Do Actions Speak Louder Than Words? [*]
The Response of Asset Prices to
Monetary Policy Actions and Statements

Refet S. Gürkaynak,

Brian Sack,

and

Eric T. Swanson

Board of Governors of the Federal Reserve System
Washington, DC 20551

Abstract

We investigate the effects of U.S. monetary policy on asset prices using a high-frequency event-study analysis. We test whether these effects are adequately captured by a single factor—changes in the federal funds rate target—and find that they are not. Instead, we find that two factors are required. These factors have a structural interpretation as a "current federal funds rate target" factor and a "future path of policy" factor, with the latter closely associated with FOMC statements. We measure the effects of these two factors on bond yields and stock prices using a new intraday dataset going back to 1990. According to our estimates, both monetary policy actions and statements have important but differing effects on asset prices, with statements having a much greater impact on longer-term Treasury yields.

November 1, 2004

[*] We thank Ben Bernanke, Stefania D'Amico, Jon Faust, Ken Kuttner, Jonathan Wright and seminar participants at Bilkent, Koç and Sabancı Universities and at the Central Bank of Turkey for valuable discussions, comments, and suggestions, and Andrea Surratt and Kunal Gullapalli for excellent research assistance. The views in this paper, and any errors and omissions, should be regarded as those of authors, and do not necessarily reflect those of the individuals listed above, the Federal Reserve Board, or any other individual within the Federal Reserve System.

1. Introduction

The Federal Reserve's announcement following its policy meeting on January 28, 2004, led to one of the largest reactions in the Treasury market on record, with two- and five-year yields jumping 21 and 25 basis points (bp) respectively in the half-hour surrounding the announcement—the largest movements around any FOMC (Federal Open Market Committee) announcement over the 14 years for which we have data. Even more remarkably, this outsized reaction was spurred not by what the FOMC *did*, but rather by what it *said*: Indeed, the decision to leave the current federal funds rate unchanged was completely anticipated by financial markets, but the FOMC's decision to drop the phrase "policy accommodation can be maintained for a considerable period" from its accompanying statement and replace it with "the Committee believes it can be patient in removing its policy accommodation" was read by financial markets as indicating that the FOMC would begin tightening policy sooner than previously expected.[1] On this date, then, treating the monetary policy action as a 0 bp surprise change in the current federal funds rate target would be missing the whole story.

In this paper, we investigate the extent to which this observation is true more generally: Is the effect of monetary policy announcements on asset prices adequately characterized by a single factor, namely the surprise component of the change in the current federal funds rate target? We perform a test of this hypothesis using the rank test of Cragg and Donald (1997) and strongly reject the hypothesis of a single factor. By contrast, we do not reject the hypothesis that the effects of monetary policy on asset prices are characterized by two factors. By performing a suitable rotation of these unobserved factors, we show that they have a structural interpretation as a "current federal funds rate target" factor, corresponding to surprise changes in the current federal funds rate target, and a "future path of policy" factor, corresponding to changes in futures rates out to horizons of one year that are independent of changes in the current funds rate target. We show that this latter ("path") factor has typically been associated with significant changes in FOMC statements, such as the example of January 28, above. In this way, we generalize and improve the single-factor analysis of the effects of monetary policy on asset prices performed by

[1] For example, the front page of *The Wall Street Journal* reported the following morning that "Investors interpreted the omission of 'considerable period' as a signal that the Fed is closer to raising interest rates than many thought" (Ip, 2004).

earlier authors, such as Cook and Hahn (1989), Kuttner (2001), Cochrane and Piazzesi (2002), Rigobon and Sack (2003), Ellingsen and Soderstrom (2003), and Bernanke and Kuttner (2004).

To measure the effects of monetary policy actions and statements on asset prices, we present a new dataset, going back to 1990, that captures changes in asset prices in a 30-minute and a one-hour window bracketing every FOMC announcement (we use the term "announcement" to refer to any means through which a policy decision was communicated to financial markets, whether that be an explicit press release or an open market operation). The use of intraday data turns out to be particularly important for measuring monetary policy surprises and the response of asset prices on a number of days in the early 1990s, when the FOMC eased policy just a few hours on the heels of a weak employment report released earlier in the day. The use of intraday data also allows us to measure more precisely the response of asset prices to monetary policy actions and statements, as both asset prices and policy expectations move in response to other news over the course of the day (of which the employment report is but the most dramatic example).

The two-factor approach advocated in this paper importantly adds to our understanding of the response of asset prices to monetary policy announcements. Indeed, each of the factors has significant, but differing, effects on asset prices. For example, we find that, relative to the "target" factor, the "path" factor has a larger positive impact on the long end of the term structure but a smaller negative impact on equity prices. One possible explanation for this pattern is that the statements that seem to drive the path factor lead to a greater extent to positive revisions in investors' assessment of the future path of output and inflation, consistent with a story first formalized by Romer and Romer (2000).[2]

The remainder of the paper proceeds as follows. Section 2 provides a detailed study of policy surprises—as measured by the surprise in the current policy setting—and measures the asset price responses to these surprises. Here, we establish that using intraday data provides some

[2] This story has been questioned on the basis of a pure "target" factor analysis by Faust, Swanson, and Wright (2004b). Those authors find that surprise tightenings in what we call the "target" factor convey essentially *no* positive information about the future path of output or inflation. However, like all of the previous literature, those authors did not consider changes in what we call the "path" factor, which our results suggest could be more informative about these variables.

advantages for measuring monetary policy surprises accurately and for isolating the effects of these surprises on asset prices. In Section 3, we broaden the definition of policy surprises using a factor analysis and investigate the asset price responses to these surprises. Section 4 concludes. A complete listing of our monetary policy announcement dates, times, and shock measures extending back to 1990 is provided in an appendix, and a second appendix describes the computation of our unobserved factors in detail.

2. The Effects of Changes in the Federal Funds Rate Target on Asset Prices

2.1 Methodology

We begin our analysis in the framework of one-dimensional measures of monetary policy surprises that has been used in the existing literature. To measure the effects of unexpected monetary policy actions (changes in the federal funds rate) on asset prices, we rely on the following regression, which has been frequently estimated in the literature:

$$\Delta y_t = \alpha + \beta \Delta x_t + \varepsilon_t \qquad (2.1)$$

where Δx_t denotes the surprise component of the change in the federal funds rate target announced by the FOMC, Δy_t denotes the change in a bond yield or stock market index over an interval that brackets the monetary policy announcement, and ε_t is a stochastic error term that captures the effects of other factors that influence the asset in question.

We use a high-frequency event-study analysis to estimate equation (2.1). One generally cannot estimate (2.1) using monthly or quarterly data due to simultaneous equations and omitted variables bias: in particular, 1) the change in monetary policy could actually be a *response* of monetary policy to the change in the asset price that took place earlier in the month or quarter, due to the direct effects of stock market wealth on the economic outlook or due to the signal that term spreads provide about future economic activity and inflation,[3] or 2) both the change in

[3] Rigobon and Sack (2003) discuss reasons why asset prices might be expected to feed back into monetary policy. Using a heteroskedasticity-based identification procedure, they estimate a statistically and economically significant response of monetary policy to the stock market, and this response has the expected positive sign. Using their heteroskedasticity-based procedure, Rigobon and Sack (2002) also estimate the size of the endogeneity and omitted variables problems in estimating equation (2.1).

monetary policy and the change in the asset price could be responding to important macroeconomic news (captured by ε_t) that was released earlier in the period, such as an employment report.[4] In either case, the classical regression assumption that ε_t is orthogonal to Δx_t is violated.[5]

These problems can be mitigated by using higher-frequency data to shrink the time period around the policy decision. Kuttner (2001), for example, uses daily data to measure changes in Treasury yields and the surprise component of FOMC monetary policy announcements. Cochrane and Piazzesi (2002) and Ellingsen and Soderstrom (2003) perform variations on this analysis, and Bernanke and Kuttner (2004) apply the method to measure the effects of monetary policy announcements on the stock market. However, as noted by Rudebusch (1998) and Bernanke and Kuttner (2004), simultaneity in (2.1) is still a potential problem even at daily frequency because the FOMC for a time often changed its target for the federal funds rate just hours after (and in response to) the Bureau of Labor Statistics' employment report release. As a result, event-study regressions using daily data in part capture the endogenous response of asset prices and monetary policy to the information that was released earlier in the day, as well as noise from other financial market developments that took place throughout the day.

We address this potential problem by estimating regression (2.1) using intraday data to measure both the funds rate surprise Δx_t and the change in the asset price Δy_t. By measuring these changes in a sufficiently narrow window of time around the monetary policy announcement, we can be sure that the FOMC decision was in no way influenced by asset price movements or other macroeconomic news over that interval. In addition, by shrinking the event-study window down to an hour or less, it becomes much less likely that any other significant events took place within

[4] Asset prices can respond to macroeconomic news for many reasons other than changes in monetary policy expectations: First, information about economic output is likely to influence expectations of corporate earnings and dividends, hence stock prices; second, information about the government budget or current account deficit would, assuming home bias in savings and imperfect Ricardian equivalence, affect bond yields; third, investors' appetite for risk can change in response to economic developments, to name a few examples.

[5] One way to partially account for these issues is to estimate a VAR for the asset price, the policy instrument, and other relevant macroeconomic variables, as in Leeper, Sims, and Zha (1996) and Evans and Marshall (1998). The problem with this approach is that the recursive identifying restrictions typically employed are not plausible for fast-moving financial market variables. (Two exceptions to this rule are the heteroskedasticity-based identification procedure used by Rigobon and Sack (2002, 2003) and the high-frequency identification procedure used by Cochrane and Piazzesi (2002) and Faust, Swanson, and Wright (2004a).)

this narrow window that might have influenced asset prices, thereby increasing the precision of our estimates.

2.2 Dates and Times of Monetary Policy Announcements

To perform the above analysis using intraday data, we first put together a complete list of dates and times of monetary policy announcements from January 1990 through May 2004. In February 1994, the FOMC began issuing a press release after every meeting and every change in policy, and thus the announcement dates and times are simply those of the corresponding press releases.[6] Prior to 1994, the FOMC did not explicitly announce changes in its target for the federal funds rate, but such changes were implicitly communicated to financial markets through the size and type of open market operation. Thus, prior to 1994, the date and time of a monetary policy announcement are typically those of the next open market operation following the FOMC decision.[7]

The dates, times, and methods of communication of FOMC monetary policy announcements are reported in Table A1 of Appendix A. Note that this listing includes not just dates on which the FOMC actually changed the federal funds rate, but also dates on which there was an FOMC meeting followed by no change in policy, since in some cases the FOMC's decision not to change policy surprised financial markets and led to movements in asset prices. The rightmost column of Table A1 reports all other major macroeconomic data releases that took place on each date, before the monetary policy announcement. From the table, we can see that eight monetary policy announcements occurred on the date of an employment report release, seven

[6] Since 1995, these press releases have occurred at about 2:15pm after regularly scheduled FOMC meetings; press releases for intermeeting policy moves and FOMC decisions in 1994 were released at varying times throughout the day. We obtained all of these dates and times from the Office of the Secretary of the Federal Reserve Board.

[7] On a few occasions between 1990 and 1994, the FOMC issued, prior to the open market operation, a press release announcing a change in the *discount* rate offered to depository institutions, and market participants correctly inferred from the press release a corresponding change in the federal funds rate as well. On those occasions, we set the time of the monetary policy announcement to the time of the discount rate change press release. Open market operations over this period were conducted at 11:30am every day. There are a few dates on which volatility in the federal funds market prevented the Open Market Desk from successfully communicating the FOMC's intentions for the funds rate the first morning after the FOMC's decision—see Kuttner (2003). On these dates, we regard the announcement as having taken place on whichever morning the Credit Markets column of the Wall Street Journal regarded as a clear signal of the Fed's intentions, as reported by Kuttner (2003). This is more of an issue prior to 1990 than for our sample period in this paper.

announcements occurred on the date of a GDP release, nine occurred on the date of a CPI release, and five on the date of a PPI release, to name just a few.

2.3 The Surprise Component of Federal Funds Rate Changes

For each monetary policy announcement, we measure the surprise component of the change in the federal funds rate target using federal funds futures. We use the surprise component of monetary policy announcements in estimating regression (2.1) because changes in policy that are expected by financial markets should have little or no effect on asset prices, a hypothesis that is confirmed by Kuttner (2001). Thus, using the raw changes in the federal funds rate target as the right-hand side variable Δx_t would impart an errors-in-variables bias to our estimates of β to the extent that the monetary policy decisions were correctly anticipated by financial markets.

Federal funds futures have traded on the Chicago Board of Trade exchange since October 1988 and settle based on the average effective federal funds rate that is realized for the calendar month specified in the contract. Thus, daily changes in the current-month futures rate largely reflect revisions to the market's expectations for the federal funds rate over the remainder of the month. As described in Appendix B, the change in the current month's contract rate on the day of an FOMC announcement can be scaled up to account for the timing of the announcement within the month, and thereby measure the surprise component of the FOMC's announcement for the federal funds rate. For the present paper, we acquired tick-by-tick data on all federal funds futures contract trades from January 1990 to the present from Genesis Financial Technologies. To provide a sense of the quality of this data and its advantages, Figure 1 graphs the data on three illustrative dates:

1. June 25, 2003, was the date of a regularly scheduled FOMC meeting. Trades were intermittent throughout the day until just before and just after the FOMC's press release at 2:15pm. At that time, the FOMC announced that it was lowering its target for the federal funds rate from 1.25% to 1%. According to surveys and press reports both before and after the policy announcement, many market participants had been expecting the FOMC to ease policy by 50 bp at the meeting. Thus, this decision is characterized as a 13 bp tightening under our measure.

This example illustrates two key points: First, financial markets seem to fully assimilate all information contained in the monetary policy announcement within just a few minutes—i.e., there is no evidence of learning or sluggish adjustment going on after about 2:20pm in this example. Second, the federal funds rate surprise is not necessarily in the same direction as the federal funds rate action itself.

2. April 9, 1992, was the date of an intermeeting monetary policy move. The FOMC reduced its target for the federal funds rate from 4% to 3.75% that morning, but given that this date precedes 1994, the FOMC did not issue a press release about its change in policy to the public. As can be seen in the figure, trading in federal funds futures was thin until shortly before the open market operation at 11:30am. At that time, the Open Market Desk injected a significant quantity of reserves into the market, and market participants correctly inferred from this that the FOMC had changed its target for the funds rate, causing the futures rate to move quickly to the new target rate.[8]

3. September 4, 1992, witnessed the release of a very weak employment report at 8:30am. In response to that report, investors significantly revised downward their expectations for the federal funds rate, pushing the futures rate down sharply. Sometime after the poor data release, the FOMC decided to reduce its target for the federal funds rate from 3.25% to 3%. Again, because there was no press release, the FOMC's decision became known to the markets at 11:30am, the time of the open market operation. In contrast to the middle panel, however, the FOMC's decision for the funds rate on this date was essentially completely anticipated by the time it was signaled to the market—indeed, our intraday measure of the funds rate surprise (reported in Table A2, below) is 0 bp. By contrast, the daily measure of the funds rate surprise is −22 bp, because it incorporates the *endogenous* policy response to the weak employment report. In this case, we would not want to use the daily measure of the funds rate surprise in an event-study regression, because it would suffer from the omitted variables problem discussed earlier (in that the employment report itself has sizable effects on stock prices, bond yields, and monetary policy expectations).

[8] The federal funds futures contract rate falls to 3.85% after the announcement rather than the new funds rate target of 3.75% because nine days of the month have already elapsed with an average federal funds rate of 4%, which will result in a month-average funds rate for April of 3.85%.

To focus in on the monetary policy decision itself, we compute policy surprises by looking at changes in the futures rate in narrow windows around the FOMC announcements. More specifically, Table A2 in Appendix A reports two intraday measures, a "tight" window and a "wide" window, which begin 10 (15) minutes prior to the monetary policy announcement and end 20 (45) minutes after the policy announcement, respectively, for the period from January 1990 through May 2004.[9] For comparison, Table A2 also reports a "daily" window that begins with the financial market close the day before the policy announcement and ends with the financial market close the day of the policy announcement. On most of the days in our sample, the two intraday measures are quite similar to the daily measure: the average absolute difference between the daily and two intraday surprise measures is only about two basis points, and the difference is zero on many days. There are a few days, however, on which the differences between the intraday measures and the daily measure are quite large: for example, there are five observations for which the discrepancy between the tight shock and the daily shock exceeds 10 bp. Each of those observations took place before 1994 on the day of an employment report release, as in the example of September 4, 1992, discussed previously. Figure 2 makes this point graphically: as can be seen in the top panel, the tight window and daily window surprises are in very close agreement on all but a handful of dates, almost all of which correspond to days on which the FOMC was responding to an employment report release. By contrast, in the bottom panel of the figure, we see that the two intraday measures are in very close agreement on all dates in our sample.

We draw two conclusions from these observations. First, the FOMC decision accounted for the vast majority of the movement in the federal funds futures rate on all of the non-employment-report days in our sample. This is perhaps surprising, given the large number of other data releases that also coincided with monetary policy announcements in Table A1, and is in itself is an important finding: it shows that for samples that exclude employment report dates, or samples that begin in 1994, the surprise component of monetary policy announcements can be measured

[9] When there is no federal funds futures trade exactly at the beginning of the specified window, we use the most recent price. When there is no trade exactly at the end of the specified window, we use the next available trade price. Federal funds futures trading is often sparse early in our sample period, but becomes significantly more dense around the times of macroeconomic data releases and monetary policy announcements.

very well using just daily data. Second, FOMC decisions were priced into the federal funds futures market almost immediately—quickly enough to be completely captured by our tight, 30-minute window—consistent with the examples of June 25, 2003, and April 9, 1992, discussed above. Thus, we can feel comfortable focusing on the analysis using our tight window of 30 minutes, although we will report results using the wider one-hour window as well.

2.4 The Effect of Federal Funds Rate Changes on Asset Prices

Table 1 presents our results for regression equation (2.1) estimated using intraday data on bond yields and stock prices.[10] The independent variable is the surprise component of the change in the federal funds rate target just described, and the dependent variable is the change in the financial variable measured over the same window. We present results for the tight (30-minute), wide (one-hour), and daily windows described above.

Our results for stock prices imply that, on average, a surprise 25 bp tightening in the federal funds rate leads to a little more than 1% fall in the S&P 500, and these estimates are highly significant. The estimated coefficients do not differ greatly across the intraday and daily regressions, although the effects of the omitted employment report variable can be seen clearly in the scatter plots in Figure 3: the handful of days on which the policy decision followed an employment report, shown by the hollow points, do not appear unusual when the intraday data are used, but in the daily data they stand out as large policy easings that yielded no gains in equity prices, most likely due to the negative direct influence of the weak employment reports. The most striking feature of Figure 3, however, is the increase in tightness of the relationship as we move from daily to intraday data. By eliminating the effects of employment reports and other news that occurred on the days of monetary policy announcements, the relationship between monetary policy actions and equity prices becomes much clearer in the figure. This advantage also stands out in the regression results in Table 1, in terms of the much greater precision of the coefficient estimates and a tripling of the R^2 from .12 to .35.

[10] We obtained tick-by-tick Treasury yield data back to June 1991 for on-the-run Treasury securities from GovPX, a consortium of interdealer brokers that accounted for a large portion of trading volume in Treasury securities over our sample. For equity prices, we obtained five-minute intraday quotes on the S&P 500 index back to the mid-1980s, which are available from a variety of sources.

Intraday data yield additional benefits for our Treasury yield regressions. As shown in Figure 4, employment report days (the hollow points) stand out in the daily data as very large funds rate surprises and large changes in the three-month T-bill rate in the same direction, reflecting the fact that the employment report has a very large influence on both the FOMC decision and the short end of the Treasury yield curve.[11] By contrast, those days do not stand out at all when the intraday windows are used. Moreover, employment reports appear to have a larger effect on the T-bill rate relative to the measured policy surprise than do actual policy announcements. Because of this, the estimated coefficient in the regression is biased upward if daily data are used. As with equity prices, the response of the T-bill rate to monetary policy actions is also estimated much more precisely using intraday data, reflected in the much smaller standard errors (about half the size of the daily measures) and the much higher R^2 (.80 vs. .56).

The differences in the coefficients between the intraday regressions and the daily regression become much smaller at horizons of two years or more, but this observation is somewhat misleading, as a single outlier, January 3, 2001, pulls the daily estimate towards the intraday one (shown in Figure 5).[12] Without that one observation, the daily regression would estimate a response of the ten-year rate to the FOMC announcement of 0.30 rather than the statistically insignificant 0.17 that is estimated including the outlier. By contrast, using the intraday data, the estimated coefficient changes only very slightly (from 0.13 to 0.16) when we exclude that observation. As before, the precision of our estimates also improves dramatically using intraday data, with the standard errors being about half as large. This makes the response of the ten-year Treasury yield—which is statistically indistinguishable from zero using daily data—significantly greater than zero (albeit small) using our tight-window data.

The response of the term structure can also be expressed in terms of forward rates. We compute the five-year forward Treasury rate beginning five years ahead from five- and ten-year Treasury yields using the Campbell-Shiller-Schoenholtz (1983) approximation. The estimated response of

[11] Recall that our intraday Treasury data extend back only to June 1991, so our Treasury yield regressions and graphs contain 18 fewer observations (and only five employment report dates instead of eight).

[12] On that day, although the FOMC unexpectedly eased policy, which would normally be associated with a fall in Treasury yields, market participants reportedly became much more optimistic about the economic outlook as a result, leading to a huge rally in equity markets (including an astounding 14 percent rise in the Nasdaq that afternoon) and an *upward* shift in Treasury yields. This response appears as a very large outlier in the daily data.

the forward rate to the policy surprise is negative over this sample, consistent with the findings of Gürkaynak, Sack, and Swanson (2003) (GSS) that long-horizon forward rates typically move in the direction opposite that of the monetary policy surprise. However, our estimates here are statistically insignificant, likely because we cannot compute a forward rate that starts sufficiently far ahead.[13] (GSS present their finding in terms of the nine-year-ahead one-year forward rate.)

3. The Effects of FOMC Statements on Asset Prices

3.1 Testing for Additional Dimensions of Monetary Policy Announcements

The preceding section assumed that the effects of FOMC announcements on asset prices are adequately described by a single factor, namely the surprise component of the change in the federal funds rate target. Although this assumption is standard in the literature, it is not clear that one degree of freedom is sufficient. For example, many FOMC announcements in recent years (such as the example of January 28, 2004, given in the Introduction) have involved little or no surprise in the current funds rate target, yet changes in the wording of FOMC announcements about the outlook for policy and the economy seemed to have very significant effects on financial markets. Might it be the case, then, that this observation holds more generally—i.e., that there are additional dimensions to the effects of monetary policy on asset prices beyond the FOMC's decision for the current federal funds rate target?

We investigate this question using a factor analysis. In particular, let X denote a T x n matrix with rows corresponding to monetary policy announcements and columns corresponding to the asset prices included. Each element of X reports the change in the corresponding asset price in a 30-minute window of time around the corresponding FOMC announcement. We wish to know to what extent the matrix X can be represented in the form:

$$X = F\Lambda + \eta \tag{3.1}$$

[13] Unfortunately, intraday data are only available for the five- and ten-year Treasury notes, which gives us the forward rate over a five-year span. This longer forward rate may not capture movements in long-horizon forward rates as well as the nine-year-ahead one-year rate.

where F is a $T \times m$ matrix of unobserved factors (with $m<n$), Λ is a matrix of factor loadings, and η is a $T \times n$ matrix of white noise disturbances. The hypothesis that a single factor (the surprise component of changes in the federal funds rate, say) adequately describes X is a statement that there exists a $T \times 1$ vector F and constants λ_i, $i=1,...,n$, such that the matrix X is described by $F \times [\lambda_1,...,\lambda_n]$ up to white noise.

This restriction on the structure of the data X can be tested using the matrix rank test of Cragg and Donald (1997). In brief, the null hypothesis that X is described by m_0 common factors can be tested against the alternative that X is described by $m > m_0$ factors by measuring the minimum distance between Cov(X) and the covariance matrices of all possible factor models (3.1) with m_0 factors. This distance, after a suitable normalization, has a limiting χ^2 distribution with $(n-m_0) \times (n-m_0+1)/2 - n$ degrees of freedom.

We test how many factors are required to explain movements around FOMC announcements in federal funds futures and eurodollar futures contracts with one year or less to expiration.[14] We focus on these short-maturity instruments in particular (rather than the whole yield curve and the stock market) because these instruments have been found to be the most tightly linked to financial market expectations about the stance of monetary policy over the upcoming year.[15] By restricting attention to these instruments, then, we are focusing as tightly as possible on the effects of monetary policy announcements on asset prices that operate through changes in the expected path of the federal funds rate over the upcoming year.

Results of this test are reported in Table 2. The hypothesis of zero or one common factor is clearly rejected at standard significance levels. The hypothesis that X is described by 2 factors is

[14] We use five contracts that characterize the expected path of the federal funds rate over the next year: the current-month and three-month-ahead federal funds futures contracts and the two-, three-, and four-quarter-ahead eurodollar futures contracts. Details are provided in Appendix B. Results are very similar if we use all federal funds futures and eurodollar futures contracts with one year or less to expiration, but many of these contracts overlap. The five contracts above parsimoniously characterize the expected path of policy.

[15] Gürkaynak, Sack, and Swanson (2002) show that these rates are the best financial market predictors of the federal funds rate at horizons out to a year, suggesting that changes in these rates are driven to a large extent by changes in policy expectations. Piazzesi and Swanson (2004) find evidence of time-varying risk premia in federal funds futures and eurodollar futures; we follow their recommendation and look at changes in these rates on the days of (in fact, within the days of) FOMC announcements, which has the advantage of differencing out risk premia that vary only slowly, such as at business cycle frequencies.

not rejected at even the 10% level. We conclude that monetary policy announcements are characterized by two dimensions rather than one.[16]

We estimate the unobserved factor matrix [F_1, F_2] by principal components, as is commonly done in the literature.[17] This procedure decomposes the matrix X into a set of orthogonal vectors F_i, $i = 1,..., n$, where F_1 is the (length-T) vector that has maximum explanatory power for X, F_2 is the vector that has maximum explanatory power for the residuals of X after projecting each column on F_1, and so on (details are provided in Appendix B). We restrict attention in what follows to the first two factors (F_1 and F_2) estimated by this procedure, as was suggested by our rank test above and which together explain about 95% of the variation in X.

3.2 A Structural Interpretation of the Two Factors

The two factors F_1 and F_2 explain a maximal fraction of the variance of X, but do not have a structural interpretation. For example, both factors are correlated with the surprises in the current federal funds rate target, so we cannot interpret one factor as the change in the federal funds rate target and the other factor as some other dimension of monetary policy. To address this deficiency and allow for a more structural interpretation of the factors, we perform a rotation of F_1 and F_2 to yield two new factors, called Z_1 and Z_2, which are still orthogonal and explain the matrix X to exactly the same extent that F_1 and F_2 did, but for which the second factor (Z_2) has no effect on the current federal funds rate. In other words, we define

$$Z = F\,U$$

in such a way that U is a 2x2 orthogonal matrix and the second column of Z is a vector that is associated on average with *no change in the current-month federal funds futures rate*. As a result of this transformation, we can regard the unexpected change in the current target for the federal funds rate as being driven exclusively by Z_1 (plus a small amount of white noise), and we can interpret Z_2 as all other aspects of the FOMC announcement that moved near-term interest rates *without* changing the current federal funds rate. The factor Z_2 therefore includes any

[16] We can also apply this rank test to the changes in all of our Treasury yields and stock prices around monetary policy announcements and we get very similar results. In particular, we clearly reject zero or one factors but do not reject that two factors are sufficient.

[17] The primary alternative would be Kalman filtering, which would be optimal under the assumption of normally-distributed residuals. However, that assumption does not appear to be well-satisfied by our data.

information (besides the decision for the current target rate) that affects the expected path for monetary policy. Accordingly, we refer to Z_1 and Z_2 as the "target" factor and the "path" factor, respectively. The estimated values for the target and path factors for each monetary policy announcement in our sample are reported in Table A3 of Appendix A.

Note that that the target factor (Z_1) defined in this way should be similar—though not exactly equal—to the measure of federal funds target surprises that we presented in the previous section and reported in Table A2. To check the tightness of the relationship between these two measures, we regressed (results not reported) our target surprises from Table A2 on the factor Z_1 and found that Z_1 is in fact very close to our previous measure, with an R^2 of .91 and a correlation of over 95%. Thus, to enhance the interpretation of Z_1 as surprise changes in the federal funds rate target, we normalize its scale so that a change of .01 in Z_1 corresponds to a surprise of 1 bp in the federal funds target rate. To aid in interpreting the second factor, we normalize its scale so that the effect of Z_2 on the four-quarter-ahead eurodollar futures rate is exactly the same as the effect of Z_1 on the four-quarter-ahead eurodollar futures rate, about 53 bp.[18]

Figure 6 plots the two factors over time, where dates on which there was an FOMC statement are plotted as solid bars and those on which there was no FOMC statement (dates prior to 1994 and dates from 1994 to 1999 on which there was no change in the federal funds rate target) are plotted as hollow bars. As can be seen in the figure, there have been many large realizations of the path factor in recent years, while realizations of the path factor prior to 1994 (and on non-statement days in general) were typically very small. This observation is all the more remarkable in light of the fact that monetary policy surprises as conventionally measured (the target factor) are as big or bigger in the early part of our sample as those that have taken place more recently.

In Table 3, we verify this observation econometrically by regressing the absolute value of the path factor on a constant and a dummy variable for all dates on which there was an FOMC statement. The coefficient on the dummy variable is positive and highly statistically significant,

[18] These normalizations are for the July 1991-May 2004 sample, the period for which we have the bond markets data. As the two factors are constructed to be orthogonal over the full (January 1990-May 2004) sample, there is a minor correlation between them in to regression results presented below.

indicating a strong association between FOMC statements and the path factor. This can also be seen in Table 4, which gives the dates of the ten largest observations of the path factor over our sample and shows that eight of these ten observations (and 22 of the top 25) correspond to dates on which an FOMC statement accompanied the federal funds rate target decision; moreover, financial market commentary on these dates (as reported in the Credit Markets column of the Wall Street Journal the following day) often directly attribute the move in the bond market on those dates to specifics of the FOMC statement. Nonetheless, there are a few exceptions to the correspondence between the path factor and FOMC statements, with December 20, 1994, being the most significant. On that date, market participants were reportedly nervous about inflationary pressures arising from output growth overshooting potential (the subject of a speech by Vice Chairman Blinder just a few days before), and the failure of the FOMC to move at the December meeting was regarded by some participants as perhaps requiring greater tightening down the road (Pesek and Young (1994)).

Our finding of the importance of policy statements in moving near-term interest rates is in line with the results of Kohn and Sack (2002). That paper used a simple regression to control for the effects of target surprises, with the residual then capturing the influence of all other variables, including policy statements. They found that the variance of this residual was much higher on days that the FOMC released statements—a finding that closely corresponds to the results presented in Table 3. However, by using intraday data and performing a factor analysis, we are able to *quantify* the second factor and to make stronger statements about its importance for the response of asset prices to monetary policy announcements.

It is important to emphasize that we do not regard Z_2, and FOMC statements more generally, as a policy tool that is independent from the federal funds rate target. Instead, Z_2 should be thought of as containing information relevant to the future path of Z_1.

One interesting feature of the path factor is that—in contrast to the target factor—there is evidence that financial markets may take some time to digest its implications. For example, if we regress a "wide" (one-hour) window measure of the path factor Z_2 on the "tight" (30-minute) window measure of the factor (both calculated as above), we get an R^2 of about .83. By contrast,

if we perform the same exercise on the target surprise factor Z_1, we get a much higher R^2 of .98 (which is consistent with Figures 1 and 2). A natural interpretation of this finding is that changes in the federal funds rate target itself are immediately and clearly observable to all financial market participants within minutes of the announcement while, by contrast, FOMC statements about the policy and economic outlook typically require time to digest and are subject to a great deal of uncertainty with respect to how they are interpreted by other financial market participants, so that the process of assimilating the information contained in the statements is not instantaneous. Nonetheless, we continue to emphasize our "tight" window responses in the analysis below because most of the policy information is incorporated within that window and having a narrower window reduces the amount of noise in our left-hand-side variables, increasing the precision of our estimates.

3.3 The Response of Asset Prices to the "Target Factor" and "Path Factor"

We now investigate the effects of each of these two dimensions of the monetary policy announcement on asset prices. For each monetary policy announcement from January 1990 through May 2004, we have estimates of the target factor and path factor components of the announcement. As in section 2, we also have data on the change in a variety of asset prices in a narrow window bracketing the monetary policy announcement. We regress these asset price changes on the two factors to measure their effects on the asset in question:

$$\Delta y_t = \alpha + \beta Z_{1,t} + \gamma Z_{2,t} + \varepsilon_t \qquad (3.1)$$

Results are presented in Table 5. As we would expect from the very close correspondence between our target factor and the federal funds rate target surprise in section 2 (and from the orthogonality of Z_2 to Z_1), the estimated coefficients on the target factor (Z_1) are very similar to those we estimated previously in Table 1. In particular, we estimate that a 1 percentage point surprise tightening in the federal funds rate would, in the absence of any surprises in the accompanying FOMC statement, lead to a decline of 4.3% in the S&P500, and increases of 47, 27, and 12 bp in two-, five-, and ten-year Treasury yields, respectively.

The novel feature of Table 5, however, is our estimates of the effects of the path factor (Z_2) on asset prices. As can be seen in the table, the effect of this factor on the one-year-ahead eurodollar future rate is the same as the effect of the target factor, by definition.[19] However, the path factor has effects on the other financial variables that differ considerably from the target factor. In particular, the path factor has a much greater impact on the long end of the yield curve, with a 1 percentage point innovation to the factor causing responses of 36 and 27 bp in five- and ten-year Treasury yields, respectively. Thus, FOMC statements that move year-ahead policy expectations appear to have much greater effects on the long end of the yield curve than do changes in the federal funds target rate itself, *even when they generate the same size movement in one-year-ahead interest rates.* Moreover, as can be seen by comparing the R^2 statistics from the one-factor and two-factor regressions, the path factor explains *three to ten times* as much of the variation in intermediate- and long-term Treasury yields as do changes in the federal funds rate target around FOMC announcements. Thus, by focusing only on changes in the federal funds rate target, previous studies have been omitting by far the most important component of monetary policy decisions, especially in recent years when target funds rate changes have often been fully anticipated.

By contrast, the effect of changes in the path factor on the stock market appears to be smaller than the effect of changes in the funds rate target, amounting to only about -1% for a 1 percentage point innovation.[20] Given the yield curve findings above, this result is somewhat surprising: for longer-maturity Treasury securities, policymakers' statements seem to have much larger effects than changes in the current federal funds rate, but the effect of statements on stock prices, which also have very long durations, is smaller.

[19] The path factor is orthogonal to the monetary policy surprise (and the target factor) over our full sample, January 1990-May 2004. The coefficient of the MP Surprise on the path factor reported in the table is not exactly zero because we are running this regression over a shorter sample, July 1991-May 2004.

[20] If we omit January 3, 2001 (which was the date of a large positive path factor surprise and a very large rally in equity markets), our coefficient estimate on Z_2 changes only moderately to -1.5%, but does become statistically significant at the 10% level. Omitting January 3 changes the response to Z_1 virtually not at all, as discussed in the previous section. Also, restricting our stock market regression sample to start in July 1991 (the same as for our bond yield regressions) hardly changes our estimated coefficients. Thus, the observation that changes in the path factor have a much smaller effect on stock prices than changes in the target factor is a robust feature of the data.

One possible explanation for this finding is that FOMC statements convey information not just about the future course of monetary policy, but also about the intermediate-term outlook for economic activity. A large positive realization of the path factor, for example, might be related to a statement suggesting that the FOMC sees greater output or inflation going forward than markets had been expecting. Gürkaynak, Sack, and Swanson (2003) show that long-term yields move substantially and positively in response to positive surprises in macroeconomic data releases for output and inflation; thus, if in fact FOMC statements do reveal information about the future course of these variables, the strong response of long-term yields to the path factor in this paper would be completely consistent with those earlier results. Moreover, to the extent that financial markets revise upward their forecasts of output (and hence earnings and dividends) in response to positive path factor surprises, then the tendency for stocks to fall in response would be muted by the upwardly-revised economic outlook.

4. Conclusions

Do central bank actions speak louder than words? We find that the answer to this question is a qualified "No." In particular, we find that viewing the effects of FOMC announcements on financial markets as driven by a single factor—changes in the federal funds rate target—is inadequate. Instead, we find that a second policy factor—one not associated with the current federal funds rate decision of the FOMC but instead with statements that it releases—accounted for more than three-fourths of the explainable variation in the movements of five- and ten-year Treasury yields around FOMC meetings.

We emphasize that our findings do not imply that FOMC statements represent in any way an *independent* policy tool. In particular, FOMC statements likely exert their effects on financial markets through their influence on financial market expectations of *future* policy actions. Viewed in this light, our results do not indicate that policy actions are secondary so much as that their influence comes earlier—when investors build in expectations of those actions in response to FOMC statements (and perhaps other events, such as speeches and testimony by FOMC members).

This finding has important implications for the literature on the effects of monetary policy on asset markets or the economy more broadly. In particular, we find that previous studies estimating the effects of changes in the federal funds rate on bond yields and stock prices have been missing most of the story. This is especially true in recent years, when FOMC decisions regarding the target for the federal funds rate have rarely been a surprise and instead changes in the wording of FOMC statements typically have been the major driver of financial market responses.

References

Bernanke, Ben and Kenneth Kuttner (2004). "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *Journal of Finance*, forthcoming.

Cochrane, John and Monika Piazzesi (2002), "The Fed and Interest Rates: A High Frequency Identification," *American Economic Review Papers and Proceedings* 92, 90-101.

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

Cragg, John G. and Stephen G. Donald (1997). "Inferring the Rank of a Matrix," *Journal of Econometrics* 76, 223-50.

Ellingsen, Tore and Ulf Soderstrom (2003). "Monetary Policy and the Bond Market", unpublished manuscript, Bocconi University.

Evans, Charles and David Marshall (1998). " Monetary Policy and the Term Structure of Nominal Interest Rates: Evidence and Theory," *Carnegie-Rochester Conference Series on Public Policy* 49, 53-111.

Faust, Jon, Eric Swanson, and Jonathan Wright (2004a). "Identifying VARs Based on High-Frequency Futures Data," *Journal of Monetary Economics*, forthcoming.

Faust, Jon, Eric Swanson, and Jonathan Wright (2004b). "Do Federal Reserve Policy Surprises Reveal Superior Information About the Economy?" unpublished manuscript Federal Reserve Board.

Gürkaynak, Refet (2004). "Using Federal Funds Futures Contracts for Monetary Policy Analysis," working paper, Federal Reserve Board.

Gürkaynak, Refet, Brian Sack, and Eric Swanson (2002). "Market-Based Measures of Monetary Policy Expectations," Federal Reserve Board Finance and Economics Discussion Series 2002-40.

Gürkaynak, Refet, Brian Sack, and Eric Swanson (2003). "The Excess Sensitivity of Long-Term Interest Rates: Evidence and Implications for Macroeconomic Models," Federal Reserve Board Finance and Economics Discussion Series 2003-50.

Ip, Greg (2004). "Fed Clears Way For Future Rise In Interest Rates," *The Wall Street Journal*, January 29, 2004, A1.

Kohn, Donald and Brian Sack (2004), "Central Bank Talk: Does It Matter and Why?" forthcoming in *Macroeconomics, Monetary Policy, and Financial Stability* (Ottawa: Bank of Canada).

Krueger, Joel T. and Kenneth N. Kuttner (1996), "The Fed Funds Futures Rate as a Predictor of Federal Reserve Policy," *Journal of Futures Markets* 16, 865-879.

Kuttner, Kenneth (2001), "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market," *Journal of Monetary Economics*, 523-544.

Kuttner, Kenneth (2003). "The Revelation of Funds Rate Changes, 1989-92: What Did the Markets Know and When Did They Know It?" unpublished manuscript, Oberlin College.

Leeper, Eric, Christopher Sims, and Tao Zha (1996). "What Does Monetary Policy Do?" *Brookings Papers on Economic Activity* 2, 1-63.

Pesek, William and Lauren Young (1994). "Bond Prices Finish Little Changed After Fed Decides to Keep Rates at Their Current Levels," *The Wall Street Journal*, December 21, C22.

Piazzesi, Monika and Eric Swanson (2004). "Futures Rates as Risk-Adjusted Forecasts of Monetary Policy," *NBER Working Paper 10547*.

Rigobon, Roberto and Brian Sack (2002), "The Impact of Monetary Policy on Asset Prices," *NBER Working Paper 8794.*

Rigobon, Roberto and Brian Sack (2003). "Measuring the Reaction of Monetary Policy to the Stock Market," *Quarterly Journal of Economics* 118, 639-669.

Romer, Christina and David Romer (2000). "Federal Reserve Information and the Behavior of Interest Rates," *American Economic Review* 90, 429-57..

Rudebusch, Glenn (1998), "Do Measures of Monetary Policy in a VAR Make Sense?," *International Economic Review* 39, 907-931.

Shiller, Robert, John Campbell, and Kermit Schoenholtz (1983), "Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates," *Brookings Papers on Economic Activity* 1, 173-217.

Table 1: Response of Asset Prices to Changes in the Federal Funds Rate

	Tight Window			Wide Window			Daily		
	Constant (std err)	*MP Surprise (std err)*	R^2	*Constant (std err)*	*MP Surprise (std err)*	R^2	*Constant (std err)*	*MP Surprise (std err)*	R^2
S&P500	-0.099*** (0.035)	-4.040*** (1.102)	.35	-0.072 (0.043)	-4.560*** (1.063)	.36	0.154* (0.092)	-4.033*** (1.552)	.12
3-Month Bill	-0.005** (0.002)	0.538*** (0.040)	.80	-0.007** (0.003)	0.584*** (0.038)	.77	-0.003 (0.005)	0.669*** (0.086)	.56
6-Month Bill	-0.005 (0.003)	0.522*** (0.057)	.63	-0.007* (0.003)	0.569*** (0.053)	.65	-0.008 (0.005)	0.627*** (0.083)	.54
2-Year Note	-0.002 (0.005)	0.454*** (0.087)	.39	-0.001 (0.006)	0.474*** (0.091)	.32	-0.006 (0.007)	0.424*** (0.116)	.23
5-Year Note	0.000 (0.004)	0.263*** (0.080)	.18	0.001 (0.006)	0.267*** (0.099)	.13	-0.007 (0.007)	0.314** (0.141)	.12
10-Year Note	-0.001 (0.004)	0.125** (0.058)	.07	0.001 (0.005)	0.129 (0.079)	.04	-0.006 (0.006)	0.166 (0.124)	.04
5-Year Forward Rate 5 Years Ahead	-0.002 (0.003)	-0.067 (0.049)	.02	0.001 (0.004)	-0.060 (0.061)	.01	-0.005 (0.006)	-0.038 (0.113)	.00

Note: Sample is all monetary policy announcements from Jan 1990 through May 2004 (July 1991 through May 2004 for Treasury yields), resulting in 133 observations (115 for Treasury yields). MP Surprise denotes surprise component of change in the federal funds rate. Tight Window is 30 minutes long, Wide Window is 1 hour long, and Daily Window is 1 day long. Heteroskedasticity-consistent standard errors reported in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively. See text for details.

Table 2: Tests of Number of Factors Characterizing Monetary Policy Announcements

H_0: Number of Factors	Wald Statistic	χ^2 Degrees of Freedom	*p*-value	Number of Obs.
0	35.19	10	.0001	133
1	15.45	5	.009	133
2	2.11	1	.146	133

Note. Test is from Cragg and Donald (1997) and tests the null hypothesis of N_{H0} factors against the alternative of $N>N_{H0}$ factors.

Table 3: Estimated Effects of Policy Satements on the Size of the Path Factor

Dependent Variable	Constant *(std. err.)*	Statement *(std. err.)*	R^2	Number of Obs.
$Abs(Z_2)$	0.046^{***}	0.078^{***}	.20	133
	(0.006)	(0.015)		

Note. Heteroskedasticity-consistent standard errors reported in parentheses. *** denotes significance at 1%.

Table 4: Ten Largest Observations of the Path Factor

Date	Z_1 (Target Factor)	Z_2 (Path Factor)	Statement	Financial Market Commentary
Jan. 28, 2004	-1.5	43.8	✓	Statement drops commitment to keep policy unchanged for "a considerable period," bringing forward expectations of future tightenings
Jul. 6, 1995	-7.9	-40.5	✓	First easing after long (17-month) series of tightenings raises expectations of further easings; statement notes that inflationary pressures have receded
Aug. 13, 2002	8.8	-38.5	✓	Statement announces balance of risks has shifted from neutral to economic weakness
May 18, 1999	0.0	34.2	✓	Statement announces change in policy bias going forward from neutral to tightening
May 6, 2003	5.8	-28.3	✓	Statement announces balance of risks now dominated by risk of "an unwelcome substantial fall in inflation"
Dec. 20, 1994	-16.0	28.2		Surprise that FOMC not tightening considering recent comments by Blinder on "overshooting"; some fear Fed may have to tighten more in 1995 as a result
Oct. 5, 1999	-3.1	26.8	✓	Statement announces change in policy bias going forward from neutral to tightening
Oct. 28, 2003	4.3	-25.2	✓	Statement leaves the "considerable period" commitment unchanged, pushing back expectations of future tightenings
Oct. 15, 1998	-23.5	-24.7	✓	First intermeeting move since 1994 and statement pointing to "unsettled conditions in financial markets... restraining aggregate demand" increases expectations of further easings
Apr. 9, 1992	-18.8	-23.9		Intermeeting policy easing; first interest rate move since 1991

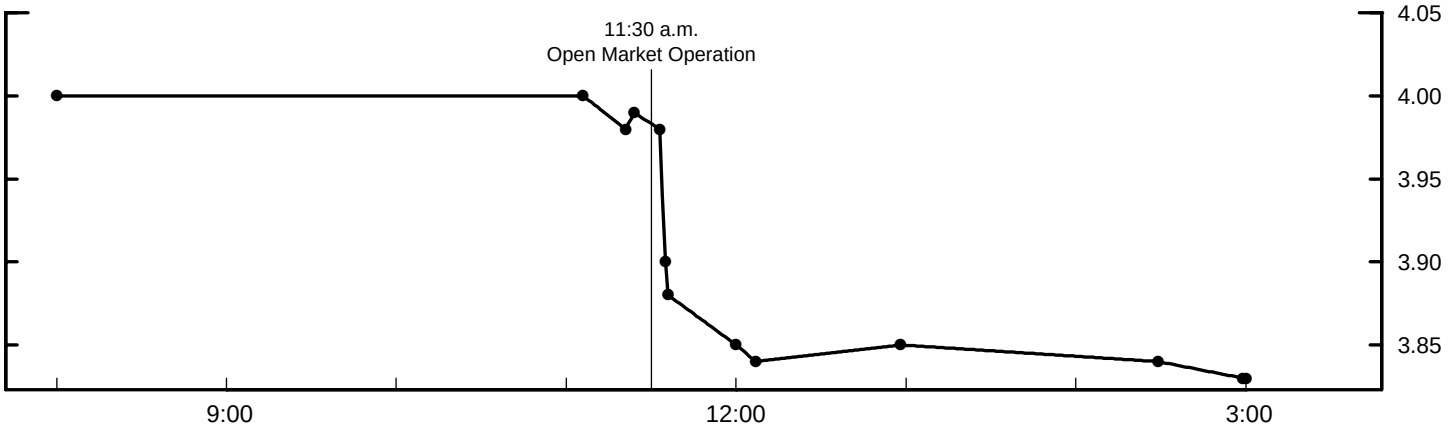
Table 5: Response of Asset Prices to Target and Path Factors

	One Factor			Two Factors			
	Constant (std err)	*Target Factor (std err)*	R^2	*Constant (std err)*	*Target Factor (std err)*	*Path Factor (std err)*	R^2
MP Surprise	-0.021*** (0.002)	1.000*** (0.043)	.92	-0.021*** (0.002)	1.000*** (0.044)	0.011 (0.024)	.93
1-Year-Ahead Eurodollar Future	-0.018*** (0.006)	0.534*** (0.078)	.34	-0.018*** (0.001)	0.535*** (0.018)	0.534*** (0.015)	.98
S&P 500	-0.008 (0.042)	-4.261*** (1.112)	.36	-0.008 (0.041)	-4.261*** (1.174)	-0.938 (0.570)	.40
2-Year Note	-0.011** (0.005)	0.468*** (0.081)	.39	-0.011*** (0.002)	0.469*** (0.033)	0.401*** (0.022)	.94
5-Year Note	-0.006 (0.005)	0.265*** (0.078)	.18	-0.005** (0.002)	0.266*** (0.045)	0.357*** (0.034)	.80
10-Year Note	-0.003 (0.004)	0.121** (0.058)	.07	-0.003 (0.002)	0.121*** (0.039)	0.271*** (0.025)	.74
5-Year Forward Rate 5 Years Ahead	0.002 (0.003)	-0.101** (0.047)	.07	0.002 (0.003)	-0.100** (0.047)	0.146*** (0.028)	.33

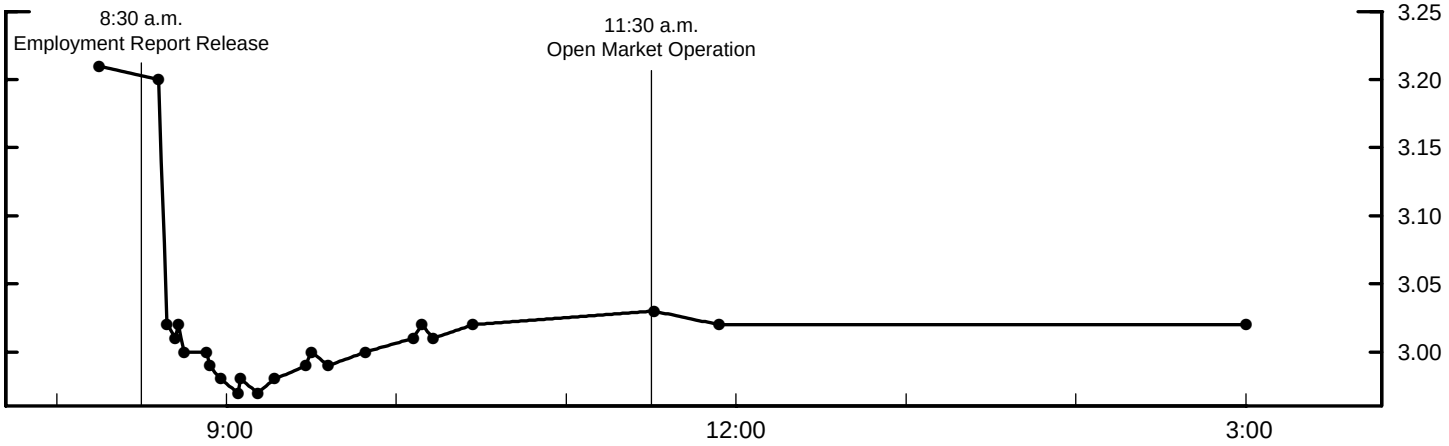
Note: Sample is all monetary policy announcements from July 1991 to May 2004 (Januray 1990 to May 2004 for S&P 500). Target factor and path factor are defined in the main text. Heteroskedasticity consistent standard errors reported in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% respectively. See text for details.

Figure 1
Intraday Trading in Federal Funds Futures Contracts

(a) April 9, 1992 (April 1992 Contract)



(b) September 4, 1992 (September 1992 Contract)



(c) June 25, 2003 (July 2003 Contract)

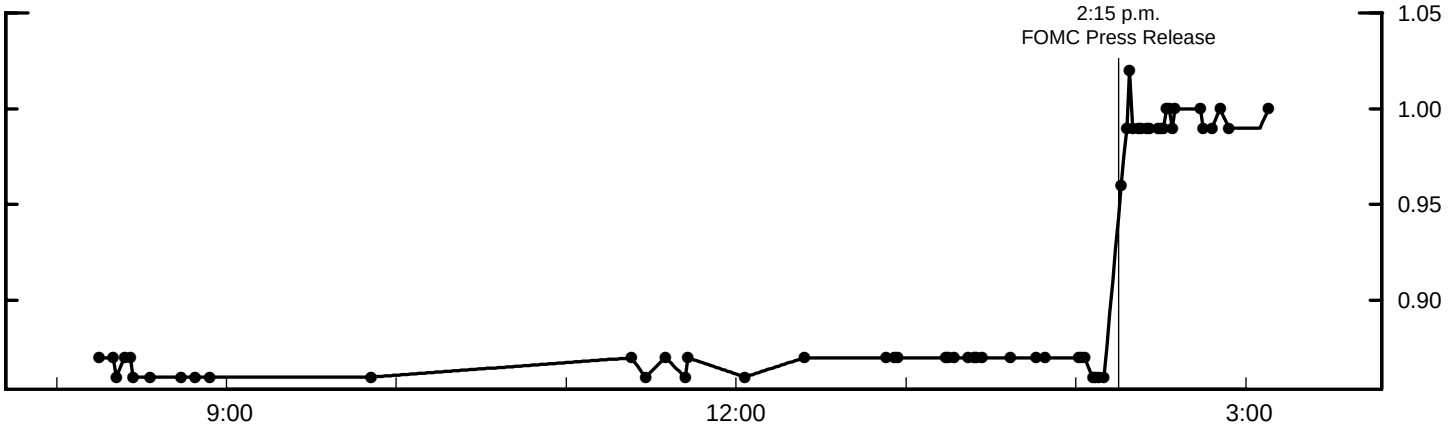
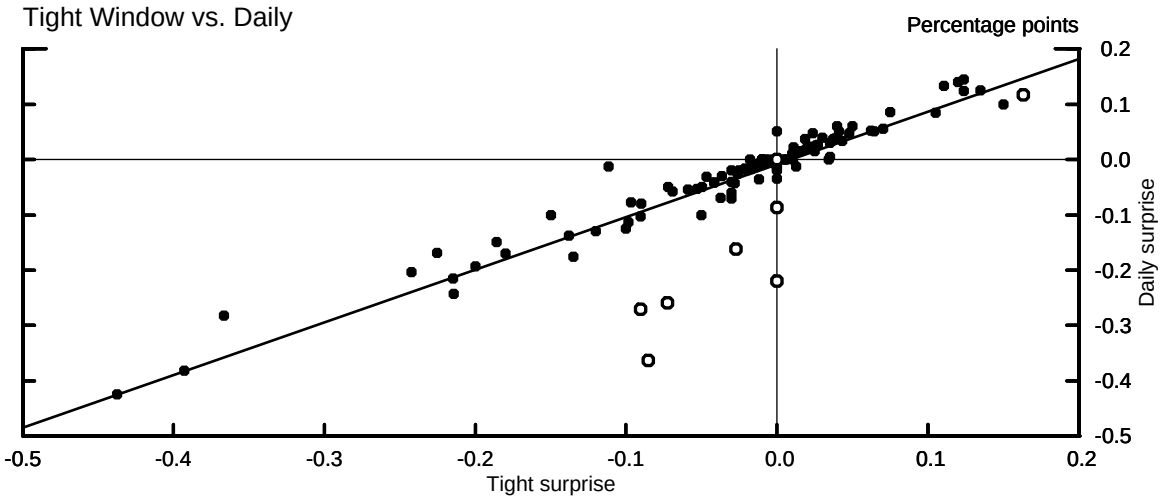
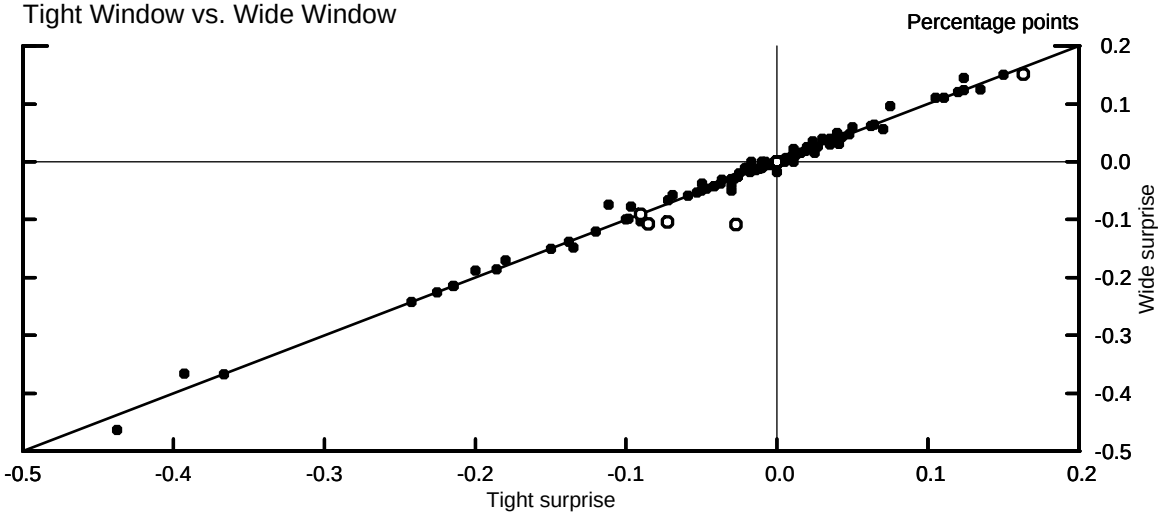


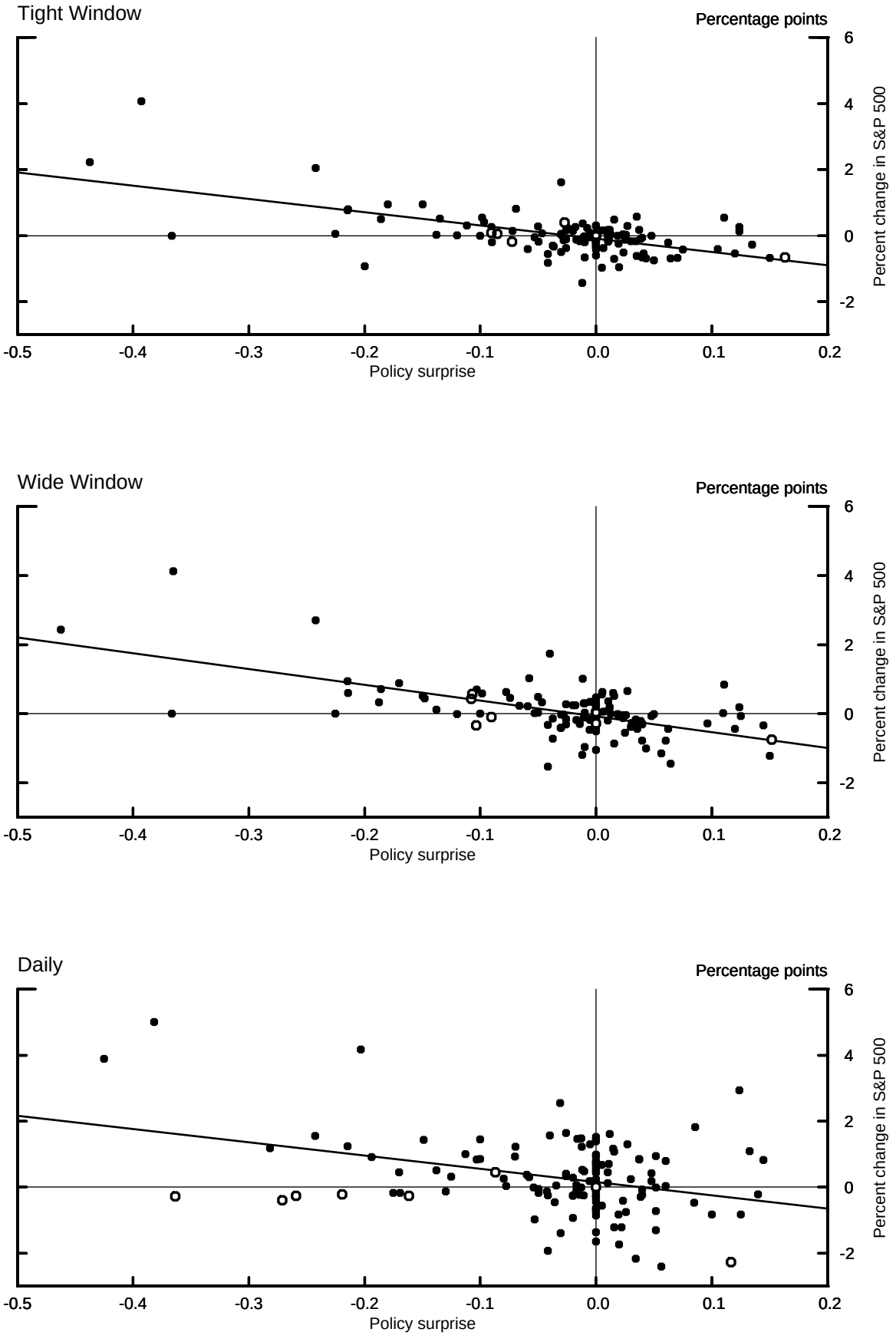
Figure 2
Measures of Surprises in the Federal Funds Rate Target





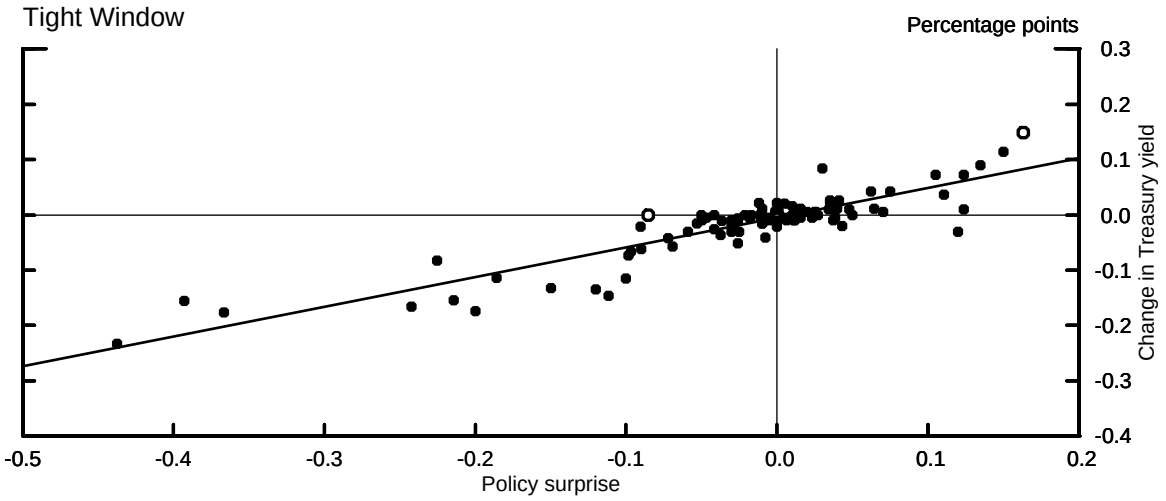
Note: Hollow circles denote days of employment report releases

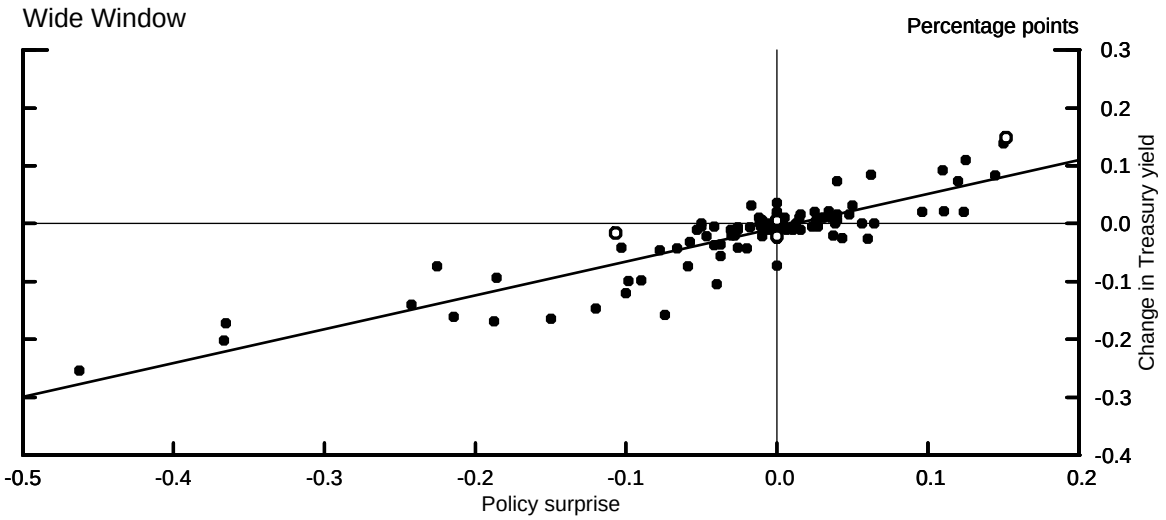
Figure 3
Response of S&P 500 to Monetary Policy Surprises

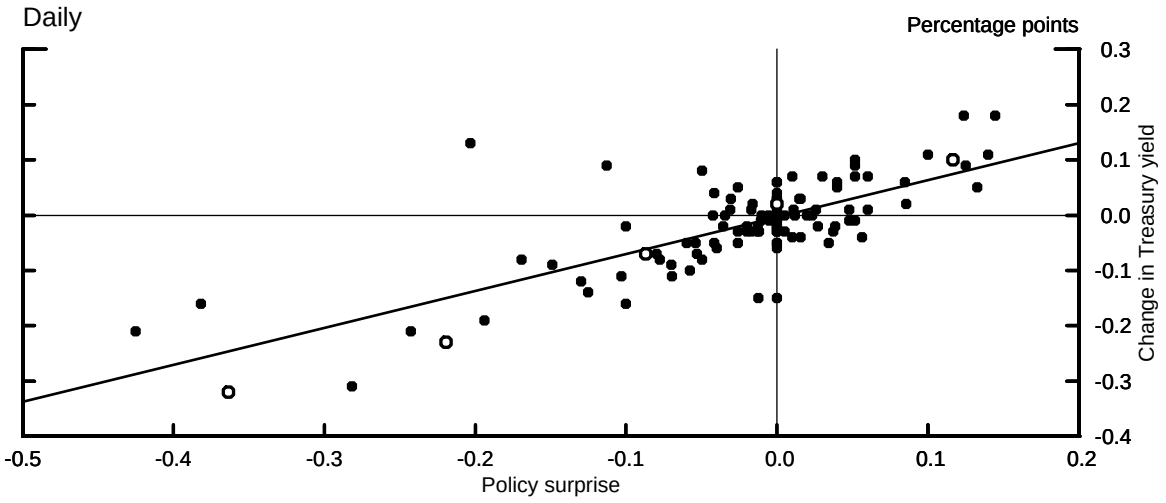


Note: Hollow circles denote days of employment report releases

Figure 4
Response of Three-month Treasury Yield to Monetary Policy Surprises

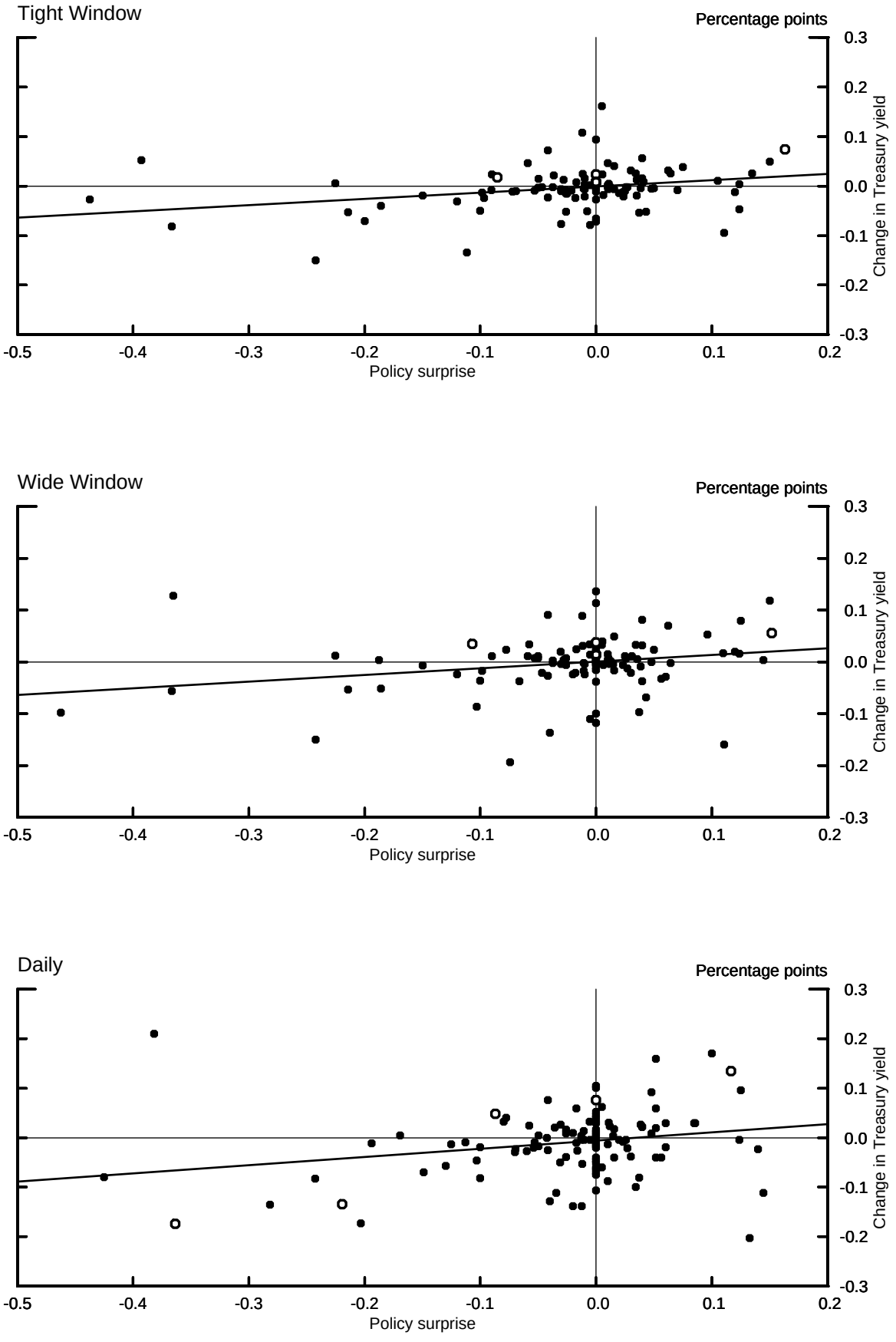






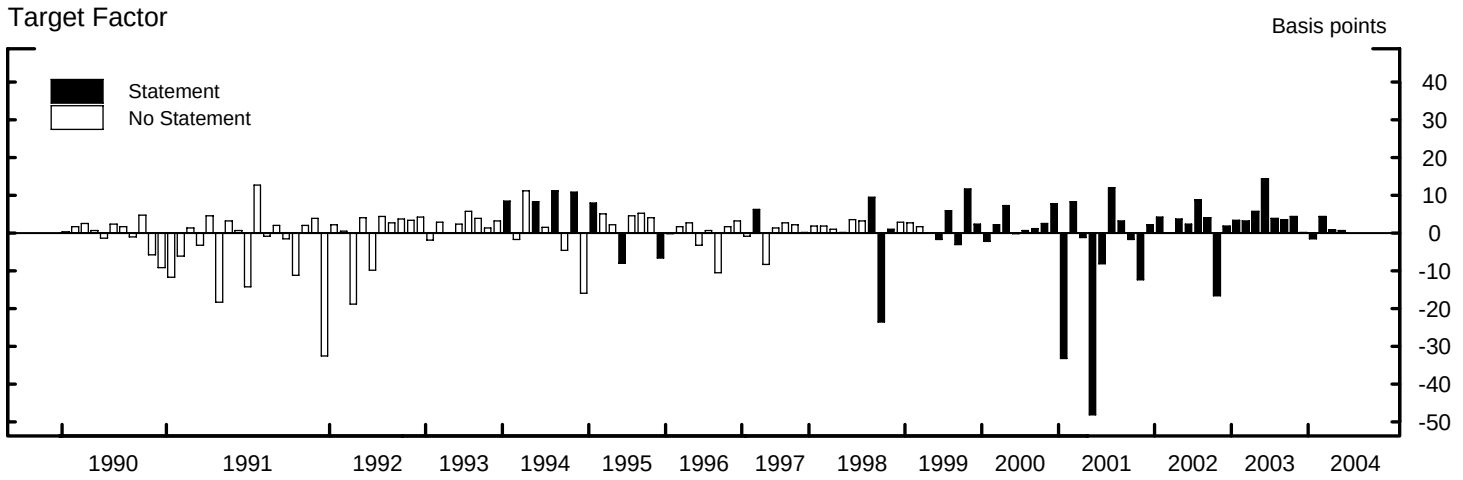
Note: Hollow circles denote days of employment report releases

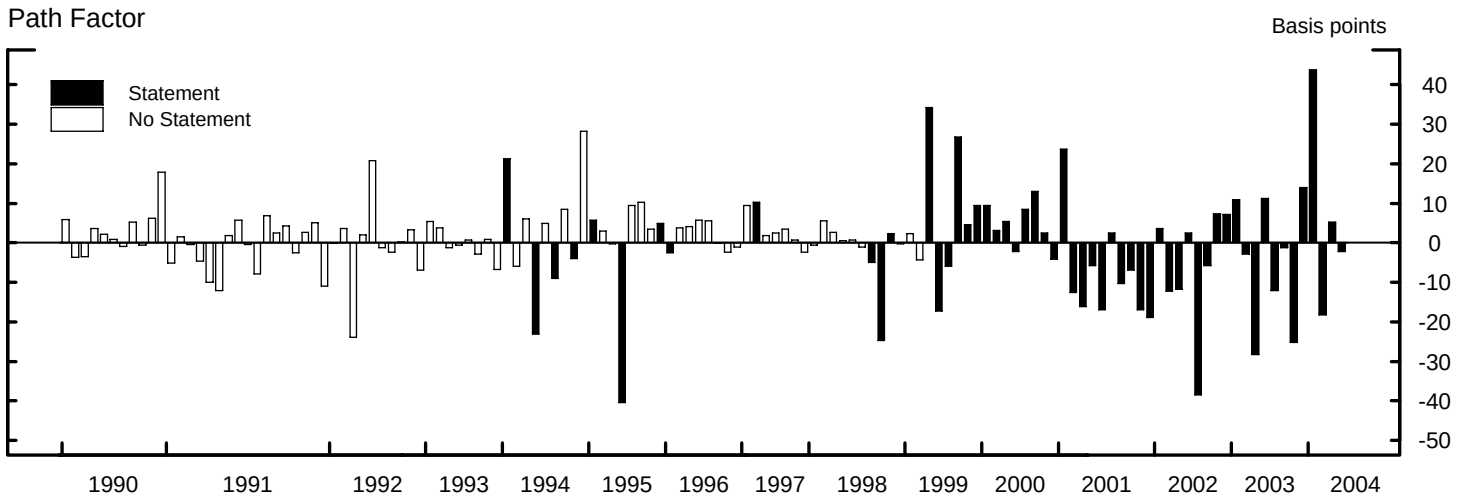
Figure 5
Response of Ten-year Treasury Yield to Monetary Policy Surprises



Note: Hollow circles denote days of employment report releases

Figure 6
Monetary Policy Surprises as Two Factors





Appendix A1

Monetary Policy Announcement Dates and Times

Date	Time	Method of Announcement	Intermeeting Move?	Other Macroeconomic Data Releases That Day
8-Feb-90	11:30am	Open Market Operation		
28-Mar-90	11:30am	Open Market Operation		GNP and NIPAs, New Home Sales
16-May-90	11:30am	Open Market Operation		CPI, Housing Starts and Permits
5-Jul-90	11:30am	Open Market Operation		Auto Sales
13-Jul-90	11:30am	Open Market Operation	✓	PPI, Retail Sales
22-Aug-90	11:30am	Open Market Operation		
3-Oct-90	11:30am	Open Market Operation		Auto Sales, Factory Orders
29-Oct-90	11:30am	Open Market Operation	✓	
14-Nov-90	11:30am	Open Market Operation		Retail Sales
7-Dec-90	11:30am	Open Market Operation	✓	Employment Report
18-Dec-90	3:30pm	Discount Rate Change Press Release		CPI, Merchandise Trade
8-Jan-91	11:30am	Open Market Operation	✓	
1-Feb-91	9:15am	Discount Rate Change Press Release	✓	Employment Report, NAPM Survey
7-Feb-91	11:30am	Open Market Operation		
8-Mar-91	11:30am	Open Market Operation	✓	Employment Report
27-Mar-91	11:30am	Open Market Operation		GNP and NIPAs
30-Apr-91	9:30am	Discount Rate Change Press Release	✓	Consumer Confidence, ECI, Factory Orders
15-May-91	11:30am	Open Market Operation		Business Inventories
5-Jul-91	11:30am	Open Market Operation		Employment Report
6-Aug-91	11:30am	Open Market Operation	✓	
21-Aug-91	11:30am	Open Market Operation		U.S. Budget Deficit
13-Sep-91	9:10am	Discount Rate Change Press Release	✓	CPI, Retail Sales
2-Oct-91	11:30am	Open Market Operation		New Home Sales
30-Oct-91	11:30am	Open Market Operation	✓	New Home Sales, PCE, Personal Income
6-Nov-91	8:45am	Discount Rate Change Press Release		
6-Dec-91	11:30am	Open Market Operation	✓	Employment Report
18-Dec-91	11:30am	Open Market Operation		
20-Dec-91	8:30am	Discount Rate Change Press Release	✓	GDP and NIPAs, U.S. Budget Deficit
6-Feb-92	11:30am	Open Market Operation		Factory Orders
1-Apr-92	11:30am	Open Market Operation		NAPM Survey
9-Apr-92	11:30am	Open Market Operation	✓	PPI
20-May-92	11:30am	Open Market Operation		Merchandise Trade
2-Jul-92	9:15am	Discount Rate Change Press Release	✓	Employment Report, Factory Orders
19-Aug-92	11:30am	Open Market Operation		Merchandise Trade
4-Sep-92	11:30am	Open Market Operation	✓	Employment Report
7-Oct-92	11:30am	Open Market Operation		
18-Nov-92	11:30am	Open Market Operation		Merchandise Trade
23-Dec-92	11:30am	Open Market Operation		Consumer Confidence, Durable Goods Orders, PCE
4-Feb-93	11:30am	Open Market Operation		Factory Orders
24-Mar-93	11:30am	Open Market Operation		Durable Goods Orders
19-May-93	11:30am	Open Market Operation		Merchandise Trade
8-Jul-93	11:30am	Open Market Operation		
18-Aug-93	11:30am	Open Market Operation		
22-Sep-93	11:30am	Open Market Operation		U.S. Budget Deficit
17-Nov-93	11:30am	Open Market Operation		Housing Starts and Permits
22-Dec-93	11:30am	Open Market Operation		GDP and NIPAs

4-Feb-94	11:05am	Post-Meeting Press Release		Employment Report
22-Mar-94	2:20pm	Post-Meeting Press Release		Merchandise Trade
18-Apr-94	10:06am	Post-Meeting Press Release	✓	
17-May-94	2:26pm	Post-Meeting Press Release		Housing Starts and Permits
6-Jul-94	2:18pm	Post-Meeting Press Release		Auto Sales
16-Aug-94	1:18pm	Post-Meeting Press Release		Housing Starts and Permits
27-Sep-94	2:18pm	Post-Meeting Press Release		Consumer Confidence
15-Nov-94	2:20pm	Post-Meeting Press Release		Ind Production, Cap Utilization, International Trade
20-Dec-94	2:17pm	Post-Meeting Press Release		International Trade
1-Feb-95	2:15pm	Post-Meeting Press Release		Leading Indicators, Auto Sales
28-Mar-95	2:15pm	Post-Meeting Press Release		Consumer Confidence
23-May-95	2:15pm	Post-Meeting Press Release		
6-Jul-95	2:15pm	Post-Meeting Press Release		Leading Indicators, Auto Sales
22-Aug-95	2:15pm	Post-Meeting Press Release		
26-Sep-95	2:15pm	Post-Meeting Press Release		Consumer Confidence
15-Nov-95	2:15pm	Post-Meeting Press Release		CPI, Ind. Prod., Cap. Util, Business Inventories
19-Dec-95	2:15pm	Post-Meeting Press Release		GDP and NIPAs, Housing Starts and Permits
31-Jan-96	2:15pm	Post-Meeting Press Release		PPI, Purchasing Managers Survey
26-Mar-96	11:39am	Post-Meeting Press Release		Consumer Confidence
21-May-96	2:15pm	Post-Meeting Press Release		U.S. Budget Deficit
3-Jul-96	2:15pm	Post-Meeting Press Release		Factory Orders, Auto Sales
20-Aug-96	2:15pm	Post-Meeting Press Release		International Trade
24-Sep-96	2:15pm	Post-Meeting Press Release		Consumer Confidence
13-Nov-96	2:15pm	Post-Meeting Press Release		PPI
17-Dec-96	2:15pm	Post-Meeting Press Release		Housing Starts and Permits
5-Feb-97	2:15pm	Post-Meeting Press Release		Factory Orders, Auto Sales
25-Mar-97	2:15pm	Post-Meeting Press Release		Consumer Confidence, Existing Home Sales
20-May-97	2:15pm	Post-Meeting Press Release		
2-Jul-97	2:15pm	Post-Meeting Press Release		Factory Orders
19-Aug-97	2:15pm	Post-Meeting Press Release		Housing Starts and Permits
30-Sep-97	2:15pm	Post-Meeting Press Release		Consumer Confidence, New Home Sales
12-Nov-97	2:15pm	Post-Meeting Press Release		
16-Dec-97	2:15pm	Post-Meeting Press Release		CPI, Housing Starts and Permits
4-Feb-98	2:12pm	Post-Meeting Press Release		
31-Mar-98	2:15pm	Post-Meeting Press Release		Consumer Confidence
19-May-98	2:15pm	Post-Meeting Press Release		Housing Starts and Permits
1-Jul-98	2:15pm	Post-Meeting Press Release		NAPM Survey, Leading Indicators, Auto Sales
18-Aug-98	2:15pm	Post-Meeting Press Release		CPI, International Trade
29-Sep-98	2:15pm	Post-Meeting Press Release		Consumer Confidence
15-Oct-98	3:15pm	Intermeeting Press Release	✓	PPI, Business Inventories
17-Nov-98	2:15pm	Post-Meeting Press Release		CPI, Business Inventories
22-Dec-98	2:15pm	Post-Meeting Press Release		
3-Feb-99	2:12pm	Post-Meeting Press Release		Auto Sales
30-Mar-99	2:12pm	Post-Meeting Press Release		Consumer Confidence
18-May-99	2:11pm	Post-Meeting Press Release		Housing Starts and Permits
30-Jun-99	2:15pm	Post-Meeting Press Release		Leading Indicators
24-Aug-99	2:15pm	Post-Meeting Press Release		
5-Oct-99	2:12pm	Post-Meeting Press Release		Leading Indicators
16-Nov-99	2:15pm	Post-Meeting Press Release		Industrial Production, Capacity Utilization
21-Dec-99	2:15pm	Post-Meeting Press Release		U.S. Budget Deficit
2-Feb-00	2:15pm	Post-Meeting Press Release		New Home Sales, Leading Indicators, Auto Sales
21-Mar-00	2:15pm	Post-Meeting Press Release		International Trade
16-May-00	2:15pm	Post-Meeting Press Release		CPI, Housing Starts and Permits

28-Jun-00	2:15pm	Post-Meeting Press Release		Durable Goods Sales
22-Aug-00	2:15pm	Post-Meeting Press Release		
3-Oct-00	2:12pm	Post-Meeting Press Release		New Home Sales, Leading Indicators
15-Nov-00	2:12pm	Post-Meeting Press Release		Ind. Prod., Cap. Util., Business Inventories
19-Dec-00	2:15pm	Post-Meeting Press Release		International Trade
3-Jan-01	1:13pm	Intermeeting Press Release	✓	
31-Jan-01	2:15pm	Post-Meeting Press Release		GDP and NIPAs, New Home Sales
20-Mar-01	2:15pm	Post-Meeting Press Release		International Trade, U.S. Budget Deficit
18-Apr-01	10:54am	Intermeeting Press Release	✓	Leading Indicators, International Trade
15-May-01	2:15pm	Post-Meeting Press Release		
27-Jun-01	2:12pm	Post-Meeting Press Release		
21-Aug-01	2:15pm	Post-Meeting Press Release		
17-Sep-01	8:20am	Intermeeting Press Release	✓	
2-Oct-01	2:15pm	Post-Meeting Press Release		
6-Nov-01	2:20pm	Post-Meeting Press Release		
11-Dec-01	2:15pm	Post-Meeting Press Release		
30-Jan-02	2:15pm	Post-Meeting Press Release		GDP and NIPAs
19-Mar-02	2:15pm	Post-Meeting Press Release		International Trade
7-May-02	2:15pm	Post-Meeting Press Release		
26-Jun-02	2:15pm	Post-Meeting Press Release		Durable Goods Orders, New Home Sales
13-Aug-02	2:15pm	Post-Meeting Press Release		Retail Sales
24-Sep-02	2:15pm	Post-Meeting Press Release		Consumer Confidence
6-Nov-02	2:15pm	Post-Meeting Press Release		
10-Dec-02	2:15pm	Post-Meeting Press Release		
29-Jan-03	2:15pm	Post-Meeting Press Release		
18-Mar-03	2:15pm	Post-Meeting Press Release		Housing Starts and Permits
6-May-03	2:15pm	Post-Meeting Press Release		
25-Jun-03	2:15pm	Post-Meeting Press Release		Drbl Goods Ords, New Home Sales, Exist Home Sales
12-Aug-03	2:15pm	Post-Meeting Press Release		
16-Sep-03	2:15pm	Post-Meeting Press Release		CPI
28-Oct-03	2:15pm	Post-Meeting Press Release		Durable Goods Orders, Consumer Confidence
9-Dec-03	2:15pm	Post-Meeting Press Release		
28-Jan-04	2:15pm	Post-Meeting Press Release		Durable Goods Orders, New Home Sales
16-Mar-04	2:15pm	Post-Meeting Press Release		Housing Starts and Permits
4-May-04	2:15pm	Post-Meeting Press Release		Factory Orders

Appendix A2

Monetary Policy Surprises

Date	---Monetary Policy Surprise (bp)--- Tight Window (30 min.)	Wide Window (1 hour)	Daily Window (1 day)	---Differences (bp)--- Daily - Tight	Wide - Tight	Intermeeting Move?	Employment Report?
8-Feb-90	-1.4	-1.4	-1.4	0.0	0.0		
28-Mar-90	0.0	0.0	0.0	0.0	0.0		
16-May-90	0.0	0.0	0.0	0.0	0.0		
5-Jul-90	0.0	0.0	0.0	0.0	0.0		
13-Jul-90	-13.8	-13.8	-13.8	0.0	0.0	✓	
22-Aug-90	0.0	0.0	0.0	0.0	0.0		
3-Oct-90	1.1	2.2	2.2	1.1	1.1		
29-Oct-90	-3.0	-3.0	-2.0	1.0	0.0	✓	
14-Nov-90	1.9	1.9	3.8	1.9	0.0		
7-Dec-90	-9.0	-9.0	-27.1	-18.1	0.0	✓	✓
18-Dec-90	-21.5	-21.5	-21.5	0.0	0.0		
8-Jan-91	-13.5	-14.8	-17.5	-4.0	-1.4	✓	
1-Feb-91	-7.3	-10.4	-25.9	-18.7	-3.1	✓	✓
7-Feb-91	0.0	0.0	0.0	0.0	0.0		
8-Mar-91	-2.7	-10.8	-16.2	-13.5	-8.1	✓	✓
27-Mar-91	-2.0	-1.0	-2.0	0.0	1.0		
30-Apr-91	-18.0	-17.0	-17.0	1.0	1.0	✓	
15-May-91	1.9	1.9	1.9	0.0	0.0		
5-Jul-91	0.0	0.0	0.0	0.0	0.0		✓
6-Aug-91	-18.6	-18.6	-14.9	3.7	0.0	✓	
21-Aug-91	12.4	12.4	12.4	0.0	0.0		
13-Sep-91	-5.3	-5.3	-5.3	0.0	0.0	✓	
2-Oct-91	-1.1	-1.1	-1.1	0.0	0.0		
30-Oct-91	-3.0	-5.0	-6.0	-3.0	-2.0	✓	
6-Nov-91	-10.0	-10.0	-12.5	-2.5	0.0		
6-Dec-91	0.0	0.0	-8.7	-8.7	0.0	✓	✓
18-Dec-91	4.8	4.8	4.8	0.0	0.0		
20-Dec-91	-36.6	-36.6	-28.2	8.5	0.0	✓	
6-Feb-92	1.3	1.3	-1.3	-2.5	0.0		
1-Apr-92	1.0	1.0	1.0	0.0	0.0		
9-Apr-92	-21.4	-21.4	-24.3	-2.9	0.0	✓	
20-May-92	0.0	0.0	0.0	0.0	0.0		
2-Jul-92	-8.6	-10.7	-36.3	-27.8	-2.1		✓
19-Aug-92	2.6	2.6	2.6	0.0	0.0		
4-Sep-92	0.0	0.0	-21.9	-21.9	0.0	✓	✓
7-Oct-92	0.0	0.0	5.2	5.2	0.0		
18-Nov-92	-5.0	-5.0	-10.0	-5.0	0.0		
23-Dec-92	3.9	3.9	3.9	0.0	0.0		
4-Feb-93	0.0	0.0	-1.2	-1.2	0.0		
24-Mar-93	0.0	0.0	0.0	0.0	0.0		
19-May-93	-2.6	-2.6	-2.6	0.0	0.0		
8-Jul-93	2.7	2.7	2.7	0.0	0.0		
18-Aug-93	0.0	0.0	0.0	0.0	0.0		
22-Sep-93	0.0	0.0	0.0	0.0	0.0		
17-Nov-93	2.3	2.3	2.3	0.0	0.0		
22-Dec-93	0.0	0.0	0.0	0.0	0.0		

Date	---Monetary Policy Surprise (bp)--- Tight Window (30 min.)	Wide Window (1 hour)	Daily Window (1 day)	---Differences (bp)--- Daily - Tight	Wide - Tight	Intermeeting Move?	Employment Report?
4-Feb-94	16.3	15.2	11.7	-4.7	-1.2		✓
22-Mar-94	0.0	0.0	-3.4	-3.4	0.0		
18-Apr-94	15.0	15.0	10.0	-5.0	0.0	✓	
17-May-94	11.1	11.1	13.3	2.2	0.0		
6-Jul-94	-5.0	-3.7	-5.0	0.0	1.2		
16-Aug-94	12.4	14.5	14.5	2.1	2.1		
27-Sep-94	-9.0	-9.0	-8.0	1.0	0.0		
15-Nov-94	12.0	12.0	14.0	2.0	0.0		
20-Dec-94	-22.6	-22.6	-16.9	5.6	0.0		
1-Feb-95	6.2	6.2	5.2	-1.0	0.0		
28-Mar-95	-1.0	0.0	0.0	1.0	1.0		
23-May-95	0.0	0.0	0.0	0.0	0.0		
6-Jul-95	-11.2	-7.4	-1.2	9.9	3.7		
22-Aug-95	3.4	3.4	0.0	-3.4	0.0		
26-Sep-95	3.0	4.0	4.0	1.0	1.0		
15-Nov-95	4.0	5.0	6.0	2.0	1.0		
19-Dec-95	-9.0	-10.3	-10.3	-1.3	-1.3		
31-Jan-96	-3.0	-3.0	-7.0	-4.0	0.0		
26-Mar-96	1.0	1.0	1.0	0.0	0.0		
21-May-96	0.0	0.0	0.0	0.0	0.0		
3-Jul-96	-7.2	-6.6	-5.0	2.2	0.6		
20-Aug-96	-2.8	-2.8	-4.2	-1.4	0.0		
24-Sep-96	-12.0	-12.0	-13.0	-1.0	0.0		
13-Nov-96	-1.8	-1.8	0.0	1.8	0.0		
17-Dec-96	1.1	0.0	1.1	0.0	-1.1		
5-Feb-97	-3.7	-3.0	-3.0	0.6	0.6		
25-Mar-97	4.0	4.0	4.0	0.0	0.0		
20-May-97	-9.9	-9.9	-11.3	-1.4	0.0		
2-Jul-97	-2.1	-1.1	-1.6	0.5	1.1		
19-Aug-97	0.0	0.0	-1.3	-1.3	0.0		
30-Sep-97	0.0	0.0	0.0	0.0	0.0		
12-Nov-97	-4.2	-4.2	-4.2	0.0	0.0		
16-Dec-97	0.0	0.0	-1.0	-1.0	0.0		
4-Feb-98	0.0	0.0	0.0	0.0	0.0		
31-Mar-98	-1.0	-1.0	0.0	1.0	0.0		
19-May-98	-2.6	-2.6	-2.6	0.0	0.0		
1-Jul-98	-0.5	-0.5	-0.5	0.0	0.0		
18-Aug-98	1.2	1.2	1.2	0.0	0.0		
29-Sep-98	5.0	6.0	6.0	1.0	1.0		
15-Oct-98	-24.2	-24.2	-20.3	3.9	0.0	✓	
17-Nov-98	-6.9	-5.8	-5.8	1.2	1.2		
22-Dec-98	0.0	-1.7	-1.7	-1.7	-1.7		
3-Feb-99	0.6	0.6	0.0	-0.6	0.0		
30-Mar-99	-1.0	0.0	0.0	1.0	1.0		
18-May-99	-1.2	-1.2	-3.6	-2.4	0.0		
30-Jun-99	-3.0	-4.0	-4.0	-1.0	-1.0		
24-Aug-99	3.5	3.0	3.0	-0.5	-0.5		
5-Oct-99	-4.2	-4.2	-4.2	0.0	0.0		
16-Nov-99	7.5	9.6	8.6	1.1	2.1		

Date	---Monetary Policy Surprise (bp)--- Tight Window (30 min.)	Wide Window (1 hour)	Daily Window (1 day)	---Differences (bp)--- Daily - Tight	Wide - Tight	Intermeeting Move?	Employment Report?
21-Dec-99	1.6	1.6	1.6	0.0	0.0		
2-Feb-00	-5.9	-5.9	-5.4	0.5	0.0		
21-Mar-00	-4.7	-4.7	-3.1	1.6	0.0		
16-May-00	4.1	3.1	5.2	1.0	-1.0		
28-Jun-00	-2.5	-2.0	-2.0	0.5	0.5		
22-Aug-00	-1.7	0.0	-1.7	0.0	1.7		
3-Oct-00	0.0	-0.6	0.0	0.0	-0.6		
15-Nov-00	-1.0	-1.0	0.0	1.0	0.0		
19-Dec-00	6.5	6.5	5.2	-1.3	0.0		
3-Jan-01	-39.3	-36.5	-38.2	1.1	2.8	✓	
31-Jan-01	3.5	4.0	0.5	-3.0	0.5		
20-Mar-01	7.1	5.6	5.6	-1.4	-1.4		
18-Apr-01	-43.8	-46.3	-42.5	1.3	-2.5	✓	
15-May-01	-9.7	-7.8	-7.8	1.9	1.9		
27-Jun-01	10.5	11.0	8.5	-2.0	0.5		
21-Aug-01	1.6	1.6	1.6	0.0	0.0		
17-Sep-01	omitted	omitted	omitted	omitted	omitted	✓	
2-Oct-01	-3.7	-3.7	-7.0	-3.2	0.0		
6-Nov-01	-15.0	-15.0	-10.0	5.0	0.0		
11-Dec-01	-0.8	0.0	0.0	0.8	0.8		
30-Jan-02	2.5	1.5	1.5	-1.0	-1.0		
19-Mar-02	-2.6	-2.6	-2.6	0.0	0.0		
7-May-02	0.7	0.7	0.0	-0.7	0.0		
26-Jun-02	0.0	0.0	-2.0	-2.0	0.0		
13-Aug-02	4.3	4.3	3.4	-0.9	0.0		
24-Sep-02	2.0	2.5	2.0	0.0	0.5		
6-Nov-02	-20.0	-18.8	-19.4	0.6	1.3		
10-Dec-02	0.0	0.0	0.0	0.0	0.0		
29-Jan-03	1.0	0.5	0.5	-0.5	-0.5		
18-Mar-03	2.4	3.6	4.8	2.4	1.2		
6-May-03	3.7	3.7	3.7	0.0	0.0		
25-Jun-03	13.5	12.5	12.5	-1.0	-1.0		
12-Aug-03	0.0	0.0	0.0	0.0	0.0		
16-Sep-03	1.1	1.1	0.0	-1.1	0.0		
28-Oct-03	-0.5	-0.5	0.0	0.5	0.0		
9-Dec-03	0.0	0.0	0.0	0.0	0.0		
28-Jan-04	0.5	0.0	0.0	-0.5	-0.5		
16-Mar-04	0.0	0.0	0.0	0.0	0.0		
4-May-04	-1.2	-1.2	-0.6	0.6	0.0		

Appendix A3

Target and Path Factors

Date	Target Factor	Path Factor	FOMC Statement?
8-Feb-90	0.3	5.9	
28-Mar-90	1.8	-3.7	
16-May-90	2.6	-3.6	
5-Jul-90	0.7	3.6	
13-Jul-90	-1.3	2.2	
22-Aug-90	2.4	0.9	
3-Oct-90	1.7	-0.9	
29-Oct-90	-1.0	5.2	
14-Nov-90	4.7	-0.5	
7-Dec-90	-5.7	6.2	
18-Dec-90	-9.2	17.9	
8-Jan-91	-11.7	-5.2	
1-Feb-91	-6.1	1.4	
7-Feb-91	1.4	-0.4	
8-Mar-91	-3.1	-4.7	
27-Mar-91	4.6	-9.9	
30-Apr-91	-18.3	-12.1	
15-May-91	3.2	1.8	
5-Jul-91	0.8	5.7	
6-Aug-91	-14.3	-0.4	
21-Aug-91	12.7	-7.8	
13-Sep-91	-0.8	6.9	
2-Oct-91	2.0	2.5	
30-Oct-91	-1.6	4.3	
6-Nov-91	-11.2	-2.5	
6-Dec-91	2.1	2.6	
18-Dec-91	3.8	5.0	
20-Dec-91	-32.6	-11.0	
6-Feb-92	2.2	-0.2	
1-Apr-92	0.5	3.6	
9-Apr-92	-18.8	-23.9	
20-May-92	4.0	2.1	
2-Jul-92	-9.8	20.8	
19-Aug-92	4.4	-1.2	
4-Sep-92	2.7	-2.4	
7-Oct-92	3.7	0.2	
18-Nov-92	3.4	3.3	
23-Dec-92	4.3	-6.9	
4-Feb-93	-1.9	5.3	
24-Mar-93	2.9	3.8	
19-May-93	0.0	-1.2	
8-Jul-93	2.4	-0.7	
18-Aug-93	5.8	0.6	
22-Sep-93	3.9	-2.9	
17-Nov-93	1.3	0.9	
22-Dec-93	3.3	-6.7	
4-Feb-94	8.6	21.2	✓
22-Mar-94	-1.8	-6.0	
18-Apr-94	11.2	6.0	
17-May-94	8.2	-23.0	✓
6-Jul-94	1.5	4.9	
16-Aug-94	11.3	-9.1	✓
27-Sep-94	-4.6	8.4	
15-Nov-94	10.8	-4.0	✓
20-Dec-94	-16.0	28.2	
1-Feb-95	7.9	5.8	✓
28-Mar-95	5.0	3.0	
23-May-95	2.3	-0.4	
6-Jul-95	-7.9	-40.5	✓
22-Aug-95	4.7	9.4	
26-Sep-95	5.3	10.3	
15-Nov-95	4.1	3.5	
19-Dec-95	-6.6	4.9	✓
31-Jan-96	-0.1	-2.5	✓
26-Mar-96	1.7	3.9	
21-May-96	2.7	4.0	
3-Jul-96	-3.2	5.7	
20-Aug-96	0.6	5.6	
24-Sep-96	-10.6	-0.1	
13-Nov-96	1.7	-2.4	
17-Dec-96	3.2	-1.1	
5-Feb-97	-0.8	9.4	
25-Mar-97	6.4	10.2	✓
20-May-97	-8.3	1.8	
2-Jul-97	1.3	2.6	
19-Aug-97	2.6	3.5	
30-Sep-97	2.2	0.8	
12-Nov-97	0.1	-2.4	
16-Dec-97	1.9	-0.6	
4-Feb-98	1.9	5.6	
31-Mar-98	1.1	2.7	
19-May-98	0.2	0.5	
1-Jul-98	3.5	0.7	
18-Aug-98	3.2	-1.0	
29-Sep-98	9.5	-5.0	✓
15-Oct-98	-23.5	-24.7	✓
17-Nov-98	1.0	2.4	✓
22-Dec-98	2.9	-0.3	
3-Feb-99	2.8	2.3	
30-Mar-99	1.7	-4.3	
18-May-99	0.0	34.2	✓
30-Jun-99	-1.7	-17.3	✓
24-Aug-99	5.9	-6.0	✓
5-Oct-99	-3.1	26.8	✓
16-Nov-99	11.8	4.6	✓
21-Dec-99	2.4	9.4	✓
2-Feb-00	-2.3	9.5	✓
21-Mar-00	2.2	3.1	✓
16-May-00	7.3	5.4	✓
28-Jun-00	-0.1	-2.2	✓
22-Aug-00	0.7	8.4	✓
3-Oct-00	1.3	13.0	✓
15-Nov-00	2.6	2.5	✓
19-Dec-00	7.8	-4.1	✓
3-Jan-01	-33.2	23.7	✓
31-Jan-01	8.4	-12.5	✓
20-Mar-01	-1.1	-16.1	✓
18-Apr-01	-48.2	-5.8	✓
15-May-01	-8.2	-16.9	✓
27-Jun-01	12.0	2.5	✓
21-Aug-01	3.2	-10.3	✓
2-Oct-01	-1.6	-6.9	✓
6-Nov-01	-12.4	-16.9	✓
11-Dec-01	2.3	-18.9	✓
30-Jan-02	4.3	3.7	✓
19-Mar-02	0.0	-12.3	✓
7-May-02	3.8	-11.8	✓
26-Jun-02	2.4	2.4	✓
13-Aug-02	8.8	-38.5	✓
24-Sep-02	4.0	-5.8	✓
6-Nov-02	-16.6	7.4	✓
10-Dec-02	1.9	7.2	✓
29-Jan-03	3.4	11.0	✓
18-Mar-03	3.2	-2.8	✓
6-May-03	5.8	-28.3	✓
25-Jun-03	14.4	11.2	✓
12-Aug-03	3.9	-12.1	✓
16-Sep-03	3.5	-1.3	✓
28-Oct-03	4.3	-25.2	✓
9-Dec-03	0.2	14.0	✓
28-Jan-04	-1.5	43.8	✓
16-Mar-04	4.4	-18.3	✓
4-May-04	0.9	5.2	✓

Appendix B: Data and Methods for Calculating Factors

Let X denote the matrix of changes in asset prices described in section 3, with 133 rows corresponding to monetary policy announcements and 5 columns corresponding to futures contracts with one year or less to maturity. The third through fifth columns of X are the changes in price of the second, third, and fourth eurodollar futures contracts, which have 1.5, 2.5, and 3.5 quarters to expiration on average (eurodollar futures have expiration dates that lie about two weeks before the end of each quarter).[1] The first two columns of X are essentially the changes in the current-month and three-month-ahead federal funds futures contracts, but contain a scaling adjustment to account for the timing of FOMC meetings within those months, as follows.

Fed funds futures have a payout that is based on the average effective federal funds rate that prevails over the calendar month specified in the contract. Thus, immediately before an FOMC meeting, at time $t-\Delta t$, the implied rate from the current-month federal funds future contract, *ff1*, is largely a weighted average of the federal funds rate that has prevailed so far in the month, r_0, and the rate that is expected to prevail for the reminder of the month, r_1:[2]

$$ff1_{t-\Delta t} = \frac{d1}{D1} r_0 + \frac{D1 - d1}{D1} E_{t-\Delta t}(r_1) + \rho 1_{t-\Delta t}, \qquad \text{(B.1)}$$

where *d1* denotes the day of the FOMC meeting, *D1* is the number of days in the month, and $\rho 1$ denotes any term or risk premium that may be present in the contract. Then, by leading this equation to time t (20 minutes after the policy announcement) and differencing, the surprise component of the change in the federal funds rate target, which we call *mp1,* is given by:[3]

[1] Thus, the second eurodollar futures contract can have as little as one quarter plus one day to expiration and as much as two quarters to expiration, with an average horizon of 1.5 quarters over our sample. On expiration, eurodollar futures settle based on the spot 90-day eurodollar rate, which is closely tied to expectations for the federal funds rate over the subsequent 90-day period. Thus, these three eurodollar futures contracts are related to federal funds rate expectations from 1.5-2.5, 2.5-3.5, and 3.5-4.5 quarters ahead, respectively.

[2] For simplicity, assume that federal funds rate is always equal to the target rate set by the FOMC, so that we do not have to differentiate between the target and actual rates. This has no impact on the surprise measures due to the differencing involved.

[3] Kuttner (2001) also uses this method. For FOMC meetings that occur very late in the month (i.e., in the last seven days of the month), we use the unscaled change in the *next*-month fed funds futures contract to avoid multiplying by a very large scale factor in (B.2), which could unduly magnify changes in bid-ask spreads or other factors, since fed funds futures are only priced to the nearest half basis point.

$$mp1_t = (ff1_t - ff1_{t-\Delta t})\frac{D1}{D1 - d1}. \qquad \text{(B.2)}$$

Note that to interpret (B.2) as the surprise change in monetary policy expectations, we need to assume that the change in the risk premium ρ in this narrow window of time is small in comparison to the change in expectations itself. Piazzesi and Swanson (2004) provide some evidence that this assumption is not inconsistent with the data.

We can apply a similar procedure to measure the change in expectations about r_2, the federal funds rate target that will prevail after the *second* FOMC meeting from now. Let *ff2* denote the federal funds futures rate for the month containing the second FOMC meeting (typically the three-month-ahead contract). Then

$$ff2_{t-\Delta t} = \frac{d2}{D2}E_{t-\Delta t}(r_1) + \frac{D2 - d2}{D2}E_{t-\Delta t}(r_2) + \rho 2_{t-\Delta t}. \qquad \text{(B.3)}$$

where *d2* and *D2* are the day of that FOMC meeting and the number of days in the month containing that FOMC meeting, respectively, and *ρ2* denotes any risk premium in the contract. By leading this equation to time *t* and differencing, the change in expectations for that second FOMC meeting, which we call *mp2*, is given by:

$$mp2_t = \left[(ff2_t - ff2_{t-\Delta t}) - \frac{d2}{D2}mp1_t \right] \frac{D2}{D2 - d2}. \qquad \text{(B.4)}$$

Additional details can be obtained from various sources.[4]

As described in section 3, we decompose X into its principal components after normalizing each column to have zero mean and unit variance. We let F_1 and F_2 denote the first two principal components of X, and normalize each of them to have unit variance.

[4] Gürkaynak (2004) discusses measuring policy expectations and surprises at horizons farther ahead than the current meeting, Gürkaynak, Sack, and Swanson (2002) show that federal funds futures are the best financial market predictors of the federal funds rate with the smallest average term premium, Piazzesi and Swanson (2004) estimate to what extent risk premia in these markets vary over time, and Kuttner (2001) discusses the construction and some uses of *mp1*.

To allow for a more structural interpretation of these unobserved factors, we rotate them so that the first factor corresponds to surprise changes in the current federal funds rate target and the second factor corresponds to moves in interest rate expectations over the coming year that are not driven by changes in the current funds rate. In other words, we define a 133x2 matrix Z by

$$Z = FU\,, \tag{B.5}$$

where

$$U = \begin{bmatrix} \alpha_1 & \beta_1 \\ \alpha_2 & \beta_2 \end{bmatrix},$$

and where U is identified by four restrictions. First, the columns of U are normalized to have unit length (which normalizes Z_1 and Z_2 to have unit variance). Second, the new factors Z_1 and Z_2 should remain orthogonal to each other:

$$E(Z_1 Z_2) = \alpha_1\beta_1 + \alpha_2\beta_2 = 0\,. \tag{B.6}$$

Lastly, we impose the restriction that Z_2 does not influence the current policy surprise, *mp1,* as follows. Let γ_1 and γ_2 denote the (known) loadings of *mp1* on F_1 and F_2, respectively. Since

$$F_1 = \frac{1}{\alpha_1\beta_2 - \alpha_2\beta_1}\left[\beta_2 Z_1 - \alpha_2 Z_2\right] \tag{B.7}$$

$$F_2 = \frac{1}{\alpha_1\beta_2 - \alpha_2\beta_1}\left[\alpha_1 Z_2 - \beta_1 Z_1\right] \tag{B.8}$$

it follows that:

$$\gamma_2\alpha_1 - \gamma_1\alpha_2 = 0,$$

which is the final restriction. It is then easy to solve for the unique matrix U satisfying these restrictions.

Finally, as noted in section 3, we rescale Z_1 and Z_2 so that Z_1 moves the current policy surprise *mp1* one-for-one and Z_2 has the same magnitude effect on the year-ahead eurodollar futures rate as Z_1 has on that rate (about 53bp).