



Pre-announcement effects, news effects, and volatility: Monetary policy and the stock market

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Abstract

I examine pre-announcement and news effects on the stock market in the context of public disclosure of monetary policy decisions. The results suggest that the stock market tends to be relatively quiet – conditional volatility is abnormally low – on days preceding regularly scheduled policy announcements. Although this calming effect is routinely reported in anecdotal press accounts, it is statistically significant only over the past four to five years, a result that I attribute to changes in the Federal Reserve’s disclosure practices in early 1994. The paper also looks at how the actual interest rate decisions of policy makers affect stock market volatility. The element of surprise in such decisions tends to boost stock market volatility significantly in the short run, and positive surprises – higher-than-expected values of the target federal funds rate – tend to have a larger effect on volatility than negative surprises. The implications of the results for broader issues in the finance and economics literatures are also discussed. Published by Elsevier Science B.V.

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1. Introduction

Anecdotal press accounts tend to confirm the common notion that daily fluctuations in stock prices are importantly affected by macroeconomic announcements,

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such as changes in the stance of monetary policy. Yet, a consistent, statistically significant link between macroeconomic news and movements in stock prices has been surprisingly elusive, both for economic data releases in general and for changes in the monetary policy stance in particular.¹

This paper presents new statistical evidence that US stock prices do respond reliably to macroeconomic news conveyed by monetary policy decisions regarding the target federal funds rate, which is the main monetary policy instrument in the United States. Departing from most previous work on the relationship between monetary policy and the stock market – which has primarily focused on the impact of policy decisions on the *level* of stock returns – this paper also emphasizes the potential impact of unanticipated monetary policy on the *volatility* of stock returns.²

I look at the relationship between monetary policy and daily stock market volatility from two vantage points: days around regularly scheduled meetings of the Federal Open Market Committee (FOMC) – the main monetary policymaking body in the United States – and days of actual policy decisions involving the target level of the federal funds rate. Along the first dimension, I examine whether the existence of regularly scheduled policy meetings per se has a measurable effect on stock market volatility.³ Judging from reports in the popular press, the answer to this question would be yes, as evidenced, for instance, by numerous news stories associating days of relative calm in the markets with upcoming FOMC meetings.⁴ I find statistical support for such headlines, but only after taking into account the effects of changes in the monetary policy news arrival process over the years. In particular, such “pre-announcement” effects are present only over the past five years or so, a period when the majority of policy decisions have actually been taken at the FOMC’s regularly scheduled meetings.

Turning to the days of actual policy decisions – regardless of whether they were announced on regularly scheduled meeting days – I find some evidence that such decisions tend to boost volatility in the stock market. As suggested by theory, the effect of policy decisions is greatest if I exclude those decisions that were fully anticipated by market participants. The results also suggest that positive surprises – higher-than-

¹ Empirical analysis of the relationship between macroeconomic data and stock prices includes Berry and Howe (1994), Mitchell and Mulherin (1994), Ederington and Lee (1993), Cutler et al. (1989), Roll (1988), and many others. Recent papers that have focused on how asset prices in general respond to monetary policy actions – proxied by changes in the target federal funds rate – include Bomfim and Reinhart (2000), Kuttner (2000), Roley and Sellon (1998), Thornton (1998), and Reinhart and Simin (1997).

² Chen et al. (1999) also examined monetary policy effects on stock market volatility, but their focus was on the effect of discount rate decisions on stock market volatility. Previously, Castanias (1979) had also examined the relationship between discount rate decisions and the volatility of stock returns.

³ Since 1981, there have been eight regularly scheduled meetings of the FOMC per year, generally with six to eight weeks between meetings. Meeting dates for each year are announced to the public during the second half of the previous year.

⁴ For instance, in the morning of August 24, 1999 – a policy meeting day – a CNNfn news wire noted that trading in the stock market was “very quiet ... amid anticipation that the Federal Reserve would raise interest rates in the afternoon”.

expected values of the target federal funds rate – tend to have a larger effect on volatility than negative surprises, consistent with both the leverage and volatility-feedback hypotheses studied by Black (1976) and French et al. (1987), respectively. On the whole, I find that, from previously depressed levels the day before an FOMC meeting, a surprise increase in the target federal funds rate at that meeting boosts market volatility to well above typical levels.

Besides identifying monetary policy announcements as an important source of short-run volatility in the stock market, this paper also addresses broader issues in the finance literature. First, by looking at policy decisions that were taken both at scheduled FOMC meetings and on other, ad hoc, days, I am able to examine whether the markets respond differently to scheduled and unscheduled announcements.⁵ Second, by focusing on days before regularly scheduled meetings, I examine a topic that has received surprisingly little attention from the literature: The question of whether the imminent release of market-relevant information has a discernible impact on the stock market.⁶ Lastly, the findings call attention to a well-known result that is often overlooked in empirical studies of the relationship between news and volatility: the prediction from theory that it is only the surprise element of any piece of news that should affect asset prices. Indeed, perhaps the failure of many papers in the finance literature to detect a significant relationship between market volatility and the arrival of new information stems from the inability to appropriately distinguish what was truly new in the information released from what had already been built into market prices.⁷

The paper is organized as follows. The next section provides a brief description of the news arrival process for monetary policy, i.e., of how monetary policy decisions have been released to the public over the past decade. I also discuss the theoretical implications of recent changes in the news arrival process for the way the markets react to policy announcements. Section 3 describes the empirical framework that is used to test such implications and compares it to methodologies used in much of the economics and finance literatures to examine the markets' response to economic news. The data set used in the empirical analysis is described in Section 4, which also discusses the derivation of the market-implied policy expectations measure used throughout the paper. Section 5 discusses the results, and Section 6 concludes.

⁵ Two recent empirical papers that also look at this issue include Andersen and Bollerslev (1998), who briefly discuss the potentially different effects on volatility of scheduled versus unscheduled announcements, and Li and Engle (1998), who estimate the degree of persistence heterogeneity regarding the two types of announcements in the Treasury futures market. Kim and Verrecchia (1991) use a theoretical model to examine the effects of scheduled and unscheduled announcements on market participants' information gathering efforts.

⁶ Jones et al. (1998) examine a similar question in the US Treasury securities market, Li and Engle (1998) analyze the Treasury futures market, and French et al. (1989) look at the agricultural futures market.

⁷ Papers that report only a weak relationship between market activity and news include Roll (1988), Cutler et al. (1989), Mitchell and Mulherin (1994), and Berry and Howe (1994).

2. The news arrival process: Public release of monetary policy decisions

My focus is on decisions involving the target level of the federal funds rate, the main monetary policy instrument in the United States. Such decisions have been relayed to the public primarily in two ways.⁸ Until the end of 1993, the Federal Reserve “announced” its intentions regarding the target rate through the size and type of open market operations conducted by its trading desk in New York.⁹ As a result, given that most decisions on the target rate were taken in the afternoon, after the federal funds market was virtually closed, there was usually a one-day lag between the decision and the “announcement”. All that changed in February of 1994, when the FOMC adopted its current practice of issuing formal press releases on the same day a decision to change the target rate is made. Consequently, the lag between decisions and announcements no longer exists.

The timing of policy announcements has also changed since February 1994. Between June 1989 and December 1993, only a relatively small proportion (24%) of all decisions to change the target fed funds rate were taken on regularly scheduled policy meeting days. Since then only three such decisions have been taken outside of scheduled FOMC meetings, with 85% of all policy actions between February 1994 and December 1998 actually taken and formally announced on meeting days.

2.1. *News arrival and market volatility*

In thinking about the potential channels through which monetary policy affects stock market volatility in the short run, finance theory and existing empirical work involving the Treasury securities and futures markets suggest two possibilities. First, there is the potential for pre-announcement effects, the first leg of a phenomenon that Jones et al. (1998) dubbed the “calm-before-the-storm” effect. Jones et al. find that conditional volatility in the Treasury market tends to be lower in the days leading up to releases of major economic data – the “calming” or pre-announcement effect – and then higher on the day of the announcement itself – the “storm” or news effect. Indeed, such phenomenon is routinely reported in the financial press, and is also supported by studies of other financial markets (Li and Engle, 1998; French et al., 1989). Thus, in examining the potential link between market volatility and policy decisions, this paper starts out by looking at the question of whether monetary policy decisions can be linked to statistically significant pre-announcement effects in the stock market.

The second channel through which monetary policy decisions potentially affect market volatility relates to the nature of the decision itself. For instance, the announcement of the policy decision may reveal new information not previously incorporated into asset prices and volatility may rise while market participants process the

⁸ Bomfim and Reinhart (2000) provide a detailed discussion of the disclosure practices adopted by the FOMC over the 1989/98 period.

⁹ Feinman (1993) discusses the types of open market operations used and their signaling content.

newly received information (see, e.g., Harris and Raviv, 1993; Varian, 1989). I shall call this the “news” effect. Note that while the pre-announcement effect is, by definition, independent of the policy decision that is ultimately announced, the news effect is intimately tied to it. In particular, close scrutiny of the news effect should help determine whether monetary policy decisions constitute fundamental news not previously built into stock market prices or whether they are viewed as a reaction to information about the economy that was already in the public domain.¹⁰

2.2. Testable implications

Given the changes in the monetary policy news arrival process described in this section, and based on the theoretical considerations just discussed, this paper formulates two working hypothesis regarding the effect of the monetary policymaking process on the short-run volatility of the stock market. To the extent that FOMC-meeting days are viewed by market participants as days of major economic news, they should leave an imprint on market volatility, and such imprint should be particularly noticeable in the post-1993 sample, when most policy decisions were actually made and announced on FOMC-meeting days. In addition, to the extent that policy decisions affect volatility, it is the element of surprise in such announcements that should matter most. Accordingly, failure to distinguish between anticipated and unanticipated policy decisions would tend to bias the news effect on volatility downwards. Below I describe a modeling framework that allows for formal testing of these theoretical implications.

3. A model of volatility with announcement effects

The empirical model is an extension of the work of Jones et al. (1998) and Andersen and Bollerslev (1997, 1998). In particular, in its general form, the model is characterized by the following set of equations:

$$r_t = x_t' \beta + u_t \quad (1)$$

$$u_t = \sqrt{s_t} e_t \quad (2)$$

$$E(e_t | \Omega_{t-1}) = 0 \text{ and } E(e_t^2 | \Omega_{t-1}) = h_t \quad (3)$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2 \quad (4)$$

¹⁰ Several studies in the economics literature detect little or no effect of monetary policy decisions on the short-run behavior of the stock market – see, e.g., Bomfim and Reinhart (2000) and the references therein. A recent paper by Madura and Schnusenberg (2000) reports a significant effect, but their analysis was limited to bank stock prices. The scope of all these studies, however, was limited to first-moment considerations – policy effects on the level of stock returns – while implicitly assuming that the second moment – the variance of stock returns – remained constant.

Eq. (1) describes the evolution of stock returns, r_t . Accordingly, the conditional mean of daily stock returns is given by $x_t'\beta$, and u_t captures the unpredictable movements in daily returns. As shown in Eq. (2), these movements have two components: (i) a potentially non-normal stochastic element, e_t , with time varying conditional heteroskedasticity $h_t - \Omega_{t-1}$ in Eq. (3) denotes the information set – and (ii) a deterministic scale factor, s_t , which provides the main channel for days of policy announcements to have a separate effect on volatility. Following Bollerslev (1986), e_t is assumed to follow a GARCH(1,1) process, as in Eq. (4).

Eqs. (2) and (3), along with the definition of s_t , imply that the conditional variance of u_t is given by:

$$E(u_t^2 | \Omega_{t-1}) = s_t h_t \quad (5)$$

which in turn implies that return volatility is greater than would be suggested by a simple GARCH(1,1) model on days when s_t is greater than 1.

3.1. Specializing the model

As noted above, one of the issues I examine is whether days around regularly scheduled FOMC meetings significantly affect market volatility. A simple specification for s_t that would be useful in this context is given by:

$$s_t = 1 + \delta_1 I_t^{(\text{FOMC})} + \delta_2 I_t^{(\text{FOMC}^-)} + \delta_3 I_t^{(\text{FOMC}^+)} \quad (6)$$

where $I_t^{(\text{FOMC})}$ is a dummy variable set to one on days of regularly scheduled meetings of the FOMC and zero elsewhere. For instance, if the empirical results were that δ_1 is significantly greater than zero, that would suggest that volatility is boosted on days of regularly scheduled FOMC meetings. $I_t^{(\text{FOMC}^-)}$ is a dummy variable set to 1 on days immediately preceding regularly scheduled meetings of the FOMC and zero elsewhere, and thus a finding that δ_2 is negative would be evidence of the pre-announcement effect. $I_t^{(\text{FOMC}^+)}$ is similarly defined for days immediately following an FOMC meeting.

It is straightforward to see that Eq. (6) can be modified to address the other questions posed by this paper. Indeed, in the next section I shall rely on a dummy variable that is set to 1 on days of announcements that were not fully anticipated by the markets and zero on all other days. To sum up, the empirical framework is such that the conditional volatility of stock returns is explicitly modeled and estimated jointly with the conditional mean specification. More important for the purposes of this paper, the model allows for a direct channel for days of policy announcements and policy meetings to affect volatility.

3.2. Comparison to other empirical studies of announcement effects

The model presented above can be thought of as more general version of a basic framework used in a growing number of studies in the monetary economics literature. These papers essentially follow an event-study approach, in that they are mainly concerned with measuring the financial markets' reaction to monetary policy

actions. At the heart of the event-study approach is the estimation of equations like (1), where the variance of u_t is either assumed to be constant or not modeled explicitly. The vector x_t is supposed to capture a measure of the policy action, and the estimation sample comprises only days of policy action. A typical example is the early work of Cook and Hahn (1989), who examined the Treasury securities market's reaction to monetary policy actions. Cook and Hahn used ordinary least squares to estimate Eq. (1) with x_t' defined as $[1, \Delta f_t]$, where f_t denotes the target federal funds rate, and r_t is redefined to denote the change in a given Treasury yield.

More recently, Roley and Sellon (1998) also estimated a particular version of Eq. (1), both for the Treasury securities and stock markets. In addition to the days of actual changes to the target fed funds rate examined by Cook and Hahn (1989), Roley and Sellon also included days of regularly scheduled FOMC meetings in their sample. Moreover, instead of simply looking at observed changes in the target rate, Roley and Sellon used federal funds futures rates to estimate the element of surprise in each policy decision. Mapping their analysis back to Eq. (1), we would have $x_t' = [1, \Delta f_t^{(u)}]$, where $\Delta f_t^{(u)}$ denotes the difference between actual and expected values of the target rate.¹¹

The model used in this paper differs from the traditional event-study framework in several key respects. First, I explicitly model the time-varying nature of financial market volatility; second, I allow for policy effects both on the level and variance of returns, and, third, I use all daily observations on stock returns, not just those that correspond to days of policy announcements. Nonetheless, the vector x_t in Eq. (1) does incorporate a key feature of traditional event-study approach: It includes a proxy for the change in the markets' perceptions of the near-term monetary policy outlook.¹²

The approach used in this paper also differs in a significant way from other studies undertaken in the finance literature to assess the relationship between news and market volatility. In particular, a common approach used in this literature is to use the number of news items arriving over a given period as a proxy for the information flow hitting the markets at that point in time (e.g. Mitchell and Mulherin, 1994; Jones et al., 1998). One potential drawback of this methodology is that it does not control for the information content of news items and thus does not distinguish anticipated from unanticipated announcements. In this paper, I explicitly address this drawback: While I rely on an analytical framework that is widely used in the news-volatility literature, I modify it by taking steps to isolate the element of surprise in the announcements.¹³

¹¹ Other papers that use similar estimation approaches include Bomfim and Reinhart (2000), Kuttner (2000), and Thornton (1996).

¹² Near-term policy expectations are discussed in detail in the next section.

¹³ Since writing the first draft of this paper, I have come across a recent paper by Li and Engle (1998) that also attempts to isolate the element of surprise in announcements. While I use futures prices to proxy for market participants' expectations, Li and Engle rely on survey data.

4. Data and computation of market-implied expectations

All data are daily and run from June 1989 to December 1998. The beginning of the sample is dictated by the availability of the federal funds futures data, which are used in the construction of the policy expectations measure.¹⁴ Stock returns are proxied by daily percentage changes in the Standard & Poors 500 index. I use Federal Reserve data on policy meeting dates and on the target federal funds rate.¹⁵

While other recent papers have opted to use intraday data to examine the link between economic news and the stock market, the use of daily data here is dictated by the nature of the problem at hand. In particular, the exact time of the day of the change in the target federal funds rate was not always clear to market participants, especially in the first half of the sample when no explicit policy announcements were made by the Federal Reserve. However, as noted by Chen et al. (1999) and many others, a drawback of relying on daily data is to diminish the precision with which the models are estimated and to create the potential for a confounding effect associated with the fact that other economic data could also be released during FOMC-meeting days. For instance, most FOMC meetings take place on a Tuesday and, if Tuesdays tend to be days of significant non-monetary policy data releases, the finding of a significant coefficient on the dummy variable associated with FOMC-meeting days could simply be a reflection of the impact of the other economic data typically released on Tuesdays. Two aspects of the analysis help mitigate such a confounding effect: First, the empirical analysis uses day-of-the-week dummies to control, among other things, for week days that may be more likely to have heavier information flows than others. Second, although most FOMC meetings fall on Tuesdays, they are roughly scheduled six to eight weeks apart and do not systematically coincide with the frequency of any one economic data release.

4.1. Market participants' expectations

As discussed in Section 3, the change in market participants' near-term monetary policy expectations is a potentially important element of x_t in Eq. (1). For any given day in the sample, this variable is defined as the change in the futures rate implied by the contract set to mature at the end of the following month. As of day t , we can write the futures rate implicit in next month's contract as

¹⁴ The Fed funds futures market was established in 1989 by the Chicago Board of Trade, where contracts are currently traded based on the average daily value of the federal funds rate in the current month, as well as several months ahead. Thornton (1996) provides an overview of the nature of the contract, and Krueger and Kuttner (1996) report that expectations derived from fed funds futures contracts are efficient forecasts of the funds rate.

¹⁵ I am interested in FOMC-meeting days to the extent that they correspond to days of scheduled monetary policy announcements. Given that there was a one-day lag between meetings and announcements in most of the pre-1994 sample, what I call an FOMC-meeting day over most of that period is actually the day after the official meeting date.

$$F_t^{(1)} = \left(\sum_{j=t_1}^{t_m} [E(f_j|\Omega_t) + \phi_t^{(j-t)}] \right) (1/(t_m - t_1 + 1)) \quad (7)$$

where t_1 and t_m are the first and last days of next month, respectively. $E(f_j|\Omega_t)$ is the expected value of the Fed funds rate on day j conditional on information available at day t , and $\phi_t^{(j-t)}$ is the corresponding forward premium.

Given Eq. (7), computing the change in near-term policy expectations is straightforward. Following Kuttner (2000), I abstract from changes in forward premiums and write

$$\Delta F_t^{(1)} = \left(\sum_{j=t_1}^{t_m} [E(f_j|\Omega_t) - E(f_j|\Omega_{t-1})] \right) (1/(t_m - t_1 + 1)) \quad (8)$$

It is easy to see that $\Delta F_t^{(1)}$ will be positive (negative) if the information released on day t leads market participants to expect monetary policy to be tighter (easier) in the near term than had been previously thought.

An equation similar to Eq. (8) is also used in the empirical analysis to measure the element of surprise in policy announcements. As discussed in Section 5, that element is measured as the appropriately scaled one-day change in the futures rate corresponding to the current-month contract.

5. Estimation results

I estimate various versions of the general model described in Section 3 using the quasi-maximum likelihood procedure discussed in Bollerslev and Wooldridge (1992). The estimated versions of all specifications discussed in this section allow for day-of-the-week effects on volatility, as well as a lagged dependent variable in the conditional mean equation.¹⁶ Day-of-the-week effects are included in the equation for the scale factor s_t so that we can, for instance, distinguish a potentially significant “Monday effect” from any pre-announcement effect – most FOMC meetings are held on Tuesdays.¹⁷ The inclusion of lagged stock returns in Eq. (1) is also standard in the finance literature, where a small, but statistically significant autocorrelation coefficient is commonly reported for most asset returns (see, e.g., Jones et al. (1998)).

5.1. Pre-announcement effects

I start by estimating a model formed by Eqs. (1)–(4) and (6), which I shall call model 1. As discussed above, model 1 allows me to test whether market volatility

¹⁶ I also estimated versions of the model that allowed for day-of-the-week effects in the conditional mean equation. The main thrust of the findings remained unaffected. These additional results are available upon request.

¹⁷ The finding of significant day-of-the-week effects on asset prices is widely reported in the literature (see, e.g., French, 1980; Jones et al., 1998; Li and Engle, 1998).

is systematically different on days around regularly scheduled FOMC meetings. Estimation results are reported in the first column of Table 1, where all test statistics are computed as in Bollerslev and Wooldridge (1992) and are thus robust to non-normality of u_t .

Looking at the conditional mean equation first, the estimates indicate that near-term revisions in policy expectations have a negative and statistically significant effect on stock returns: For each basis-point increase in the expected average daily value of the funds rate in the following month, daily stock market returns are reduced by 0.04 percentage point.¹⁸ In addition, the results detect a very small but significant degree of autocorrelation in stock returns.

Turning to the conditional variance equations, individual t statistics suggest that volatility is abnormally high on FOMC-meeting days, but no significant effects on volatility are found on either the day before or the day after meetings. Moreover, the statistically significant effect on volatility of FOMC-meeting days should be interpreted with care: A Wald test for the joint hypothesis that the coefficients on all three FOMC-day dummies are zero cannot be rejected at the 10% significance level.

Judging from the results for model 1, the popular notion that the markets are calmer than normal on days leading up to FOMC meetings does not appear to have empirical support. Indeed, not only there appears to be no “calm” before the storm, but one might even question whether the data support the notion of the storm itself – the idea that volatility is boosted on FOMC-meeting days. Model 1 suggests that days around regularly scheduled FOMC meetings are apparently just like other days and leave no statistically significant imprint on the daily volatility of stock returns.

Still, model 1 misses an important aspect of reality. As discussed in Section 2, the news arrival process for monetary policy decisions changed significantly in 1994, and the FOMC’s new policy disclosure practices suggest that policy meeting days might have become more important in the eyes of market participants since then. To test for this hypothesis I replace Eq. (6) in model 1 with the following:

$$s_t = 1 + \delta_1 I_t^{(\text{FOMC})} + \delta_2 I_t^{(\text{FOMC}^-)} + \delta_3 I_t^{(\text{FOMC}^+)} + I_t^{(94)} (\delta_4 I_t^{(\text{FOMC})} + \delta_5 I_t^{(\text{FOMC}^-)} + \delta_6 I_t^{(\text{FOMC}^+)}) \quad (9)$$

where $I_t^{(94)}$ is a dummy variable set to 1 on days since the beginning of 1994 and zero before then.

¹⁸ The finding of a significant coefficient on the expectations revision measure stands in marked contrast with results reported in the event-study literature, which generally have found no significant short-run policy effects on daily returns – see, e.g., Roley and Sellon (1998). At least two factors help explain the difference in findings. First, I focus on all days when the market was open and not just on days of policy action, as is customary in the event-study literature. Thus, my measure of expectations revisions captures not just the market’s reaction to a policy announcement, but also its reassessment of the policy outlook in light of new information extracted from economic data released on non-policy days. Second, unlike the event-study literature, I explicitly model the time-varying nature of return volatility.

Table 1

Are policy meeting days special?

$$r_t = \beta_0 + \beta_1 \Delta F_t^{(1)} + \beta_2 r_{t-1} + u_t, \quad u_t = \sqrt{s_t} e_t, \quad E(e_t | \Omega_{t-1}) = 0 \text{ and } E(e_t^2 | \Omega_{t-1}) = h_t,$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2,$$

$$s_t = 1 + \delta_1 I_t^{(\text{FOMC})} + \delta_2 I_t^{(\text{FOMC}^-)} + \delta_3 I_t^{(\text{FOMC}^+)} + I_t^{(94)} (\delta_4 I_t^{(\text{FOMC})} + \delta_5 I_t^{(\text{FOMC}^-)} + \delta_6 I_t^{(\text{FOMC}^+)})$$

	Model 1	Model 2
β_0	0.047 (3.321)	0.044 (3.173)
β_1	-0.040 (-7.612)	-0.040 (-7.565)
β_2	0.051 (2.378)	0.050 (2.335)
α_0	0.005 (2.382)	0.006 (2.321)
α_1	0.946 (94.217)	0.946 (93.376)
α_2	0.050 (4.966)	0.049 (4.942)
δ_1	0.463 (2.161)	0.682 (2.052)
δ_2	-0.135 (-0.861)	0.041 (0.182)
δ_3	-0.052 (-0.425)	-0.135 (-0.541)
δ_4		-0.474 (-1.192)
δ_5		-0.527 (-2.293)
δ_6		0.152 (0.526)
<i>Hypothesis tests (P-values for Wald statistics)</i>		
$\delta_1 = \delta_2 = \delta_3 = 0$	0.115	
$\delta_4 = \delta_5 = \delta_6 = 0$		0.066
$\delta_i = 0, \text{ for } i = 1, 6$		1.418e-12

Note: Robust *t*- and Wald statistics are calculated using the procedure described in Bollerslev and Wooldridge (1992). Robust *t*-statistics are shown in parenthesis. All variables are defined in the text ($N = 2414$).

I shall denote the system formed by Eqs. (1)–(4) and (9) as model 2. Eq. (9) allows FOMC-meeting days to have different effects on volatility in the pre-1994 and post-1993 periods. Estimation results are summarized in the second column of Table 1. Consistent with our working hypothesis, individual *t* statistics suggest significant calm-before-the-storm effects, in that conditional volatility is depressed on days preceding regularly scheduled post-1993 FOMC meetings – the pre-announcement effect (δ_5 is significantly negative) – and boosted, over the entire sample, on FOMC days – the news effect (δ_1 is significantly positive). Moreover, the Wald statistic for the joint hypothesis that all 3 post-1993 dummies have zero coefficients – implying no difference between the two subsamples – is rejected at the 7% significance level, and the Wald statistic for the joint hypothesis of no FOMC-meeting day effects

across the entire 1989/98 sample can be rejected with 1% significance. Thus, model 2 provides some evidence of both pre-announcement and news effects and is consistent with the calm-before-the-storm hypothesis, although pre-announcement effects are evident only after the FOMC adopted the practice of making its policy decisions mostly during the days of regularly scheduled FOMC meetings.

5.2. How do policy decisions affect volatility?

The analysis now turns to a restricted version of model 2 and takes a closer look at the news effect, i.e., to the potentially positive effect of policy announcements on conditional volatility. I impose the following restrictions on model 2:

$$H_0: \delta_2 = \delta_3 = \delta_4 = \delta_6 = 0$$

and find that they cannot be jointly rejected even at the 10% significance level. In estimating the restricted system, I also expand the coverage of the news effect to include not just days of scheduled FOMC meetings, but also all other days when the target federal funds rate was changed. The restricted model, which I shall call model 3, is formed by Eqs. (1)–(4) and (10), shown below:

$$s_t = 1 + \delta_1 I_t^{(A)} + \delta_5 (I_t^{(94)} I_t^{(\text{FOMC}^-)}) \quad (10)$$

where $I_t^{(A)}$ is set to one on policy announcement days – defined as FOMC-meeting days and other days of policy action – and zero elsewhere.

Estimation results, reported in the first column of Table 2, confirm the findings based on model 2: The pre-announcement effect is significant in the post-1993 sample – conditional volatility is about 1/2 its typical level on the day before scheduled FOMC meetings – and the news effect is significant over the entire sample – conditional volatility is about 40% above typical levels on days of FOMC decisions. The joint hypothesis that these effects are zero can be rejected at the 1% significance level.

5.3. The informational content of announcements

Model 3 makes no distinction between those FOMC decisions that were fully anticipated by market participants and those that were not. Yet, theory suggests that it is only the element of surprise in news releases that should affect market prices. I address this issue in model 4, which is identical to model 3, except that I replace $I_t^{(A)}$ with the indicator variable $I_t^{(S)}$, set to one on days of policy surprises and zero elsewhere.

$$s_t = 1 + \delta_1 I_t^{(S)} + \delta_5 (I_t^{(94)} I_t^{(\text{FOMC}^-)}) \quad (11)$$

To measure the element of surprise in the policy announcements, I rely on the methodology used and described in Kuttner (2000). In particular, I define the element of surprise on the day of the policy announcement as the appropriately scaled one-day change in the federal funds futures rate implied by the current-month contract:

$$\Delta F_t^{(0)} = \gamma_t (f_t - E(f_t | \Omega_{t-1})) \quad (12)$$

Table 2

How do policy announcements affect volatility?

$$r_t = \beta_0 + \beta_1 \Delta F_t^{(1)} + \beta_2 r_{t-1} + u_t, \quad u_t = \sqrt{s_t} e_t, \quad E(e_t | \Omega_{t-1}) = 0 \quad \text{and} \quad E(e_t^2 | \Omega_{t-1}) = h_t,$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2,$$

$$s_t = 1 + \delta_{11} I_t^{(A)} + \delta_{12} I_t^{(S)} + \delta_5 I_t^{(94)} I_t^{(\text{FOMC-})}$$

	Model 3	Model 4
β_0	0.045 (3.191)	0.046 (3.275)
β_1	-0.040 (-7.480)	-0.041 (-7.597)
β_2	0.049 (2.290)	0.049 (2.306)
α_0	0.006 (2.424)	0.006 (2.394)
α_1	0.945 (94.494)	0.946 (95.324)
α_2	0.050 (5.021)	0.049 (5.060)
δ_{11}	0.423 (2.336)	
δ_{12}		0.792 (2.731)
δ_5	-0.487 (-7.793)	-0.486 (-7.802)
<i>Hypothesis tests (P-values for Wald statistics)</i>		
$\delta_{11} = \delta_5 = 0$	1.387e-14	

Note: Robust *t*- and Wald statistics are calculated using the procedure described in Bollerslev and Wooldridge (1992). Robust *t*-statistics are shown in parenthesis. All variables are defined in the text ($N = 2414$).

where γ_t is a deterministic function of the length and number of days remaining in the current month.¹⁹

Estimation results for model 4 are reported in the second column of Table 2. Restricting our attention to days of surprise announcements has the effect of nearly doubling the news effect relative to model 3. In particular, while the pre-announcement effect remains unchanged at about -0.49, the magnitude of the news effect increases from 0.42 in model 3 to 0.79 in model 4. Both effects are highly significant, with the joint hypothesis that they are zero being rejected at the 1% level.

5.4. Same-day response to scheduled versus unscheduled policy announcements

We have already detected one important difference in the way the stock market responds to scheduled versus unscheduled announcements: Scheduled announcements

¹⁹ In theory, the right-hand side of Eq. (12) would also include a term involving changes in forward premiums. To address potential concerns about ignoring these changes, the estimation of model 4 effectively defines a surprise as a (scaled) change in the current month's futures rate in excess of two basis points. I have experimented with different thresholds for the definition of what constitutes a surprise and generally found that the main results are unaffected.

produce calm-before-the-storm effects; unscheduled announcements, by definition, do not. In addition, the fact that policy decisions have been announced both on regularly scheduled FOMC days and on days between FOMC meetings allows us to test the following hypothesis: Does the markets' same-day response to policy news vary according to whether the date of the announcement had been previously scheduled? To address this question, I modify the s_t equation in model 4 to allow for different effects on volatility from scheduled and unscheduled announcements:

$$s_t = 1 + \delta_1 I_t^{(SS)} + \delta_2 I_t^{(SU)} + \delta_5 I_t^{(94)} I_t^{(FOMC-)} \quad (13)$$

where $I_t^{(SS)}$ is a dummy variable set to 1 on days of surprise announcements released on regularly scheduled days – days of FOMC meetings – and $I_t^{(SU)}$ is analogously defined for non-FOMC-meeting policy surprises.

Estimation results for the system formed by Eqs. (1)–(4) and (13), labeled model 5, are reported in Table 3. The null of no differences between the one-day responses of market volatility to scheduled and unscheduled announcements cannot be rejected at the 20% significance level. Therefore, the evidence suggests that uncertainty about the timing of the announcement does not appear to affect the magnitude of the announcement effect on market volatility. This result should be taken with caution, however, in that some of the days that we have labeled as days of unscheduled announcements might actually have been perceived differently by market participants. For instance, Reinhart and Simin (1997) point out that seven of the 24 policy actions taken over the 1989–1992 period took place on days of monthly employment releases.²⁰

5.5. Is the effect of policy news symmetric?

Thus far the analysis has assumed that policy surprises have a symmetric effect on volatility. The work of Black (1976), French et al. (1987), Nelson (1991), and many others suggests otherwise, implying that positive interest rate surprises – funds rate higher than expected – have a stronger effect on volatility than do negative surprises.²¹ To test for asymmetric policy effects, I change model 4 as follows:

$$r_t = x_t' \beta + u_t \quad (14)$$

$$u_t = \sqrt{s_t} e_t \quad (15)$$

$$E(e_t | \Omega_{t-1}) = 0 \text{ and } E(e_t^2 | \Omega_{t-1}) = h_t \quad (16)$$

²⁰ Li and Engle (1998) and Andersen and Bollerslev (1998) have also examined the potentially different market reaction to scheduled and unscheduled announcements. For instance, Li and Engle report differing degrees of persistence in the response of volatility in the Treasury futures market to the two announcement types.

²¹ Black suggests that the so-called leverage effect is behind this asymmetry. In particular, higher interest rates induce higher leverage ratios, which in turn increase the risk associated with holding stocks and the volatility of stock returns. An alternative explanation is the volatility-feedback effect, examined by French et al. (1987). (Engle and Ng (1993) and Bollerslev et al. (1993) provide a more recent discussion of the leverage and volatility-feedback hypotheses and associated literature.)

Table 3

The effects of scheduled and unscheduled announcements

$$r_t = \beta_0 + \beta_1 \Delta F_t^{(1)} + \beta_2 r_{t-1} + u_t, \quad u_t = \sqrt{s_t} e_t, \quad E(e_t | \Omega_{t-1}) = 0 \text{ and } E(e_t^2 | \Omega_{t-1}) = h_t,$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2,$$

$$s_t = 1 + \delta_1 I_t^{(SS)} + \delta_2 I_t^{(SU)} + \delta_5 I_t^{(94)} I_t^{(FOMC-)}$$

	Model 5
β_0	0.045 (3.250)
β_1	-0.041 (-7.638)
β_2	0.049 (2.314)
α_0	0.006 (2.366)
α_1	0.946 (95.133)
α_2	0.049 (5.040)
δ_1	0.957 (2.604)
δ_2	0.308 (0.940)
δ_5	-0.485 (-7.813)
<i>Hypothesis tests (P-values for Wald statistics)</i>	
$\delta_1 = \delta_2$	0.266

Note: Robust *t*- and Wald statistics are calculated using the procedure described in Bollerslev and Wooldridge (1992). Robust *t*-statistics are shown in parenthesis. All variables are defined in the text ($N = 2414$).

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2 \tag{17}$$

$$s_t = 1 + \delta_1 I_t^{(S, \text{pos})} + \delta_2 I_t^{(S, \text{neg})} + \delta_5 I_t^{(FOMC-)} I_t^{(94)} \tag{18}$$

and call it model 6. Eqs. (15)–(17) are identical to the corresponding ones in model 4, but the conditional mean and s_t equations are changed to explicitly allow for an asymmetric effects of policy news on the first and second moments of stock returns. In particular, x_t in Eq. (14) is redefined to be $[1, \Delta F_t^{(1, \text{pos})}, \Delta F_t^{(1, \text{neg})}, r_{t-1}]'$, where $\Delta F_t^{(1, \text{pos})}$ and $\Delta F_t^{(1, \text{neg})}$ are vectors containing positive and negative revisions to near-term policy expectations, and $I_t^{(S, \text{pos})}$ and $I_t^{(S, \text{neg})}$ in Eq. (18) are dummy variables corresponding to days of positive and negative surprises, respectively.

Estimation results are summarized in Table 4. The Wald test for the null of symmetric effects on the level of stock returns cannot be rejected at usual significance levels, but the same test for the volatility of stock returns is comfortably rejected at 5% significance. Thus, a positive policy surprise – an announced value for the target federal funds rate that exceeds the market’s expectations – tends to boost stock market volatility in the short run by significantly more than negative surprises, a result that is consistent with the leverage and volatility-feedback hypotheses.

Table 4

Is the effect of policy announcements symmetric?

$$r_t = \beta_0 + \beta_{11}\Delta F_t^{(1,\text{pos})} + \beta_{12}\Delta F_t^{(1,\text{neg})} + \beta_2 r_{t-1} + u_t, \quad u_t = \sqrt{s_t}e_t, \quad E(e_t|\Omega_{t-1}) = 0 \quad \text{and} \quad E(e_t^2|\Omega_{t-1}) = h_t,$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2,$$

$$s_t = 1 + \delta_1 I_t^{(S,\text{pos})} + \delta_2 I_t^{(S,\text{neg})} + \delta_5 I_t^{(94)} I_t^{(\text{FOMC-})}$$

	Model 6
β_0	0.059 (3.618)
β_{11}	-0.052 (-5.165)
β_{22}	-0.033 (-4.883)
β_2	0.047 (2.201)
α_0	0.006 (2.403)
α_1	0.945 (95.071)
α_2	0.050 (5.118)
δ_1	1.648 (2.667)
δ_2	0.253 (1.066)
δ_5	-0.490 (-8.107)
<i>Hypothesis tests (P-values for Wald statistics)</i>	
$\beta_{11} = \beta_{12}$	0.139
$\delta_1 = \delta_2$	0.034
$\beta_{11} = \beta_{12}$ and $\delta_1 = \delta_2$	0.032

Note: Robust *t*- and Wald statistics are calculated using the procedure described in Bollerslev and Wooldridge (1992). Robust *t*-statistics are shown in parenthesis. All variables are defined in the text ($N = 2414$).

5.6. Relation to previous results reported in the literature

The finding of a significant pre-announcement effect in the stock market is consistent with results obtained by Jones et al. (1998) for the Treasury securities market and by Li and Engle (1998) and French et al. (1989) for the Treasury and agricultural futures market, respectively. Although reports of this phenomenon are common in the financial press, which generally attributes it to market participants' unwillingness to trade just ahead of the release of a significant piece of news, the theoretical literature has been relatively silent on this issue. The results presented in this paper reinforce the need for developing market microstructure models that explicitly allow volume, volatility, and information acquisition to interact in an environment with pre-determined news arrival times.²²

²² Indeed, the results of very preliminary work suggest that trading volume in the NYSE tends to be depressed in the days before FOMC meetings.

As for the news effect, the results reported in this paper also have useful implications for broader issues in the finance literature. The small and sometimes only marginally significant effect of announcements on stock market volatility – reported for models 1 through 3 – is broadly consistent with a number of papers in the finance literature – e.g., Berry and Howe (1994) and Mitchell and Mulherin (1994). However, as discussed above, models 1 through 3 suffer from one important drawback: They failed to distinguish what was truly news in the announcements from what had already been anticipated by market participants, a failure that is also present in a surprisingly large number of papers in the literature. Indeed, as suggested by the results for model 4, the news effect nearly doubled once I took steps to isolate the element of surprise in the announcement.

Lastly, the finding that policy surprises induce greater volatility is consistent with finance models that maintain that the release of public information induces greater volatility – e.g., Harris and Raviv (1993), Foster and Viswanathan (1993), and Varian (1989) – and with the existence of an asymmetric relationship between news and volatility – Black (1976), French et al. (1987), and Nelson (1991).

6. Concluding remarks

In examining the relationship between the stock market and monetary policy, this paper combined two different approaches widely used in the monetary economics and finance literatures. Financial economists have long considered the effects of releases of economic data on the volatility of asset markets by examining what happens to market volatility on news arrival dates. Meanwhile, monetary economists have examined how monetary policy surprises affect the level of stock prices by relating the element of surprise in the policy decision to the change in asset prices following the announcement of the decision. Each camp has met with only limited success in detecting a measurable relationship between news and stock prices: Several papers in the finance literature have highlighted the weak connection between the volatility of stock prices and identifiable news releases, and a majority of studies in the monetary economics literature has been unable to detect a statistically significant relationship between one-day changes in stock prices and monetary policy surprises. This paper argues that the two literatures can learn from one another. On the one hand, the finance literature's focus on economic announcements per se, without always controlling for the element of surprise in such announcements, might help explain why so many studies have failed to find a significant link between market volatility and economic news. On the other hand, by either implicitly assuming that the conditional volatility of stock returns is time invariant or by simply leaving its time-varying nature unspecified, monetary economists have failed to consider a potentially significant effect of policy surprises on the short-run behavior of the market.

The findings reported in this paper raised important questions for future work. In particular, in analyzing the market's response to scheduled and unscheduled announcements, a potentially interesting issue is whether the corresponding impulse response functions for volatility are significantly different (Li and Engle, 1998). Other

issues that also merit further consideration include a closer look at the relationship between first- and second-moment responses to policy news and the explicit analysis of risk premiums around announcement days, as in Jones et al. (1998). Lastly, the finding of highly significant pre-announcement effects in the stock market suggests a topic that deserves closer consideration by the market microstructure literature.

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References

- Andersen, T., Bollerslev, T., 1997. Intraday periodicity and volatility persistence in financial markets. *Journal of Empirical Finance* 4, 115–158.
- Andersen, T., Bollerslev, T., 1998. Deutsche Mark-Dollar volatility: Intraday activity patterns, macroeconomic announcements, and longer run dependencies. *Journal of Finance* 53, 219–265.
- Berry, T., Howe, K., 1994. Public information arrival. *Journal of Finance* 49, 1331–1346.
- Black, F., 1976. Studies in stock price volatility changes. *Proceedings of the 1976 Meetings of the American Statistical Association, Business and Economics Statistics Section*, pp. 177–181.
- Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics* 31, 307–327.
- Bollerslev, T., Chou, R., Kroner, K., 1993. ARCH modeling in finance: A review of the theory and empirical evidence. *Journal of Econometrics* 52, 5–59.
- Bollerslev, T., Wooldridge, J., 1992. Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances. *Econometric Reviews* 11, 143–172.
- Bomfim, A., Reinhart, V., 2000. Making news: Financial market effects of Federal Reserve disclosure practices, manuscript. Federal Reserve Board.
- Castanias, R., 1979. Macroinformation and the variability of stock market prices. *Journal of Finance* 34, 439–450.
- Chen, C., Mohan, N., Steiner, T., 1999. Discount rate changes, stock market returns, volatility and trading volume: Evidence from intraday data and implications for market efficiency. *Journal of Banking and Finance* 23, 897–924.
- Cook, T., Hahn, T., 1989. The effect of changes in the federal funds rate target on market interest rates in the 1970s. *Journal of Monetary Economics* 24, 331–351.
- Cutler, D., Poterba, J., Summers, L., 1989. What moves stock prices? *Journal of Portfolio Management* 15, 4–12.
- Ederington, L., Lee, J., 1993. How markets process information: News releases and volatility. *Journal of Finance* 48, 1161–1191.
- Engle, R., Ng, V., 1993. Measuring and testing the impact of news on volatility. *Journal of Finance* 48, 1749–1778.
- Feinman, J., 1993. Estimating the open market desk's daily reaction function. *Journal of Money, Credit, and Banking* 25, 231–247.

- Foster, F.D., Viswanathan, S., 1993. Variations in trading volume, return volatility and trading costs: Evidence on recent price formation models. *Journal of Finance* 48, 187–211.
- French, K., 1980. Stock returns and the weekend effect. *Journal of Financial Economics* 8, 55–69.
- French, K., Leftwich, R., Uhrig, W., 1989. The effect of scheduled announcements on futures markets, manuscript. University of Chicago.
- French, K., Schwert, W., Stambaugh, R., 1987. Expected stock returns and volatility. *Journal of Financial Economics* 19, 3–29.
- Harris, M., Raviv, A., 1993. Difference of opinion make a horse race. *Review of Financial Studies* 6, 473–506.
- Jones, C., Lamont, O., Lumsdaine, R., 1998. Macroeconomic news and bond market volatility. *Journal of Financial Economics* 47, 315–337.
- Kim, O., Verrecchia, R., 1991. Market reaction to anticipated announcements. *Journal of Financial Economics* 30, 272–309.
- Krueger, J., Kuttner, K., 1996. The Fed funds futures rate as a predictor of Federal Reserve policy. *Journal of Futures Markets* 16, 865–879.
- Kuttner, K., 2000. Monetary policy surprises and interest rates: Evidence from the Fed funds futures market, manuscript. Federal Reserve Bank of New York.
- Li, L., Engle, R., 1998. Macroeconomic announcements and volatility of treasury futures. Department of Economics Discussion paper 98-27, University of California, San Diego.
- Madura, J., Schnusenberg, O., 2000. Effect of Federal Reserve policies on bank equity returns. *Journal of Financial Research* 23, 421–447.
- Mitchell, M., Mulherin, J.H., 1994. The impact of public information on the stock market. *Journal of Finance* 49 (3), 923–950.
- Nelson, D., 1991. Conditional heteroskedasticity in asset returns: A new approach. *Econometrica* 59, 347–370.
- Reinhart, V., Simin, T., 1997. The market reaction to Federal Reserve policy action from 1989 to 1992. *Journal of Economics and Business* 49, 149–168.
- Roley, V., Sellon, G., 1998. Market reaction to monetary policy nonannouncements. Federal Reserve Bank of Kansas City. Research working paper 98-06.
- Roll, R., 1988. R^2 . *Journal of Finance* 43, 541–566.
- Thornton, D., 1996. Does the Fed's new policy of immediate disclosure affect the market. Federal Reserve Bank of St. Louis Review 78 (6), 77–88.
- Thornton, D., 1998. Tests of the market's reaction to federal funds rate target changes. Working paper. Federal Reserve Bank of St. Louis.
- Varian, H., 1989. Differences of opinion in financial markets. In: Stone, C. (Ed.), *Financial risk: Theory, evidence and implications*, Proceedings of the Eleventh Annual Economic Policy Conference of the Federal Reserve Bank of St. Louis. Kluwer, Boston, MA.