What Explains the Stock Market's Reaction to Federal Reserve Policy?

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Abstract

This paper analyzes the impact of unanticipated changes in the Federal funds target on equity prices, with the aim of both estimating the size of the typical reaction, and understanding the reasons for the market's response. On average over the May 1989 to December 2001 sample, a "typical" unanticipated 25 basis point rate cut has been associated with a 1.3 percent increase in the S&P 500 composite index. The estimated response varies considerably across industries, with the greatest sensitivity observed in cyclical industries like construction, and the smallest in mining and utilities. Very little of the market's reaction can be attributed to policy's effects on the real rate of interest or future dividends, however. Instead, most of the response of the current excess return on equities can be traced to policy's impact on expected future excess returns. JEL codes: E44, G12.

1 Introduction

The reaction of the stock market to monetary policy is clearly a topic of intense interest both to market participants and policymakers. Those holding equities would obviously like to know how possible Federal Reserve actions might affect the value of their portfolios. Similarly, an estimate of the likely effect of policy on asset prices is an important ingredient in assessing the transmission of monetary policy through the "wealth effect." The size of and

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reasons for the market's response to policy are not yet clearly understood, however, in part because of the interdependence between asset prices, monetary policy, and macroeconomic conditions.

The overall goal of this paper is to analyze the reaction of equity prices to monetary policy, using a market-based measure of unanticipated policy actions to isolate more cleanly the effects of policy. One specific objective is to document and quantify the stock market's response to monetary policy actions, both in the aggregate and for a variety of industry classifications. A second objective is to determine the reasons for the stock market's response, i.e., the extent to which the reaction can be traced to the impact of policy on (expectations of) future real interest rates and dividends.

Estimating the response of equity prices to monetary policy actions is not as easy as it may seem, however, as the market is unlikely to respond to policy actions that were already anticipated. Distinguishing between expected and unexpected policy actions is therefore essential for discerning their effects. A natural way to do this is to use the technique proposed by Kuttner (2001), which uses Fed funds futures data to construct a measure of "surprise" rate changes.[1] Explaining the market's response is harder still, as it requires an assessment of how those policy surprises affect expectations of *future* interest rates and excess returns. To do this, we adapt the procedure developed by Campbell (1991) and Campbell and Ammer (1993), which uses a vector autoregression (VAR) to calculate revisions in expectations of future interest rates, stock returns, and dividends.

The results presented in section 2 of the paper show that the market does indeed react strongly to surprise funds rate changes. For those days on which funds rate target was changed, the S&P500 registers a gain of roughly 1.3 percent in response to a surprise 25

[1] Alternatives measures exist: Cochrane and Piazzesi (2002) propose using the change in term eurodollar rates, while Rigobon and Sack (2002) utilize the eurodollar futures rate. While these measures provide useful gauges of interest rate expectations over a slightly longer horizon, Gürkaynak, Sack and Swanson (2002) show that Fed funds futures do the best job of forecasting target rate changes at a one- to five-month horizon.

basis point easing. The market reacts little, if at all, to the component of funds rate changes that are anticipated by futures market participants. The market's response to surprise policy actions varies considerably across industries, however, with the largest response in the construction sector. Mining, utilities and wholesale trade show little response.

Section 3 takes up the question of what explains equity prices' response. It turns out that only a small portion of equities' excess return variance can be explained by the effects of real interest rates or dividends; most is attributed to the induced time variation in expected excess equity returns. So while an unanticipated rate cut generates an immediate increase in equity prices, it is followed by an extended period of lower-than-normal excess returns. One interpretation of this result is that monetary policy surprises are for some reason associated with changes in the equity premium. But in the absence of a fully-developed asset pricing model, it is impossible to distinguish this interpretation from a market overreaction.

Naturally, this is not the first paper to deal with the connection between monetary policy, equity prices, and the macroeconomic environment. One recent paper is by Rigobon and Sack (2002), who estimated the contemporaneous impact of monetary policy on bond and stock prices using a novel estimator exploiting the heteroskedasticity introduced by unexpected policy actions. Other papers in this vein include Jensen, Johnson and Mercer (1996), Jensen and Mercer (1998), who examined the disaggregated response of stock prices to changes in the discount rate. Boyd, Jagannathan and Hu (2001) focused on equity prices' response to unemployment news, rather than monetary policy; but their explanation for the market's "perverse" reaction (i.e., the association of higher-than-expected unemployment with increases in equity prices) has to do with the presumed response of monetary policy. Goto and Valkanov (2000) examined the policy-induced covariance between equity prices and inflation, using policy shocks obtained from a conventional identified vector autoregression (VAR) model. Taking a less structured approach, Fair (2002) identified the largest changes in equity prices at 1- to 5-minute intervals, and found that nearly one-third of those were associated with news about monetary policy. For the most part, however, these papers have focused narrowly on the question of *how* the market responds, rather than *why*; our aim is to address both of these issues within a single framework.

2 Equities' reaction to target rate changes

This section focuses on the immediate impact of monetary policy on equity prices, both for broad stock market indices, and for individual industries. As noted in the introduction, however, one difficulty inherent in measuring policy's effects is that asset markets are forward looking, and hence tend to incorporate any information about anticipated policy changes. Some effort is therefore required to isolate the unexpected, or "surprise" policy change which might plausibly generate a market response. This does not say that asset prices respond to monetary policy only when the Fed surprises the markets, of course. Naturally, asset prices will also respond to revisions in *expectations* about future policy, which in turn may be driven by news about changing economic conditions. Unexpected policy actions merely represent convenient "natural experiments" which allow us to gauge the market reaction.

One convenient, market-based way to identify unexpected funds rate changes relies on the prices of Fed funds futures contracts, which embody expectations of the effective Fed funds rate, averaged over the settlement month.[2] Krueger and Kuttner (1996) found that the Fed funds futures rates did a good job of forecasting, efficiently incorporating available data on the likely policy actions. Kuttner (2001) subsequently used this approach to estimate the response of the term structure to monetary policy. The analysis in this section uses a similar approach to gauging the response of equity prices to unanticipated changes in the Fed funds rate from June 1989 through December 2001. A parallel set of results is then

[2]The Federal funds rate was either implicitly or explicitly the operating instrument of Federal Reserve policy over the period analyzed.

presented using policy surprises defined at a monthly frequency.

2.1 Measuring the surprise element of policy actions

A measure of the surprise element of any specific change in the Fed funds target (which was either implicitly or explicitly the operating instrument of Federal Reserve policy over the period analyzed) can be derived from the change in the futures contract's price relative to the day prior to the policy action. Specifically, the "surprise" target rate change can be calculated as the change in the "spot month" (i.e., for the month in which the target is changed) Fed funds futures rate on the day of the rate change, scaled up by a factor related to the number of days in the month affected by the change,

$$\Delta \hat{r}_t^u = \frac{m}{m-t}\left(f_{s,t}^0 - f_{s,t-1}^0\right) \;, \tag{1}$$

where $\hat{r}^u$ is the unexpected target rate change, $f_{s,t}^0$ is the spot-month futures rate on day t of month s, and m is the number of days in the month.[3] The expected component of the rate change is simply defined as the actual minus the surprise, or

$$\Delta \hat{r}_t^e = \Delta \hat{r}_t - \Delta \hat{r}_t^u \;. \tag{2}$$

Getting the timing right is crucial for the analysis of daily data. Before 1994, when the Fed began announcing changes in the funds rate target, markets generally became aware of policy actions on the day after the decision, when it was implemented by the open market desk. Any funds rate surprises, therefore, are assumed to have occurred on the day after the FOMC's decision.

December 18 1990, is an exception to this rule, however. On that day, the Fed took the unusual step of announcing a 50 basis point cut in the discount rate immediately following

[3] As discussed in Kuttner (2001), when the rate change comes on the first day of the month, $f_{s-1,m}^1$ would be used instead of $f_{s,t-1}^0$. Also, to avoid amplifying any month-end noise, when the rate change falls on one of the last three days of the month, the unscaled change one-month futures rate is used instead of the change in the spot month rate.

the FOMC meeting, this was widely (and correctly) interpreted as signaling a 25 bp funds rate cut. The decision was public at 3:30 p.m., after the close of the futures market, but before the close of the stock market.[4] Because of this unusual timing, the funds rate cut is assumed to have occurred on the 18th, and the difference between the opening future rate on the 19th and the closing rate on the 18th is used to calculate the surprise.

The announcement of target rate changes, which began in February 1994, eliminates anomalies like that of December 18, 1990. Because the change in the target rate is generally announced prior to the close of the futures market, the futures rate generally incorporates any news about monetary policy. But the post-1994 period also includes one occasion — October 15, 1998 — on which an action was announced after the close of the futures markets. Consequently, the difference between the opening rate on the 16th and the closing rate on the 15th is used to calculate the surprise.

2.2 A word on endogeneity

An important issue in this analysis is that of endogeneity, which could arise from three distinct sources. One possible source would be a direct response of monetary policy to stock market fluctuations. Empirical work on the Federal Reserve's reaction function has generally failed to find such a response, however. [See, for example, Bernanke and Gertler (1999).]

A second possible source of endogeneity is a joint response of policy and the stock market to new information. For example, the release of data indicating weaker-than-expected economic growth might plausibly lead to both a decline in the stock market, and to a cut in the target Fed funds rate. This is probably not an issue for surprises measured at a daily frequency, however, as a same-day response by the FOMC to new information would be highly unlikely. Thus, it is reasonable to interpret the surprises defined in this way as mon-

[4] See Wessel (1990).

etary policy "shocks," in the sense that they do not incorporate an endogenous reaction to macroeconomic developments.[5] The September 17, 2001 rate cut is an important exception, however: the market's sharp decline and the Fed's 50 bp rate cut were both (at least in part) responses to the preceding week's terrorist attacks. A similar co-movement would be observed if market participants believed the Fed's policy actions incorporated a response to private information. Stocks could fall on a rate cut, for example, if investors inferred from the Fed's actions that the economy was weaker than they had previously thought.

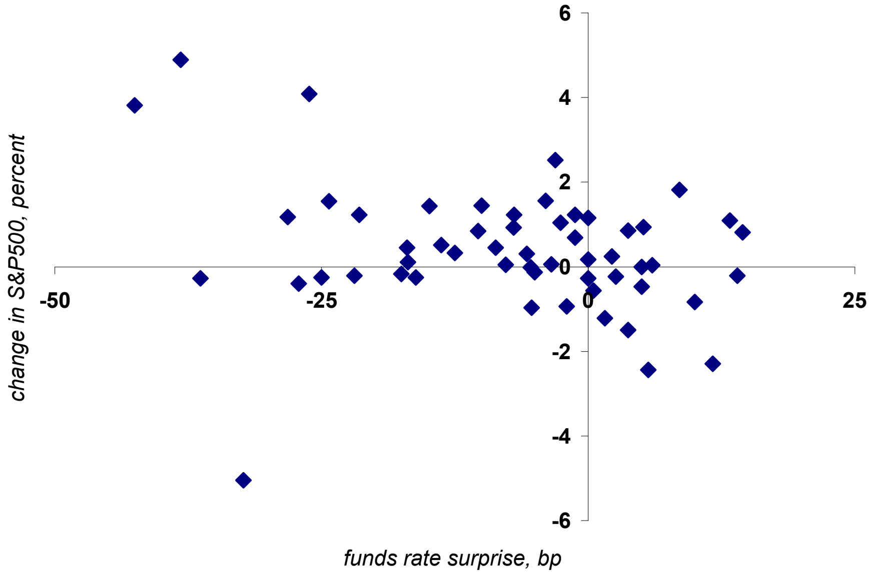
If any form of endogeneity were present, then an instrumental variables procedure, such as the heteroskedasticity-based estimator proposed by Rigobon and Sack (2002), would be required to obtain an unbiased estimate. However it is important to note that to the extent that this endogeneity exists, it would tend introduce a *downward* bias in the stock market's estimated response to monetary policy. And in any case, our results do not depend on the assumption that the FOMC bases its decision on publicly released data. Our approach is still valid, even if measured funds rate surprises include a response to private information — and indeed it provides some insight into what that information might be. Consequently, we need not take a stand on whether these surprises move markets because they represent true policy shocks, or because they reveal private information.

2.3 Results for rate change days

We start by documenting the effects of surprise policy actions on various measures of stock prices. A scatterplot of the one-day percentage change in the S&P 500 composite index against the Fed funds surprises appears in figure 1, for those days on which the funds rate target was changed. A negative correlation is clearly evident: negative surprises (unanticipated rate cuts) are associated with stock market rallies, and positive surprises (unantici-

[5] Faust, Swanson and Wright (2002) exploit this insight, and use it to derive an alternative identification scheme for monetary VARs.

Figure 1: Scatterplots of equity returns and Fed funds surprises, daily data



pated rate hikes) with declines.

One outlier in the southwest quadrant is conspicuous, however: an observation in which a sharp decline in equity prices accompanied a surprise rate cut. It turns out that this anomalous observation to corresponds to September 17, 2001 — the first trading day after the September 11 terrorist attacks. In this instance, the comovement clearly reflects the joint reaction of policy and the stock market to an exogenous shock, rather than the market's response to the Fed. This observation, therefore, is dropped from the analysis.

The first two lines of table 1 report the impact of unexpected policy actions on two broad measures of stock prices: the S&P 500 and the CRSP value-weighted index. The effect is estimated from a regression of the one-day log return (in percentage terms) on the anticipated and unanticipated components of the change in the Fed funds target (also expressed in percentage terms), i.e.,

$$\Delta p_t = \alpha + \beta_1 \Delta \hat{r}_t^e + \beta_2 \Delta \hat{r}_t^u + u_t \ , \tag{3}$$

Table 1: The response of equity prices to funds rate changes

Index	Response to target change: anticipated	unanticipated	$\bar{R}^2$	SE	firms
S&P 500 composite	1.39	−5.29	0.26	1.17	500
	(2.20)	(4.34)			
CRSP value weighted	1.42	−5.36	0.28	1.12	varies
	(2.34)	(4.59)			
CRSP manufacturing	0.66	−4.11	0.18	1.06	54
	(1.15)	(3.72)			
CRSP financial	0.98	−4.94	0.20	1.24	47
	(1.45)	(3.82)			
CRSP information	1.48	−6.37	0.23	1.50	26
	(1.83)	(4.09)			
CRSP construction	−0.44	−9.34	0.17	2.61	2
	(0.31)	(3.43)			
CRSP retail	1.10	−6.29	0.17	1.68	19
	(1.21)	(3.59)			
CRSP wholesale	0.02	−1.01	−0.02	1.01	6
	(0.03)	(0.96)			
CRSP transportation	0.93	−5.23	0.12	1.69	8
	(1.01)	(2.96)			
CRSP utilities	−0.25	0.55	−0.03	1.11	28
	(0.42)	(0.48)			
CRSP services	1.19	−4.74	0.16	1.35	18
	(1.63)	(3.37)			
CRSP mining	0.34	−1.13	−0.03	1.40	17
	(0.44)	(0.78)			

Notes: Parentheses contain t-statistics. The sample includes the 54 target rate changes from June 1989 through December 2001, excluding the observation corresponding to September 17, 2001. The dependent variable is the one-day log return, excluding dividends, expressed in percent. The unanticipated and anticipated components of the change in the Fed funds rate are given by equations 1 and 2, and are expressed in percent. The column labeled "firms" gives the number of firms in each portfolio. The regressions also include an intercept (not reported).

where p_t is the logarithm of the stock price. As in figure 1, the sample consists of those days on which the target rate was changed.[6] The (highly significant) estimated coefficient on the surprise of -5.29 implies a surprise 25 basis point rate cut typically leads to a 1.3 percent gain in the index.[7]

Consistent with the efficient markets hypothesis, the market responds much more strongly to surprises than expected actions: the coefficient on the expected component is statistically significant, but small in magnitude (and has the "wrong" sign).[8] The R^2 is also noteworthy, as it implies that 28 percent of the variance in equity prices on the days of funds rate changes is associated with monetary policy actions. The reaction is all the more remarkable, given that much of the Fed funds surprises measured at a daily frequency represent shocks to the *timing* or rate changes, rather than to the medium-term path of interest rates.[9] The stock market's generally enthusiastic response to the eleven rate cuts in 2001 (several of which were at least partly unanticipated) is consistent with this pattern. Indeed, the estimated reaction is smaller and less significant when 2001 is excluded, although statistical tests do not reject the hypothesis that the coefficient has remained constant.

To analyze the response of individual industries, we turn to portfolios constructed from CRSP stock returns, grouped according to primary NAICS code into ten indices: information technology, construction, services, manufacturing, financial, retail, transportation, wholesale trade, utilities, and mining. The remaining ten rows of table 1 report the re-

[6] An alternative would be to use the sample consisting of possible rate change days, such as those corresponding to meetings of the FOMC. Estimates based on FOMC meeting days are much less precise, however, as surprise actions at FOMC meetings have been relatively uncommon in recent years.

[7] Using their proposed heteroskedasticity-based IV procedure, Rigobon and Sack (2002) report a coefficient of -7.1 from an analogous regression. However that study used a measure of the policy surprise based on Eurodollar futures, rather than Fed funds futures, and it is this difference that accounts for much of the discrepancy.

[8] The market's non-reaction to anticipated policy actions is consistent with reporting in the financial press: after the January 31 2001 50 bp rate cut, a headline in the *Wall Street Journal* read, "With the Rate Cut Anticipated, Market's Reaction Is Anticlimactic." [Zuckerman, (2001).]

[9] This "timing hypothesis" was suggested by Kuttner (2001) as a likely explanation for the smaller-than-expected response of interest rates to Fed funds surprises. Some support for this view can be found in the results of Demiralp and Jordá (2002) and Gürkaynak, Sack and Swanson (2002).

sults from estimating equation 3 on these ten industry portfolios. (The table also reports the number of firms in each portfolio.) Not surprisingly, the largest coefficient is obtained in the construction sector, whose stock price reaction is nearly twice that of the broader market indices. The information and retail sectors also respond somewhat more strongly than the market as a whole. Little or no response is observed among stocks in mining and utility sectors, which are usually considered relatively acyclical. Not surprisingly, these sectors are also characterized by very small (or negative) $\bar{R}^2$s, reflecting the predominance of idiosyncratic factors in these firms' stock returns.

2.4 The reaction measured at monthly intervals

An alternative way to define the policy surprise is to focus on the expected change in policy at a regular, monthly horizon. Unlike the daily event study-style analysis, the regular timing is amenable to the time series approach employed below in section 3 to assess the causes of the market's response. One important feature of this approach is that any month could potentially contain a surprise policy action; another is that policy *inaction* could also create a surprise. These two features make this approach less susceptible to any sample selection issues that might arise in an analysis of rate change days.

A slightly different method is used to derive a monthly measure of unanticipated policy actions. Since the price of the Fed funds futures contract is based on the monthly average Fed funds rate, the appropriate definition would be

$$\bar{\Delta}\hat{r}_s^u \equiv \frac{1}{m}\sum_{i=1}^{m}\hat{r}_{s,i} - f_{s-1,m}^1 \quad , \tag{4}$$

where $\hat{r}_{s,i}$ is the funds rate target day i of month s, and $f_{s-1,m}^1$ is the rate corresponding to the one-month futures contract on the last (mth) day of month $s-1$.[10] The expected funds

[10]The settlement price of the Fed funds futures contract is determined by the average over the calendar month, carrying the prior business day's rate over to weekends and holidays.

rate change is defined analogously as

$$\bar{\Delta}\hat{r}_s^e \equiv f_{s-1,m}^1 - \hat{r}_{s-1,m} \quad . \tag{5}$$

The sum of the two is the average funds rate target in month s minus the target on the last day of month $s-1$. (Since this is not the first difference of either the average or the month-end funds rate target, the slightly non-standard notation $\bar{\Delta}$ is used.)

One caveat to this approach that the endogeneity issue discussed above in section 2.2 is more relevant to Fed funds surprises defined at a monthly interval, than it was for the day-ahead surprises. Rate changes unanticipated as of the end of the prior month may well include a systematic response to economic news, such as employment, output and inflation. Consequently, it is important to bear in mind that these "surprises" do not correspond to the monetary policy "shocks" as the term is used in the monetary VAR literature.

This definition of the funds rate surprise also raises a new issue: that of time aggregation. The (unavoidable) reliance on the average funds rate will attenuate the size of the policy surprises, a problem discussed in detail in Evans and Kuttner (1998). Unfortunately, without making specific assumptions about the days of possible rate changes, there is no clean way to correct for this problem.[11] Consequently, some caution is required when interpreting the magnitude of the surprises measured in this way.

Figure 2 plots the monthly change in the S&P 500 composite against the monthly surprises defined in this way. As in the daily data, a strong negative correlation is evident; and here too the September 2001 outlier is visible. As discussed above, it makes sense to drop this observation from the analysis, as it represents the common response of monetary policy and the stock market to extraordinary news.

The sample used for the analysis contains a number of very sharp stock price move-

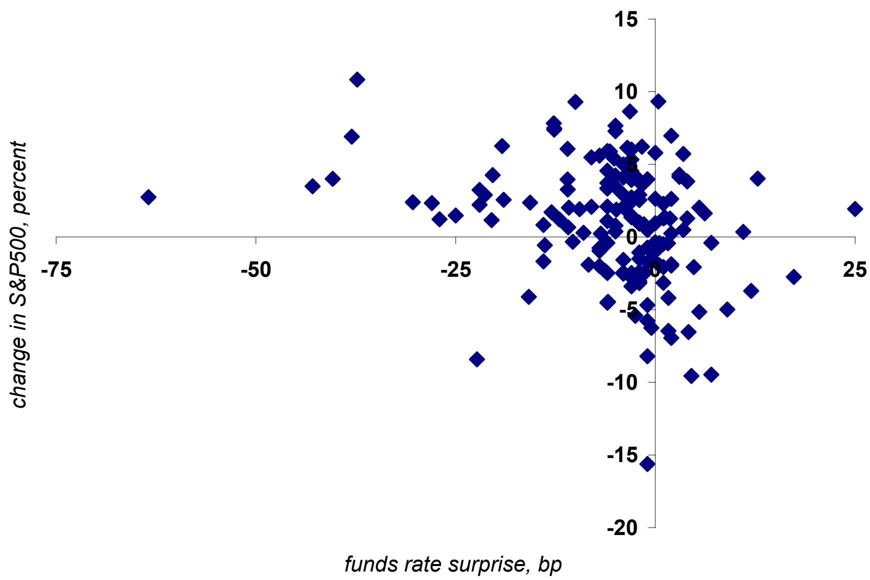
[11] After the 1994 change in protocol, for a time it seemed reasonable to assume that actions were expected only at scheduled FOMC meetings; but the three intermeeting rate cuts in 2001 have made that assumption less plausible.

Table 2: The response of equity prices at a monthly frequency

Index	Response to target change: anticipated	Response to target change: unanticipated	$\bar{R}^2$	SE	DW
S&P 500 composite	−1.54	−10.49	0.077	3.63	2.25
	(0.53)	(3.78)			
CRSP value weighted	−1.66	−9.21	0.073	3.40	2.27
	(0.64)	(3.69)			
CRSP manufacturing	−3.13	−11.57	0.081	3.92	2.24
	(1.01)	(3.87)			
CRSP financial	−0.05	−11.87	0.045	5.28	2.28
	(0.01)	(2.95)			
CRSP information	−1.00	−12.55	0.074	4.46	2.30
	(0.28)	(2.85)			
CRSP construction	−3.83	−26.23	0.065	9.83	1.78
	(0.49)	(3.50)			
CRSP retail	−8.87	−12.62	0.070	5.10	1.94
	(2.19)	(3.24)			
CRSP wholesale	−1.72	−5.15	0.003	4.23	2.44
	(0.52)	(1.60)			
CRSP transportation	−6.17	−9.70	0.022	5.96	2.09
	(1.31)	(2.14)			
CRSP utilities	−4.34	−4.82	0.008	4.24	2.09
	(1.29)	(1.49)			
CRSP services	−3.19	−11.81	0.058	4.66	1.94
	(0.86)	(3.32)			
CRSP mining	−4.45	−3.11	−0.007	6.74	2.16
	(0.83)	(0.60)			

Notes: Parentheses contain t-statistics. The dependent variable is the monthly log return, excluding dividends, expressed in percent. The unanticipated and anticipated components of the change in the Fed funds rate are given by equations 4 and 5, and are expressed in percent. The regressions also include an intercept (not reported). The sample includes 149 observations spanning May 1989 through December 2001, excluding August 1990, August 1998, and September 2001.

Figure 2: Scatterplots of equity returns and Fed funds surprises, monthly data



ments, at least two of which were in response to clearly identifiable adverse exogenous events. One is the 9.4 percent decline in the S&P 500 index in response to Iraq's invasion of Kuwait in August 1990; the second is the 14.6 percent drop in the wake of Russia's August 1998 default. Neither event prompted an immediate Fed reaction, however, and consequently neither generated a perverse, positive co-movement between the funds rate and stock prices. But they nonetheless add lot of noise to the equity return process: along with the 8.2 percent decline in September 2001, these two observations account for 18 percent of the monthly variance in the return on the S&P 500 since mid-1989. Consequently, we opt to treat these as outliers, and drop them from the analysis.[12]

Table 2 reports the results from a regression of the monthly percentage change in equity prices on the expected and unexpected components of monthly funds rate changes. The top two rows again show the response of the S&P 500 and CRSP value-weighted indices.

[12]The parameter estimates turn out to be virtually identical with these months included, but there is a modest loss of precision.

As in the results using daily data, there is a strong, statistically significant response to unanticipated rate changes, and little or no response to the anticipated actions. The $\bar{R}^2$ indicates that a respectable seven to eight percent of the variance of monthly stock price fluctuations (excluding the three "outlier" months) can be traced to policy surprises. The size and statistical significance of these estimates appear quite stable over the sample.

It is interesting to note that the magnitude of the response is nearly twice that found in analysis of rate-change days. This difference in magnitudes is readily explained by the time aggregation issue discussed above, however. In fact, if funds rate changes on average take place in the middle of the month (for example, if rate changes were distributed uniformly over the days of the month), then the magnitude of the estimated monthly surprises will be attenuated by one-half, and this would explain the doubling of the estimated response of the stock price.

The pattern of responses across industries, shown in the remaining ten rows of the table, is similar to that observed in the daily data. Again, construction exhibits the largest reaction (two to three times that of the broad market index), while the coefficients for wholesale trade, mining, and utilities are relatively small, and statistically insignificant.

3 Policy, fundamentals and stock prices

Section 2 above documented the reaction of equity returns to surprise monetary policy actions. We now turn to the specific question posed in the paper title, namely what *explains* the observed reaction. There are several reasons why an unexpected funds rate increase may lead to a decline in stock prices: it may be because of a decline in expected future dividends, an increase in the expected real interest rate used to discount those dividends, or it may increase the expected excess return (i.e., the equity premium) associated with holding stocks. Simple regressions of equity returns on surprise changes in the funds rate target are silent on the question; a more structured approach is required to disentangle the various effects.

The approach in this paper is an adaptation of the method used by Campbell (1991), and Campbell and Ammer (1993). In brief, the first element of their method is a log-linear decomposition of excess equity returns into components attributable to news about real rates, dividends, and future excess returns; the second element is the use of a vector autoregression (VAR) to calculate the relevant expectations.[13] We take the Campbell-Ammer framework one step further, however, by relating these components in turn to the news about the path of monetary policy embodied in the surprises derived from Fed funds futures. This allows us to estimate the impact of Fed funds surprises on expected future dividends, real interest rates, and expected *future* excess returns. It turns out that the largest (and only statistically significant) effect is on the future excess return component, suggesting that it is this — and not expected future dividends or real interest rates — that accounts for the observed reaction of equity prices.

The object of this analysis is the (log) excess return on equities, denoted y_{t+1}. This is defined as the total return on equities (price change plus dividends), minus the risk-free rate (taken to be the one-month Treasury bill yield). The return dated $t+1$ is measured over period t, i.e., from the beginning of period t to the beginning of period $t+1$. Let e^y_{t+1} represent the unexpected (relative to expectations formed at the beginning of period t) excess return during period t, i.e., $y_{t+1} - E_t y_{t+1}$.

Using the linearization developed by Campbell and Shiller (1988), the period t unexpected excess return on equity can be expressed in terms of the revision the expectation of discounted future dividends, the real interest rate, and future excess returns. (A sketch of

[13]Because VARs require periodic time series data, the subsequent analysis will use the monthly measure of the funds rate surprises.

the derivation can be found in the appendix.) The decomposition can be written as:

$$e^y_{t+1} = \tilde{e}^d_{t+1} - \tilde{e}^r_{t+1} - \tilde{e}^y_{t+1} \tag{6}$$

where the es represent the revision in expectations between periods t and $t+1$, and the tilde denotes a discounted sum, so that

$$\begin{aligned} \tilde{e}^d_{t+1} &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j d_{t+j} \\ \tilde{e}^r_{t+1} &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r_{t+j} \\ \tilde{e}^y_{t+1} &= (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j y_{t+1+j} \quad . \end{aligned}$$

The ρ discount factor, which comes out of the linearization, represents the steady-state ratio of the equity price to the price plus dividend; following Campbell and Ammer (1993), this is set to 0.9962. As emphasized by Campbell (1991), equation 6 is really nothing more than a dynamic accounting identity relating the current excess return to revisions in expectations. As such, it contains no real economic content, much less any specific asset pricing model; such a model would be required to provide a link between the conditional expectations of future returns and economic variables (e.g., consumption).

Implementing this decomposition obviously requires empirical proxies for the expectations appearing in equation 6. The approach of Campbell (1991) and Campbell and Ammer (1993) is to model expectations using a Vector Autoregression (VAR) involving the variables of interest (excess returns and the real interest rate) along with any other indicators that might be helpful in forecasting those variables. Calculating the discounted sum of the revisions in expectations is straightforward; to do so involves requires writing the n variable, p lag VAR as a first-order system,

$$z_{t+1} = Az_t + \varepsilon_{t+1} \quad , \tag{7}$$

where z_{t+1} is an appropriately stacked $np \times 1$ vector containing the excess equity return, the real interest rate, and any additional indicators. With the VAR expressed in this form, the ingredients of the identity 6 are given by

$$\begin{aligned} e^y_{t+1} &= s_y \varepsilon_{t+1} \ , \\ \tilde{e}^y_{t+1} &= s_y \rho A (1-\rho A)^{-1} \varepsilon_{t+1} \ , \\ \tilde{e}^r_{t+1} &= s_r (1-\rho A)^{-1} \varepsilon_{t+1} \text{ and} \\ \tilde{e}^d_{t+1} &= e^y_{t+1} + \tilde{e}^y_{t+1} - \tilde{e}^r_{t+1} \ , \end{aligned}$$

where s_y and s_r are appropriate $1 \times np$ selection matrices.

Two features of the Campbell-Ammer method deserve further comment. One is its parametric approach to constructing long-horizon expectations of stock returns: one has to assume that the dynamics of equity returns many years in the future are adequately captured by a parsimonious VAR model. To a large extent, this parametric approach is forced upon us, as the relatively short (12-year) experience with Fed funds futures is not sufficient to directly estimate the long-horizon impact on stock asset returns, particularly in light of the questionable small-sample properties of long-horizon regressions [see Nelson and Kim (1993)]. But as discussed below, the use of the VAR *does* allow us to estimate the dynamics of stock returns over a longer sample than the period for which futures data are available.

A second important feature of the approach is that dividends are not included explicitly as a variable to be forecast; given e^y_{t+1}, $\tilde{e}^y_{t+1}$ and e^r_{t+1}, e^d_{t+1} is backed out from the identity (6). In principle, it would be possible to forecast dividends directly in the VAR, and instead back out an implied $\tilde{e}^y_{t+1}$. In practice, however, this is complicated by a strong seasonal pattern, and a root near unity in the dividend process. It is important to note that to the extent that the VAR understates the predictability of excess returns, treating dividends as a residual means that the method will end up attributing *too much* of the return volatility to dividends.[14]

3.1 The forecasting VAR

The first step is to set up a VAR to capture the dynamic correlations between the excess equity return and the real interest rate (calculated as the one-month bill yield minus the log difference in the non-seasonally-adjusted CPI). The VAR will therefore include these two variables at a minimum, plus whatever other information variables are useful for forecasting them. In their original work, which analyzed the period ending in February 1987, Campbell and Ammer (1993) used a six-variable one-lag system that included, besides the real rate and equity return: the relative bill rate (defined as the three-month bill rate minus its 12-month lagged moving average), the *change* in the bill rate, the (smoothed) dividend price ratio, and a measure of the slope of the yield curve.

A slightly different specification works somewhat better in terms of adjusted R^2 in the more recent period, however. In particular, the yield spread and the change in the T-bill rate, which were useful predictors of equity returns prior to 1987, appear less informative after 1989; consequently these two variables were dropped from the VAR, in favor of year-over-year CPI inflation, which seems to have some marginal predictive power for stock returns. None of these variables is subject to historical revisions, and consequently represent information that would have been available to investors in real time.

Table 3 reports the estimated parameters from the one-lag five-variable VAR just described. The adjusted R^2 for the excess return equation of 0.0526 (excluding the effects of the three crisis dummies, which jointly account for nearly 16 percent of excess return variance), is hardly overwhelming, but shows that there is at least *some* predictability in excess returns. The only regressor significant at conventional significance levels is the relative bill

[14] A useful check on the Campbell-Ammer procedure would be to compare its implied dividend forecasts with the observed behavior of dividends. Such a comparison is beyond the scope of the present paper, however.

Table 3: VAR parameter estimates

	Equation				
Regressor	Excess return	Real rate	YOY inflation	D/P ratio	Relative bill
Excess return	−0.02 (0.40)	−0.01 (2.22)	0.00 (0.54)	−2.75 (38.6)	0.22 (2.99)
Real rate	0.30 (0.34)	0.46 (9.33)	−0.02 (3.36)	−1.29 (1.08)	−0.72 (0.58)
YOY inflation	−2.26 (1.48)	−0.18 (2.03)	0.97 (108.4)	1.79 (0.86)	0.90 (0.42)
D/P ratio	5.61 (1.51)	0.20 (0.94)	0.03 (1.21)	1.00 (198.9)	4.53 (0.86)
Relative bill	−8.24 (3.73)	−0.29 (2.34)	0.10 (7.48)	9.90 (3.30)	0.84 (26.9)
August 1990	−10.93 (2.43)	−0.50 (1.96)	0.07 (2.47)	0.06 (0.09)	0.42 (0.06)
August 1998	−17.85 (3.96)	0.02 (0.08)	0.00 (0.16)	0.58 (0.95)	−1.04 (0.16)
September 2001	−10.94 (2.41)	−0.55 (2.12)	0.01 (0.33)	1.04 (1.68)	−8.51 (1.32)
$\bar{R}^2$ overall	0.108	0.283	0.989	0.996	0.697
$\bar{R}^2$ x crisis	0.053	0.272	0.988	0.996	0.697

Notes: The excess return is the monthly log return from the CRSP value-weighted index, less the one-month Treasury bill rate. The sample is January 1973 through December 2002, with dummy variables for August 1990, August 1998, and September 2001. The coefficients (except those on the own lags) in the D/P and relative bill rate regressions have been multiplied by 100 for readability. The "overall" $\bar{R}^2$ includes the dummy variables' contribution to the variance explained accounted for by the regression; the "x crisis" $\bar{R}^2$ excludes the dummies' effects. The estimated intercepts are not reported.

rate. The dividend-price ratio has the correct sign (positive), but significant at only a 0.13 level; similarly, higher inflation is associated with a reduction in future stock returns, but again the coefficient is only significant at the 0.14 level.

3.2 A variance decomposition of equity returns

Equation 6 expresses this month's excess equity returns into three components, which may be correlated with one another. The variance of the current excess return can therefore be broken down into the sum of the three variances, plus (or minus) the relevant three covariances,

$$\begin{aligned} \mathrm{Var}(e^y_{t+1}) &= \mathrm{Var}(\tilde{e}^d_{t+1}) + \mathrm{Var}(\tilde{e}^r_{t+1}) + \mathrm{Var}(\tilde{e}^y_{t+1}) - \\ &\quad 2\mathrm{Cov}(\tilde{e}^d_{t+1}, \tilde{e}^r_{t+1}) - 2\mathrm{Cov}(\tilde{e}^d_{t+1}, \tilde{e}^y_{t+1}) + 2\mathrm{Cov}(\tilde{e}^y_{t+1}, \tilde{e}^r_{t+1}) \ , \end{aligned} \tag{8}$$

giving a sense of the relative contributions of news about real interest rates, dividends, and expected future excess returns to fluctuations in the current excess return. The results of this decomposition appear in table 4, both for the full 1973–2001 sample and for the subsample beginning in May 1989 (corresponding to the period for which Fed funds futures are available). The columns labeled "total" show the total contribution, and those labeled "share" expresses that contribution as a percentage of the excess return variance, i.e., normalizing by $\mathrm{Var}(e^y_{t+1})$.

Despite the differences in specification and sample, the results for the 1973–2001 sample are very similar to those reported by Campbell and Ammer (1993) for their 1973–87 sample. In particular, the variance in expected *future* excess returns accounts for the lion's share of the variance of the current equity return: 95 percent, compared with Campbell and Ammer's 101 percent (both are statistically significant). Dividends make a somewhat larger (but less precisely estimated) contribution here than in the Campbell-Ammer results, accounting for a marginally significant 36 percent of the excess return variance, compared to a statistically significant 14 percent in their study. In both cases, the contribution of the real interest rate is negligible (0.7 and 3 percent respectively) and statistically insignificant. These figures are in turn very similar to those for the truncated 1989–2001 subsample, shown in the right-hand portion of the table. Clearly, the dynamics of equity excess returns and real interest rates (and by implication the path of dividends) are relatively insensitive to changes in the sample period or the model specification.[15]

3.3 The effects of Fed funds surprises

The most straightforward way to analyze the impact of monetary policy within the framework introduced above is to include the Fed funds surprises in the VAR as an exogenous variable

$$z_{t+1} = Az_t + \phi\overline{\Delta}\hat{r}^u_{t+1} + \varepsilon^*_{t+1} \tag{9}$$

where ϕ is an $n \times 1$ vector capturing the contemporaneous response of the elements of z_{t+1} to the unanticipated rate change period $t+1$. The new disturbance term ε^*_{t+1} is by construction orthogonal to the funds rate surprise. This effectively breaks the VAR's one-month-ahead forecast error into a component having to do with news about monetary policy, $\phi\overline{\Delta}\hat{r}^u_{t+1}$ and an orthogonal component incorporating information about things other than policy.

An important point is that because $\Delta\hat{r}^u_{t+1}$ represents a prediction error from a rational forecast made at time t, it should be orthogonal to z_t.[16] Consistent estimates of both A and ϕ can therefore be obtained by first estimating the usual VAR (equation 7), and then regressing the VAR's one-step-ahead forecast errors on the funds rate surprises. Normally, there would be no advantage to the two-step procedure over simply estimating equation

[15]Very similar results are also obtained from models with more lags, and with the three "outlier" observations included in the analysis.

[16]Krueger and Kuttner (1996) showed that in practice, the Fed funds futures prediction errors are generally uncorrelated with lagged information.

Table 4: Variance decomposition of excess equity returns

	1973–2001		1989–2001	
	Total	Share (%)	Total	Share (%)
Var(excess return)	19.5		13.7	
Var(dividends)	7.1	36.4	6.0	43.9
		(1.7)		(2.2)
Var(real rate)	0.7	3.5	0.1	0.7
		(1.2)		(1.3)
Var(future returns)	18.5	95.0	12.1	88.1
		(2.7)		(1.6)
−2 Cov(dividends, real rate)	−2.8	−14.2	−0.4	−3.1
		(1.0)		(0.6)
−2 Cov(dividends, future excess return)	−7.7	−39.6	−3.0	−21.8
		(0.8)		(0.4)
2 Cov(future excess return, real rate)	3.7	18.8	1.1	7.8
		(1.2)		(1.0)
$\bar{R}^2$ from excess return equation	0.053		0.039	

Notes: The equity return used is the CRSP value-weighted index. Parentheses contain *t*-statistics, calculated using the delta method.

9 directly. But in our case, using the two-step procedure allows us to estimate the VAR dynamics (i.e., the coefficients in the A matrix) over a sample *longer* than the period for which Fed funds futures are available.[17] This will of course tend to improve the precision of our estimates.

3.3.1 The dynamic response to funds rate surprises

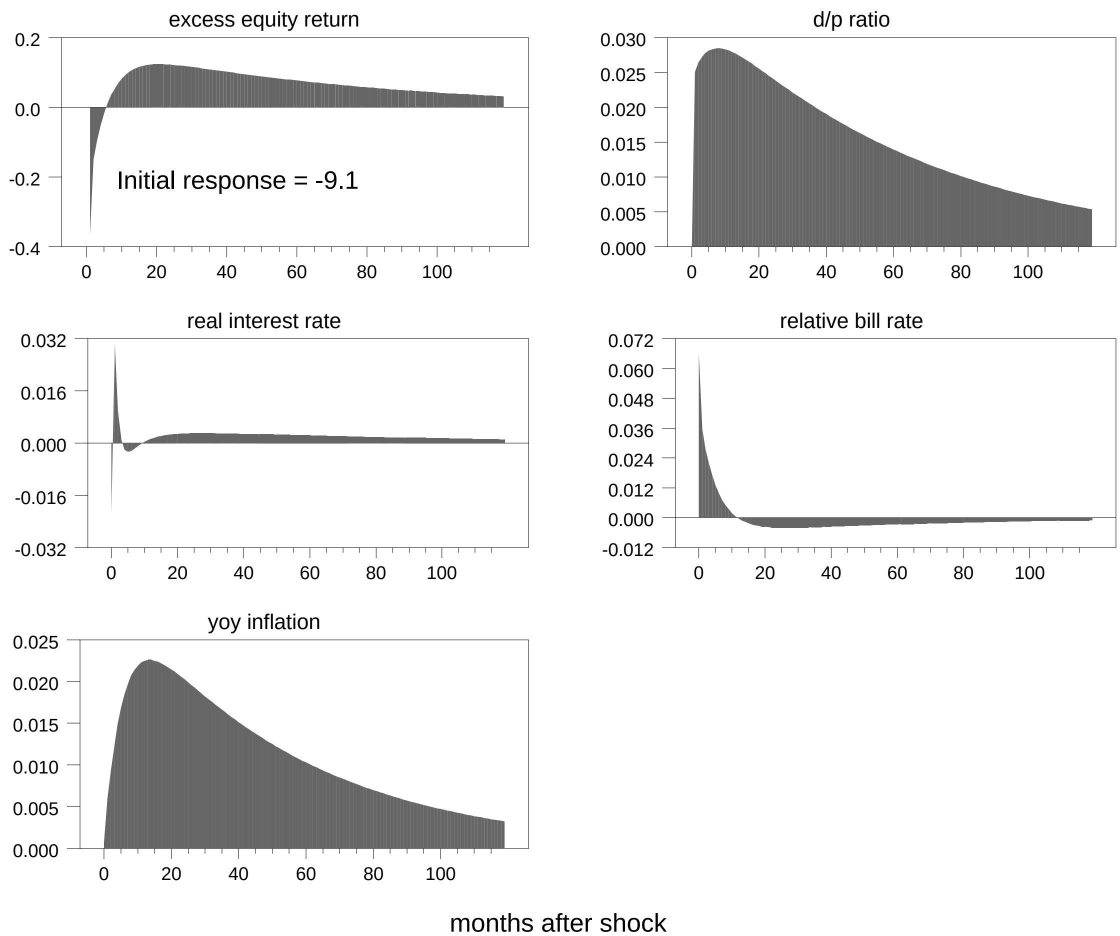
Incorporating the Fed funds surprises into the VAR in this way allows us to do two things. First, because it (partially) orthogonalizes the ε_t forecast error, we can use it to calculate the dynamic responses of the variables in the VAR to funds rate surprises. In particular, the k-month response to a one-percentage-point surprise increase in the funds rate can be expressed as $A^k\phi$. The response of each of the five variables in the model are calculated in this way, and appear in figure 3.

The upper-left-hand panel of the figure displays the response of excess returns over time. The initial decline of 9.1 percent (not shown, because of the difference in scale) is followed by several months of small negative excess returns. But after six months, equities start to exhibit small *positive* excess returns, peaking at 0.123 percent per month (1.5 percent on an annual basis), and continuing for several years. This tendency for positive excess returns to persist is apparent in the upper right-hand panel of the figure, which shows the response of the dividend-price ratio. The initial decline in equity prices leads to an abrupt increase in this ratio, which reverts gradually to its long-run level as equity prices rise.

The contractionary funds rate surprise also leads to a sizable increase in the relative bill rate, which persists several months (by construction). The *real* interest rate initially declines, however, because unexpected rate increases seem also to be associated with higher-than-expected inflation (shown in the lower left panel). The change in the real rate then

[17] Faust, Swanson and Wright (2002) employed a similar trick: they estimate the VAR parameters over the full sample, but choose an orthogonalization based on the response of interest rates over the post-1989 subsample.

Figure 3: The estimated responses to monetary policy surprises



Notes: Each panel represents the response to a 1 percent funds rate surprise, as defined in equation 4, calculated from the VAR using value-weighted CRSP returns and estimated over the 1973–2001 sample. The initial (within-month) excess return response is not shown, because of the large difference in scale. The responses are expressed in percent per month.

becomes a positive 0.03 percent (0.36 percent on an annual basis) in the subsequent month. But again because inflation is increasing, the jump in the real interest rate is transitory. Overall, the Fed funds surprise is associated with roughly a quarter-point rise in year-over-year inflation at an 18-month horizon. This result is consistent with those of Goto and Valkanov (2000), in the sense that monetary policy is, in effect, creating a negative contemporaneous correlation between inflation and excess equity returns.

The strong observed correlation between Fed funds surprises, excess returns and inflation naturally raises the question of whether it is monetary policy *per se* that causes the decline in stock prices, or the inflationary pressures to which the Fed is presumably responding. This ambiguity is likely due in part to the fact that our Fed funds surprises are not orthogonalized, and thus are not purged of any endogenous response to economic conditions.[18] It is worth noting however that even the orthogonalized monetary policy shocks of Goto and Valkanov (2000) generate a similar set of correlations between returns, inflation, and the Fed funds rate.

3.3.2 Explaining the stock market's reaction to Fed policy

The second thing this approach allows us to do is calculate the impact of the Fed funds surprises on the *discounted sums* of expected future excess returns, interest rates, and dividends. And since it is these present values that are related to the current excess return through equation 6, this provides a natural way to determine the source (or sources) of the stock market's reaction to monetary policy.

One way to assess policy's effect on these discounted sums is simply to use the VAR to calculate $\tilde{e}^d_{t+1}$, $\tilde{e}^r_{t+1}$, and $\tilde{e}^y_{t+1}$, which represent the revisions in expectations of the relevant present values, and regress these variables in turn on $\hat{r}^u_{t+1}$. Although this would provide the answer we are after, the standard errors would be misleading, as they would fail to take into

[18] Of course this ambiguity inherent in this approach is balanced by its independence from any specific set of potentially controversial identifying assumptions.

account the dependence of the $\tilde{e}$s on the estimated parameters of the VAR.

An alternative way to do the same calculation is to write out the $\tilde{e}$s in terms of the VAR coefficients. Taking $\tilde{e}^y_{t+1}$ as an example:

$$\begin{aligned}\tilde{e}^y_{t+1} &= s_y \rho A(1-\rho A)^{-1}\varepsilon_{t+1} \text{ or} \\ &= s_y \rho A(1-\rho A)^{-1}(\phi \bar{\Delta} \hat{r}^u_{t+1} + \varepsilon^*_{t+1}) \ .\end{aligned}$$

The response of the present value of expected future excess returns to the FF surprise is just

$$s_y \rho A(1-\rho A)^{-1}\phi \ .$$

Thus, the response of expected future excess returns depends not only on the ϕ vector, but also on the VAR dynamics represented by A. Similarly, the response of the present value of current and expected future real returns is

$$s_r(1-\rho A)^{-1}\phi \ ,$$

and the implied response of the present value of current and expected future dividends is

$$s_y\phi + s_y\rho A(1-\rho A)^{-1}\phi + s_r(1-\rho A)^{-1}\phi$$

or alternatively

$$(s_y + s_r)(1-\rho A)^{-1}\phi \ .$$

The standard errors for these responses can be calculated in the usual way, using the delta method.

The results of these calculations appear in table 5. The top two rows report the estimated impacts of Fed funds shocks for our two broad market gauges, the S&P 500 and the CRSP value-weighted index. The first of the four columns is the impact on the current excess return, corresponding to the initial point in the impulse response function shown in figure

Table 5: The impact of monetary policy on dividends, interest rates, and future returns

	Response of:			
Index	current excess return, e^{y}_{t+1}	future excess returns, $\tilde{e}^{y}_{t+1}$	real interest rates, $\tilde{e}^{r}_{t+1}$	dividends, $\tilde{e}^{d}_{t+1}$
S&P 500 composite	−9.23	4.58	0.42	−4.23
	(4.01)	(1.55)	(0.52)	(1.31)
CRSP value weighted	−9.10	7.26	0.24	−1.61
	(3.87)	(2.05)	(0.23)	(0.47)
CRSP manufacturing	−8.83	5.39	0.46	−2.99
	(3.64)	(2.42)	(0.82)	(1.72)
CRSP financial	−7.88	7.44	−0.03	−0.47
	(2.38)	(2.63)	(0.06)	(0.22)
CRSP information	−8.51	5.60	−0.10	−3.00
	(3.26)	(2.56)	(0.19)	(1.53)
CRSP construction	−15.83	12.19	−0.55	−4.19
	(2.21)	(1.47)	(1.33)	(0.52)
CRSP retail	−7.27	4.92	−0.18	−2.52
	(2.20)	(1.70)	(0.38)	(1.33)
CRSP wholesale	−4.29	2.57	0.03	−1.69
	(1.56)	(1.14)	(0.06)	(1.13)
CRSP transportation	−5.68	1.89	−0.42	−4.21
	(1.17)	(0.51)	(0.89)	(0.95)
CRSP utilities	−4.54	1.87	0.07	−4.21
	(1.70)	(1.01)	(0.13)	(1.91)
CRSP services	−9.71	7.53	0.18	−2.00
	(2.96)	(2.08)	(0.27)	(0.58)
CRSP mining	−2.00	0.03	0.04	−1.94
	(0.50)	(0.01)	(0.08)	(0.47)

Notes: Parentheses contain t-statistics. The sample is January 1973 through December 2001 for the S&P 500 and value-weighted indices. Due to data limitations, the sample begins in January 1975 for all the CRSP portfolios except construction; for that industry, the sample begins in January 1978.

3. The second through fourth columns show the impact of Fed funds surprises on the discounted sums appearing on the right-hand side of equation 6.

For the CRSP value-weighted index, the effect of Fed funds surprises on the excess return comes almost entirely through their impact on expected future excess returns. The statistically significant coefficient of 7.26 accounts for nearly all of the -9.10 effect on the current return, with only small and insignificant effects on the discounted sums of real rates or dividends. The results are less clear-cut for the S&P returns, where the impact of the funds rate shocks is relatively evenly split between dividends and expected future excess returns. (The real interest rate effect remains small.)

This result is readily understood in terms of the impulse responses plotted in figure 3. Funds rate shocks are estimated to have a small, but highly persistent effect on excess returns, whose discounted value (using a discount factor of 0.9962) essentially balances the current-period gain or loss. The contribution of the real interest rate is small — partly because of the lack of persistence, and partly because unexpected increases in the funds rate are typically associated with higher-than-expected inflation. So, to the extent that Fed funds shocks are followed by predictable changes in excess returns, the effects of monetary policy will be attributed to its effects on future excess returns, rather than to dividends or real interest rates.

This framework also allows us to say something about the reason for the differential impact of monetary policy across industries, as documented in tables 1 and 2. A five-variable one-lag VAR was estimated for each of the ten portfolios, in a specification like that used for the aggregate equity return. Data limitations, however, require a slightly later starting date for the portfolio-level analysis, and the number of firms in each industry is somewhat diminished.

Overall, the industry-level responses confirm the earlier conclusion that most of the stock market's reaction to monetary policy comes through the its effect on future excess returns. The response of expected future excess returns to a surprise Fed funds increase is positive, and for most portfolios, nearly equal in magnitude to the current equity return response. Four of these are also significant at the 0.05 level; one is significant at the 0.10 level. There is a marginally signifcant response of expected dividends for two industries, manufacturing and utilities. And in no case is the impact on expected real interest rates large or significant.

4 Conclusions

One contribution of this study has been to document the strong response of the stock market to unexpected monetary policy actions, using Fed funds futures data to gauge policy expectations. For the overall S&P 500 composite index, an unexpected 25 basis point rate cut would typically lead to a 1.3 percent increase in stock prices. A second important finding is that the reactions differ considerably across industries, with the most sensitive (construction) exhibiting twice the response of broad stock market aggregates. Other sectors, such as utilities, mining, and wholesale trade are largely unaffected by policy actions.

A more difficult question is *why* stock prices respond as they do to monetary policy — whether through the effects on real interest rates, expected future dividends, or expected future stock returns. The results presented in this paper showed, perhaps surprisingly, that the reaction of equity prices to monetary policy is not directly attributable to policy's effects on the real interest rate. The reasons are twofold: first, the contribution of real interest rate variance is small to begin with; and second because funds rate increases are associated with higher-than-expected inflation, monetary policy surprises have only a modest effect on real rates. Similarly, the impact of policy on (the implied path) of expected future dividends is generally quite small, although there is some evidence of a modest contribution in two industries.

Instead, the impact of monetary policy surprises on stock prices seems to come primarily through its effects on expected future excess returns — i.e., the equity premium. Exactly why policy should affect expected future returns is not clear, however. But the observed correlation between policy and inflation surprises suggests that the effect could be the result of inflation's effect on the equity premium, rather than that of monetary policy *per se*. This finding corroborates the connection between inflation, monetary policy, and stock returns documented by Goto and Valkanov (2000), although it is fair to say neither that paper nor this one has fully disentangled the precise nature of the linkages. Resolving this issue is clearly an interesting topic for future research.

Appendix: deriving equation 6

This appendix provides a brief sketch of the derivation of the log-linearized relationship between the current excess return, expected future excess returns, dividend growth, and real interest rates given in equation 6. The derivation roughly follows Campbell and Shiller (1988) and Campbell (1991).

The starting point is simply the definition of the stock return, H_{t+1}:

$$1 + H_{t+1} \equiv \frac{P_{t+1} + D_t}{P_t}$$

where P is the stock price and D is the dividend. Taking logs and letting $h_{t+1} = \ln(1 + H_{t+1})$ yields:

$$h_{t+1} = \ln(P_{t+1} + D_t) - \ln(P_t) \ .$$

The next step is to derive a log-linear approximation to $\ln(P_{t+1} + D_t)$. One way to do this is to first-difference, and express the change in the log of the sum as the weighted sum of the log differences

$$\Delta \ln(P_{t+1} + D_t) \approx \rho \Delta p_{t+1} + (1 - \rho) \Delta d_t$$

where ρ is the steady-state $P/(D + P)$. "Integrating" this expression gives

$$\ln(P_{t+1} + D_t) \approx k + \rho p_{t+1} + (1 - \rho) d_t \ ,$$

and substituting this into the expression for h_{t+1} and combining terms gives

$$\begin{aligned} h_{t+1} &\approx k - \rho \delta_{t+1} + \delta_t + \Delta d_t \\ &\approx k + (1 - \rho L^{-1}) \delta_t + \Delta d_t \ . \end{aligned} \tag{10}$$

The next step is to solve forward, giving

$$\begin{aligned} \delta_t &= (1 - \rho L^{-1})^{-1} (h_{t+1} - \Delta d_t - k) \\ &= \sum_{i=0}^{\infty} \rho^i (h_{t+1+i} - d_{t+i}) - k/(1 - \rho) \ . \end{aligned}$$

Substituting this, and a similar expression for δ_{t+1}, into equation 10 and collecting terms yields:

$$h_{t+1} - E_t h_{t+1} = -\sum_{i=1}^{\infty} \rho^i (E_{t+1} - E_t) h_{t+1+i} + \sum_{i=0}^{\infty} \rho^i (E_{t+1} - E_t) \Delta d_{t+1+i}$$

which corresponds to equation 1 in Campbell (1991).

A breakdown of *excess* returns can then be derived by expressing the equity return h_{t+1} as the sum of a risk-free rate and an excess return

$$h_{t+1} = r_{t+1} + y_{t+1} \; .$$

Because it is assumed that r_{t+1} is known at time t, the "excess return surprise" $y_{t+1} - E_t y_{t+1}$ is the same as the overall return surprise $h_{t+1} - E_t h_{t+1}$. So the risk-free rate can be included in the two-way breakdown as follows:

$$y_{t+1} - E_t y_{t+1} = -\sum_{i=1}^{\infty} \rho^i (E_{t+1} - E_t)(y_{t+1+i} + r_{t+1+i}) + \sum_{i=0}^{\infty} \rho^i (E_{t+1} - E_t) \Delta d_{t+1+i}$$

or as

$$\begin{aligned} y_{t+1} - E_t y_{t+1} &= -\sum_{i=1}^{\infty} \rho^i (E_{t+1} - E_t) y_{t+1+i} - \\ &\quad \sum_{i=1}^{\infty} \rho^i (E_{t+1} - E_t) r_{t+1+i} + \sum_{i=0}^{\infty} \rho^i (E_{t+1} - E_t) \Delta d_{t+1+i} \; . \end{aligned} \tag{11}$$

Again, because $E_t r_{t+1} = r_{t+1}$, it doesn't matter whether the summation involving the rs begins at 0 or 1. Finally, letting e^y_{t+1} represent the "excess return surprise" and replacing the summations with the corresponding $\tilde{e}$s yields equation 6.

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