. (1999). "Price Formation and Liquidity in the U.S. Treasury Market: The Response to Public Information." *Journal of Finance*, 54(5), 1901-15.

Gürkaynak, R.S., B.P. Sack, and E.T. Swanson. (2005) "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking*, May, 55-93.

Gürkaynak, R.S., B.P. Sack, and E.T. Swanson. (2007) "Market-Based Measures of Monetary Policy Expectations," *Journal of Business and Economic Statistics*, *25*, 201-12.

Hamilton, J.D. (2008). "Assessing Monetary Policy Effects Using Daily Federal Funds Futures Contracts," Federal Reserve Bank of St. Louis *Review*, *90*(4), 377-93.

Kuttner, K.N. (2001). “Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market,” *Journal of Monetary Economics*, *47*(3), 523-44.

Piazzesi, M., and E.T. Swanson. (2008). “Futures Prices and Risk-Adjusted Forecasts of Monetary Policy,” *Journal of Monetary Economics*, *55*(4), 677-691.

Poole, W., and R.H. Rasche. (2000). “Perfecting the Market’s Knowledge of Monetary Policy,” *Journal of Financial Services Research*, *18*(2-3), 255-98.

Poole, W., R.H. Rasche, and D.L. Thornton. (2002). “Market Anticipations of Monetary Policy Actions,” Federal Reserve Bank of St. Louis *Review*, *84*(4), 65-94.

Remolona, E.M., and M.J. Fleming. (1999). “What Moves Bond Prices?” Journal of Portfolio Management, *25*(4), 28-38.

Rigobon, R., and B.P. Sack. (2004) “The Impact of Monetary Policy on Asset Prices,” *Journal of Monetary Economics*, *51*, 1553-75.

Rudebusch, G.D. (1998). “Do Measures of Monetary Policy in a VAR Make Sense?” *International Economic Review*, *39*, 907-31.

Thornton, D.L. (2004). “The Fed and Short-term Interest Rates: Is It Open Market Operations, Open Mouth Operations or Interest Rate Smoothing?” *Journal of Banking and Finance*, *28*(3), 475-98.

Thornton, D.L. (2006a). “When Did the FOMC Begin Targeting the Federal Funds Rate? What the Verbatim Transcripts Tell Us,” *Journal of Money, Credit and Banking*, *38*(8), 2039-71.

Thornton, D.L. (2006b). “‘Measured Pace’ in the Conduct of Monetary Policy,” Federal Reserve Bank of St. Louis, *Monetary Trends*, June 2006.

Thornton, D.L. (2009). “The Unusual Behavior of the Federal Funds and 10-Year Treasury Rates: A Conundrum or Goodhart’s Law?” Working paper, 2007-39C, Federal Reserve Bank of St. Louis.

Table 1: Correlation Between Kuttner Shocks and Various Treasury Rates
(June 6, 1989 - June 29, 2007)

	No headline news								
Var.	Δff_t^{*u}	$tb3$	$tb6$	$t1$	$t3$	$t5$	$t7$	$t10$	$t20$
Δff_t^{*u}	1.0000								
$tb3$	0.2334	1.0000							
$tb6$	0.2453	0.7739	1.0000						
$t1$	0.2276	0.6122	0.8063	1.0000					
$t3$	0.0744	0.2631	0.4173	0.5923	1.0000				
$t5$	0.1199	0.3934	0.5896	0.7940	0.8259	1.0000			
$t7$	0.1032	0.3482	0.5352	0.7411	0.8778	0.9593	1.0000		
$t10$	0.0959	0.3276	0.5076	0.7087	0.9010	0.9401	0.9693	1.0000	
$t20$	0.0819	0.2835	0.4526	0.6462	0.9459	0.8868	0.9346	0.9526	1.0000
	Headline news								
Var.	Δff_t^{*u}	$tb3$	$tb6$	$t1$	$t3$	$t5$	$t7$	$t10$	$t20$
Δff_t^{*u}	1.0000								
$tb3$	0.3041	1.0000							
$tb6$	0.2891	0.7951	1.0000						
$t1$	0.2781	0.6384	0.8678	1.0000					
$t3$	0.0932	0.3042	0.5089	0.6434	1.0000				
$t5$	0.1764	0.4485	0.6864	0.8404	0.8514	1.0000			
$t7$	0.1523	0.3999	0.6324	0.7867	0.8952	0.9718	1.0000		
$t10$	0.1381	0.3743	0.6062	0.7579	0.9204	0.9585	0.9810	1.0000	
$t20$	0.1037	0.3145	0.5303	0.6745	0.9362	0.8887	0.9281	0.9471	1.0000

Table 2: Response to Monetary Policy Shocks (June 6, 1989 - February 2, 2000)								
	α	p-value	β_1	p-value	β_2	p-value	$\bar{R}^2$	SE
$tb3$	-0.0001	0.9046	0.8749	0.0000	-0.0322	0.6360	0.0979	0.0475
$tb6$	0.0000	0.9766	0.8563	0.0000	-0.0343	0.6080	0.0970	0.0467
$t1$	0.0001	0.9427	0.8391	0.0000	-0.0527	0.4214	0.0758	0.0517
$t3$	-0.0001	0.9326	0.5298	0.0000	-0.0474	0.4424	0.0218	0.0611
$t5$	-0.0001	0.9087	0.4858	0.0000	-0.0807	0.1824	0.0172	0.0617
$t7$	-0.0002	0.8385	0.3896	0.0000	-0.0845	0.1710	0.0112	0.0605
$t10$	-0.0004	0.7485	0.3222	0.0001	-0.0801	0.1521	0.0083	0.0577
$t20$	-0.0004	0.6883	0.2745	0.0006	-0.0844	0.0950	0.0070	0.0537

Table 3: The Appropriately Identified Response to Monetary Policy Shocks (June 6, 1989 - February 2, 2000)										
	α'	p-value	α''	p-value	β^n	p-value	β^{mps}	p-value	$\bar{R}^2$	SE
$tb3$	0.0002	0.7913	-0.0314	0.0023	0.1234	0.0000	0.6284	0.0000	0.1286	0.0467
$tb6$	0.0003	0.6965	-0.0334	0.0161	0.1350	0.0000	0.5903	0.0000	0.1348	0.0457
$t1$	0.0004	0.7132	-0.0273	0.0602	0.1583	0.0000	0.5594	0.0000	0.1157	0.0506
$t3$	0.0001	0.9411	-0.0187	0.2774	0.1527	0.0000	0.2876	0.0228	0.0489	0.0603
$t5$	0.0000	0.9737	-0.0186	0.3044	0.1344	0.0000	0.2428	0.0611	0.0371	0.0611
$t7$	0.0000	0.9727	-0.0206	0.2695	0.1242	0.0000	0.1480	0.2594	0.0290	0.0599
$t10$	-0.0002	0.8501	-0.0162	0.3408	0.1134	0.0000	0.1086	0.3692	0.0242	0.0573
$t20$	-0.0002	0.8191	-0.0187	0.2153	0.0891	0.0000	0.0743	0.5073	0.0181	0.0534

Table 4: Response to Monetary Policy Shocks (February 3, 2000 - June 29, 2007)								
	α	p-value	β_1	p-value	β_2	p-value	$\bar{R}^2$	SE
*tb*3	-0.0001	0.9287	0.4735	0.0000	0.0380	0.1621	0.0389	0.0403
*tb*6	-0.0003	0.7571	0.4199	0.0000	0.0523	0.0867	0.0416	0.0359
*t*1	-0.0006	0.5732	0.2879	0.0033	0.0241	0.4335	0.0121	0.0434
*t*3	-0.0011	0.4283	0.0003	0.9988	0.0526	0.1814	0.0001	0.0626
*t*5	-0.0011	0.4271	-0.0239	0.8947	0.0391	0.3129	0.0000	0.0625
*t*7	-0.0011	0.4148	-0.0844	0.6406	0.0044	0.8966	0.0000	0.0608
*t*10	-0.0010	0.4266	-0.1199	0.4746	-0.0018	0.9465	0.0002	0.0571
*t*20	-0.0009	0.4328	-0.1244	0.2309	-0.0166	0.4866	0.0009	0.0514

Table 5: The Appropriately Identified Response to Monetary Policy Shocks (February 3, 2000 - -June 29, 2007)										
	α	p-value	α	p-value	β^n	p-value	β^{mps}	p-value	$\bar{R}^2$	SE
*tb*3	0.0000	0.9901	-0.0189	0.0047	0.2805	0.0004	0.1631	0.1470	0.1066	0.0388
*tb*6	-0.0001	0.9181	-0.0191	0.0177	0.2055	0.0019	0.1895	0.0602	0.0871	0.0350
*t*1	-0.0006	0.5457	-0.0028	0.7538	0.2098	0.0009	0.0803	0.4907	0.0439	0.0427
*t*3	-0.0012	0.4285	0.0069	0.5828	0.1713	0.0048	-0.1355	0.4456	0.0092	0.0623
*t*5	-0.0011	0.4528	0.0025	0.8333	0.1499	0.0042	-0.1532	0.4069	0.0066	0.0622
*t*7	-0.0011	0.4528	0.0005	0.9619	0.1002	0.0365	-0.1815	0.3299	0.0027	0.0606
*t*10	-0.0010	0.4704	-0.0005	0.9561	0.0792	0.0595	-0.2007	0.2442	0.0023	0.0570
*t*20	-0.0008	0.5189	-0.0052	0.5008	0.0366	0.3713	-0.1790	0.1166	0.0010	0.0514

Table 6: Kuttner Shocks on Target Change Days (February 3, 2000 - June 29, 2007)			
Date	Kuttner shock	Date	Kuttner shock
3/21/2000	-0.03	8/10/2004	0.01
5/16/2000	0.04	9/21/2004	0.03
1/3/2001	-0.38	11/10/2004	0.00
1/31/2001	0.00	12/14/2004	0.00
3/20/2001	0.06	2/2/2005	0.00
4/18/2001	-0.43	3/22/2005	0.00
5/15/2001	-0.08	5/3/2005	0.00
6/27/2001	0.10	6/30/2005	0.00
8/21/2001	0.03	8/9/2005	0.00
9/17/2001	-0.32	9/20/2005	0.01
10/2/2001	-0.06	11/1/2005	0.00
11/6/2001	-0.10	12/13/2005	0.00
12/11/2001	0.00	1/31/2006	0.00
11/6/2002	-0.19	3/28/2006	0.00
6/25/2003	0.12	5/10/2006	-0.01
6/30/2004	-0.01	6/29/2006	-0.02

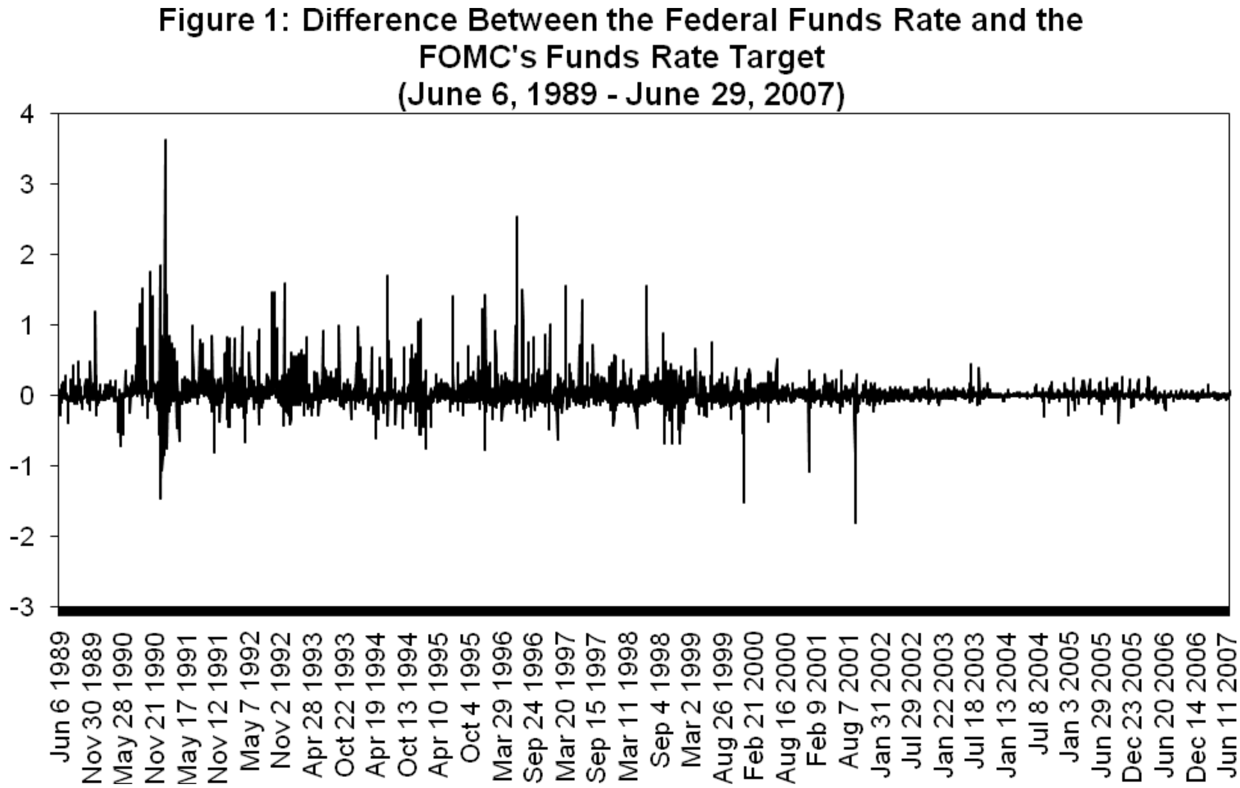
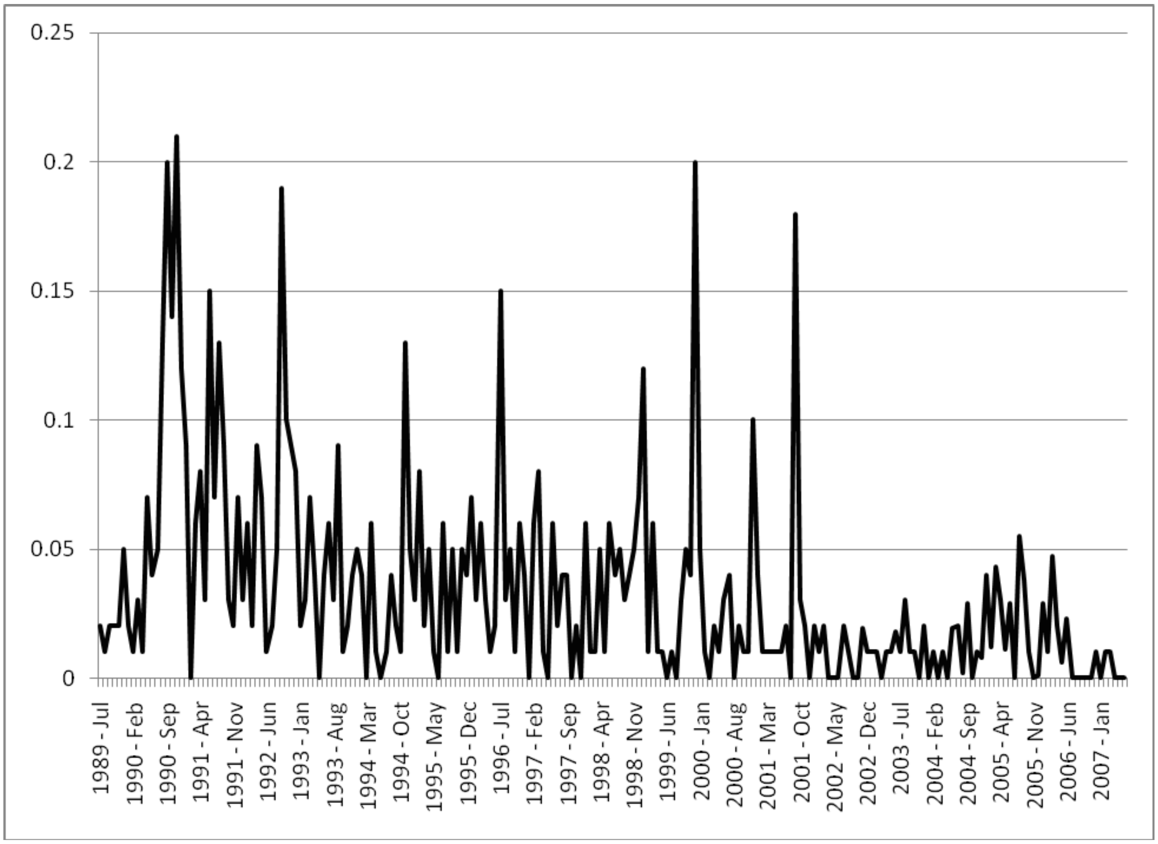


Figure 1: Difference Between the Federal Funds Rate and the FOMC's Funds Rate Target (June 6, 1989 - June 29, 2007)
4
3
2
1
0
-1
-2
-3
Jun 6 1989
Nov 30 1989
May 28 1990
Nov 21 1990
May 17 1991
Nov 12 1991
May 7 1992
Nov 2 1992
Apr 28 1993
Oct 22 1993
Apr 19 1994
Oct 13 1994
Apr 10 1995
Oct 4 1995
Mar 29 1996
Sep 24 1996
Mar 20 1997
Sep 15 1997
Mar 11 1998
Sep 4 1998
Mar 2 1999
Aug 26 1999
Feb 21 2000
Aug 16 2000
Feb 9 2001
Aug 7 2001
Jan 31 2002
Jul 29 2002
Jan 22 2003
Jul 18 2003
Jan 13 2004
Jul 8 2004
Jan 3 2005
Jun 29 2005
Dec 23 2005
Jun 20 2006
Dec 14 2006
Jun 11 2007

Figure 1: The Absolute Difference between the Effective Federal Funds Rate and the Funds Rate Target, monthly average data, July 1989 – June



Appendix A: Headline News Events
Unemployment rate
Housing starts
Industrial production
Index of leading economic indicators
GDP first announced
Producer price index
Retail sales
Consumer price index
Advanced durable goods orders
Personal income
Trade balance
Date of FOMC meetings
Date of release of FOMC minutes
Date of changes in the funds rate target

Appendix B: Kuttner Shocks Used Here and Kuttner's Shocks for Kuttner's Sample Period					
Date	Kuttner shock	Kuttner's shock	Date	Kuttner shock	Kuttner's shock
6/6/1989	-0.01	-0.01	12/20/1991	-0.28	-0.28
7/7/1989	-0.03	-0.03	4/9/1992	-0.24	-0.24
7/27/1989	0	0	7/2/1992	-0.36	-0.36
10/16/1989	-0.21	na	9/4/1992	-0.22	-0.22
10/18/1989	na	0	2/4/1994	0.12	0.12
11/6/1989	0.04	0.04	3/22/1994	-0.03	-0.03
12/20/1989	-0.17	-0.17	4/18/1994	0.1	0.1
7/13/1990	-0.14	-0.14	5/17/1994	0.13	0.13
10/29/1990	-0.02	-0.31	8/16/1994	0.14	0.14
11/14/1990	0.04	0.04	11/15/1994	0.14	0.14
12/7/1990	-0.27	-0.27	2/1/1995	0.05	0.05
12/18/1990	na	-0.21	7/6/1995	-0.01	-0.01
12/19/1990	-0.23	na	12/19/1995	-0.1	-0.1
1/8/1991	na	-0.18	1/31/1996	-0.07	-0.07
1/9/1991	-0.13	na	3/25/1997	0.03	0.03
2/1/1991	-0.26	-0.25	9/29/1998	0.06	0
3/8/1991	-0.16	-0.16	10/16/1998	-0.217	-0.26
4/30/1991	-0.17	-0.17	11/17/1998	-0.06	-0.06
8/6/1991	-0.15	-0.15	6/30/1999	-0.04	-0.04
9/13/1991	-0.05	-0.05	8/24/1999	0	0.02
10/31/1991	-0.05	-0.05	11/16/1999	0.09	0.09
11/6/1991	-0.13	-0.12	2/2/2000	-0.05	-0.05
12/6/1991	-0.09	-0.09			