Monetary Policy Shocks and Security Market Responses

By
Roger Craine
University of California at Berkeley

Vance Martin
University of Melbourne

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Abstract: This paper contributes to a recent literature that tries to filter exogenous monetary policy surprises from high frequency (daily) data. The literature uses the fact that monetary policy surprises are realized only on days that the Federal Reserve changes the Federal Funds Target, or on days that the Federal Open Market Committee (FOMC) meets and does not change the target—so-called "event days". We add to the literature in three ways: (1) we specify a more general model in which security prices respond to two sources of systematic risk (a two factor model)—a common information shock and the monetary policy shock—plus nonsystematic risk—an idiosyncratic shock. (2) We use all of the daily data while other studies use only a small sub-sample of less than 10% of the data. And (3) we use new estimation strategy that gives consistent and more efficient parameter estimates than previous studies.

Our empirical results show that efficiently estimating a more general model leads to important differences. Common shocks have an important and statistically significant impact on bond yields at all maturities. Leaving out the common information shocks leads to bad estimates of the impact of monetary policy shocks. Cochrane and Piazzesi's event study found that the yield on a 10 year bond increases in response to a positive Target surprise—which they properly label a puzzle. The factor model solves the puzzle. We get the classic textbook response—a surprise increase in the target rate leads to a decline in the yield on the 10 year bond. Finally we look at equity returns as well as bond yields which introduces a different puzzle. In any model we look at a positive Target surprise causes a large and significant decline in equity returns. A recent event study paper of equity market responses by Bernanke and Kuttner (2003) finds similar results. The question is why?

Introduction

Economists have attempted to quantify the effect of monetary policy for a long time without much success. The task is to estimate the change in a policy target caused by the change in policy. It turns out that this is very hard to do. Three basic econometric problems plague this effort. First, the policy instrument—in recent years the Fed Funds Target Rate— is endogenous. Second, economic variables respond to anticipated as well as realized changes in monetary policy. And third, economic variables respond to influences other than monetary policy changes. Figure 2.1 shows the yields on 10 year and 1 year Treasury bonds and the Fed Funds Target Rate (from now on denoted as the Target). They move together, but with no clear lead-lag relationship. Market rates respond to changes in the Target and other variables and policymakers use information in long maturity yields as an indicator of inflationary expectations. Figure 2.2 shows the Target and the 30-day Eurodollar rate for 1999-2001. The Eurodollar rate usually anticipates policy changes.

This paper contributes to a recent literature that tries to filter exogenous monetary policy surprises from high frequency (daily) data. The literature uses the fact that monetary policy surprises are only realized on days that the Federal Reserve changes the Federal Funds Target, or on days that the Federal Open Market Committee (FOMC) meets and does not change the target—so-called "event days". We add to the literature in three ways: (1) we specify a more general model in which security prices respond to two sources of systematic risk (a two factor model)—a common information shock and the monetary policy shock—plus nonsystematic risk—an idiosyncratic shock. (2) We use all of the daily data while other studies use only a small sub-sample of less than 10% of the data . And (3) we use a new estimation strategy that gives consistent and more efficient parameter estimates than previous studies.

Event study papers equate the change in an observable short maturity interest rate—Cochrane and Piazzesi (2002) use the 30-day Eurodollar rate, Bernanke and Kuttner (2003), Kuttner (2001), and Poole and Rasche (2001) use the Federal Funds Futures market rate—with the monetary policy surprise. If this identification assumption is correct, then regressing the security yield or return on the change in the short maturity yield on event days gives a consistent estimate of the response.

However, if the change in the short maturity rate on event days reflects information shocks as well as the monetary policy surprise, then the monetary policy surprise revealed by the change in the short rate is measured with error. Table 2.1 shows that the standard deviation of the change in the Eurodollar rate is 50% larger on event days, but it is hard to believe there is no information shock on event days. Poole, Rasche and Thornton (2002) were the first to explicitly recognize that the change in a short maturity interest rate on the event day measures the monetary policy shock with error. They used an errors in variables model to estimate the response of yields to the monetary policy surprise on event days. Our factor model nests the errors in variables specification.

The event study models can only use the data from event days. And event days are less than 5% of the sample. Rigobon and Sack, in an innovative paper that breaks the mold, specify a model that uses all the data. In their model the change in security prices (yields and equity returns) are jointly dependent and driven by the exogenous monetary policy shock and a common information shock. Their model is very general and under-identified. They cleverly use the fact that the monetary policy shock only occurs on event days to partially identify the model[1]. They can estimate the change in security prices in response to a monetary shock and the variance of the monetary shock, but they cannot recover any of the other model parameters. Curiously, when R&S actually estimate the model they do not use all of the daily data and they do not impose the over-identifying restrictions. They use a paired sample of event and nonevent days—only about 10% of the data and the results are sensitive to the selection of nonevent days.

Our empirical results show that efficiently estimating a more general model leads to important differences. Common shocks have an important and statistically significant impact on bond yields at all maturities. Leaving out the common information shocks leads to bad estimates of the impact of monetary policy

[1] We recognized the power of R&S's insight and used it to identify all of the parameters in the factor model.

shocks. Cochrane and Piazzesi's event study found that the yield on a 10 year bond increases in response to a positive Target surprise—which they properly label a puzzle. The factor model solves the puzzle. We get the classic textbook response—a surprise increase in the target rate leads to a decline in the yield on the 10 year bond. Finally we look at equity returns as well as bond yields which introduces a different puzzle. In any model we look at a positive Target surprise causes a large and significant decline in equity returns. A recent event study paper of equity market responses by Bernanke and Kuttner (2003) finds similar results. The question is why?

The paper is organized as follows: Section 1 presents the details of our factor model specification and compares it with the other specifications. Section 2 shows the data. Section 3 presents estimates of the factor model and compares them with the event study results and with results using Rigobon and Sack's estimator.

Section 1: Models of Monetary Shocks

A Factor Model

We use a factor model of yields[2], *i and y,* and the equity return, *r,* that is standard in finance, eg, see Campbell, Lo, and MacKindley (19??), and Campbell and Vicieria (2001). We distinguish the shortest maturity yield because event studies call the changes in the shortest yield on event days the monetary policy surprise.

We assume that yields and the equity return respond to two systematic sources of risk—a market information shock, *s*, and the monetary policy surprise, *m*--plus a security specific idiosyncratic shock, *e,*

$$\begin{aligned} \Delta i_t &= \sigma_m m_t + \sigma_s s_t \\ \Delta y_t &= \alpha_y m_t + \beta_y s_t + \sigma_y e_{yt} \\ r_t &= \alpha_r m_t + \beta_r s_t + \sigma_r e_{et} \end{aligned} \tag{1.1}$$

The shocks are independently and identically distributed with zero means and unit variances. The shortest maturity yield, *i*, has no idiosyncratic shock[3].

Identification

We identify the model by formalizing the notion that monetary policy shocks only occur on "event days." Event days are FOMC meeting days, or on days between FOMC meetings when the Fed changes the Federal Funds Target rate. The variance of the monetary policy shock,

$$Em_t^2 = \begin{cases} 1 & \text{t} \in T_{\text{Event}} \\ 0 & \text{t} \notin T_{\text{no Event}} \end{cases} \tag{1.2}$$

equals one on event days and zero on other days.

[2] Here to keep the notation simple we treat the yield vector, *y*, as a scalar. Generalization to a vector is straight-forward. Yields and returns are measured as deviations from their mean.
[3] Allowing an idiosyncratic shock in the short maturity equation means the bivariate version of the model is just identified.

The covariance matrix of yields and equity returns on event days reflects the monetary policy shock and the other shocks,

$$
\begin{aligned}
&E\left(\begin{bmatrix}\Delta i\\ \Delta y\\ r\end{bmatrix}_t,\begin{bmatrix}\Delta i & \Delta y & r\end{bmatrix}_t\right)\equiv\Omega_F \qquad t\in T_{Event}\\
&=\begin{bmatrix}\sigma_m{}^2+\sigma_s{}^2 & & \\ \alpha_y+\beta_y & \alpha_y{}^2+\beta_y{}^2+\sigma_y{}^2 & \\ \alpha_r+\beta_r & \alpha_r\alpha_y+\beta_r\beta_y & \alpha_r{}^2+\beta_r{}^2+\sigma_r{}^2\end{bmatrix}
\end{aligned}
\tag{1.3}
$$

and on nonevent days when there is no policy shock the covariance matrix is,

$$
\Omega_{\not F}=\begin{bmatrix}\sigma_s{}^2 & & \\ \beta_y & \beta_y{}^2+\sigma_y{}^2 & \\ \beta_r & \beta_r\beta_y & \beta_r+\sigma_r{}^2\end{bmatrix} \quad \mathrm{t}\in \mathrm{T}_{\mathrm{Nonevent}}
\tag{1.4}
$$

The restriction that monetary policy shocks occur only on event days identifies the model. In equation 1.3 and 1.4 there are eight unknown parameters,

$$
\theta=\{\alpha_y,\alpha_r,\beta_y,\beta_r,\sigma_m,\sigma_s,\sigma_{ey},\sigma_{er}\}
$$

and twelve unique elements of the covariance matrices. The extension to a yield vector with *n* maturities is straight-forward and increases the over-identifying restrictions.

Estimation

Generalized Method of Moments (GMM) is the natural way to estimate this model. We estimate the sample moments with the observable data. And we use GMM to estimate the unknown parameters θ and test hypotheses.

Using the notation in Hamilton (1994) Chapter 14 let $g(\theta)$ denote the vector of the deviation of the sample moments from the population moments (that are functions of the unknown parameter values). For example, the first two elements of g are,

$$
\begin{aligned}
g_{1FOMC}&=\frac{1}{T_{FOMC}}\sum_{t\in T_{FOMC}}(\Delta i_t^2-(\sigma_m{}^2+\sigma_s{}^2))\\
g_{2FOMC}&=\frac{1}{T_{FOMC}}\sum_{t\in T_{FOMC}}(\Delta y_t\Delta i_t-(\alpha_y+\beta_y))
\end{aligned}
\tag{1.5}
$$

We get consistent estimates of the unknown parameter vector from,

$$
\arg\max_\theta Q=g'W_0g \tag{1.6}
$$

where W_0 is any positive definite matrix.

And we get asymptotically efficient estimates using an optimal weighting matrix, eg see Hamilton.

Comparison with the Literature

Event Study Models

Event study models only look at event days (or windows around the event day) when the Fed changes the Fed Funds target, and/or when the FOMC meets, $t \in T_{Event}$. Since the FOMC meets only eight times a year and target changes between meetings are unusual in recent years the event study methodology only uses a small subset of the daily data. For example, between 1988 and the end of 2001 there are over 3000 trading days on the NYSE (observations on yields and returns), but only 145 event days (FOMC meeting dates and target change dates.)

Identification and Estimation

Event study models, except Poole, Rasche, and Thornton (2002), identify the monetary policy shock as the observable change in the short maturity interest rate. Cochrane and Piazessi use the change in the one-month Eurodollar rate. Bernanke and Kuttner, Kuttner, and Poole and Rasche (2000) use the change in the Fed Funds Futures rate[4]. Expressed in terms of the factor model the event study identification assumes that the common shocks are zero on FOMC days,

$$\begin{aligned}
\Delta i_t &= \sigma_m m_t + \sigma_s s_t \\
\Delta y_t &= \alpha_y \Delta i_t + \beta_y s_t + e_{yt} \\
r_t &= \alpha_r \Delta i_t + \beta_r s_t + e_{rt} \\
s_t &= 0; t \in T_{Event}
\end{aligned} \tag{1.7}$$

Under the assumption that common shocks are zero on event days least squares gives consistent and efficient—since the model is just identified—estimates of the responses to monetary policy surprises using the observations on event days. .

Comparison

The factor model nests the event study models and uses data for event and nonevent days.

Errors in Variables Model

Poole, Rasche, and Thornton (2002) is the only event study model that explicitly recognizes that changes in the short maturity interest rate reflect information surprises as well as the monetary policy surprises. They structure their model to fit a standard errors in variables framework. They add the common information shock to the short maturity interest equation but not to the longer maturity yields. In their specification the observed response, Δi, is contaminated by the information shock,

[4] The Fed Funds Futures contract is an unusual contract that depends on the average of the daily Fed Funds rates. Since it depends on the average it smoothes much of the noise in daily rate changes and probably reveals changes in expectations of the Fed's target rate. See Kuttner and Poole et al for details.

$$
\begin{aligned}
&\Delta i_t = \sigma_m m_t + \sigma_s s_t \\
&\Delta y_t = \alpha_y \Delta i_t + (e_{yt} - \alpha_y s_t); \\
&t \in T_{FOMC}
\end{aligned}
\tag{1.8}
$$

which is correlated with the equation error in their yield equation. They use Wall Street Journal articles to identify event days with no monetary surprise. On these days the variance of Δi is the variance of the information shock. Given the estimate of σ_s , they use an errors in variables estimator to get consistent estimates of the yield response coefficients, α_y.

Comparison

Our factor model nests Poole, Rasche, and Thornton's errors in variables model. We use a different, and arguably more objective, identification scheme which allows us to use all the data—not just event days.

Rigobon and Sack's Model

Rigobon and Sack specify a general simultaneous equation setup that is popular in economics. Translated into our factor setup the R&S model is,

$$
\begin{aligned}
\Delta i_t &= \sigma_m m_t + \sigma_s s_t + \sigma_i e_{it} + b_{iy} e_{yt} + b_{ir} e_{rt} \\
\Delta y_t &= \alpha_y m_t + \beta_y s_t + b_{yi} e_{it} + \sigma_y e_{yt} + b_{yr} e_{rt} \\
r_t &= \alpha_r m_t + \beta_r s_t + b_{ri} e_{it} + b_{ry} e_{yt} + \sigma_r e_{rt}
\end{aligned}
\tag{1.9}
$$

In the fully simultaneous system what we called an idiosyncratic shock, *e*, affects all the securities. The security specific shock, *e*, in their specification is nondiversifiable systematic risk. They have five factors and no diversifiable risk.

R&S Identification & Estimation

R&S's model is very general and unidentified. They cleverly use the fact that monetary policy shocks occur on event days to partially identify the model. The difference in the covariance matrices between event and nonevent days,

$$
\Delta^{RS} \equiv \Omega^{RS}{}_{F} - \Omega^{RS}{}_{\not F} = \sigma_m{}^2 \begin{bmatrix} 1 & & \\ \alpha_y & \alpha_y{}^2 & \\ \alpha_r & \alpha_r \alpha_y & \alpha_r{}^2 \end{bmatrix}
\tag{1.10}
$$

reveals the variance of the monetary shock and the response of yields and the equity return to the monetary shock. It does not reveal any information about the common or idiosyncratic shocks.

R&S could get consistent and efficient estimates of the identified parameters, α_y, α_r, and σ_m using GMM or some other systems estimator with all of the data. Instead they estimate the parameters using a single instrumental variable estimator that does not impose the nonlinear restrictions in equation 1.10. And for nonevent days they choose the day before the event day. They only use about 10% of the available data.

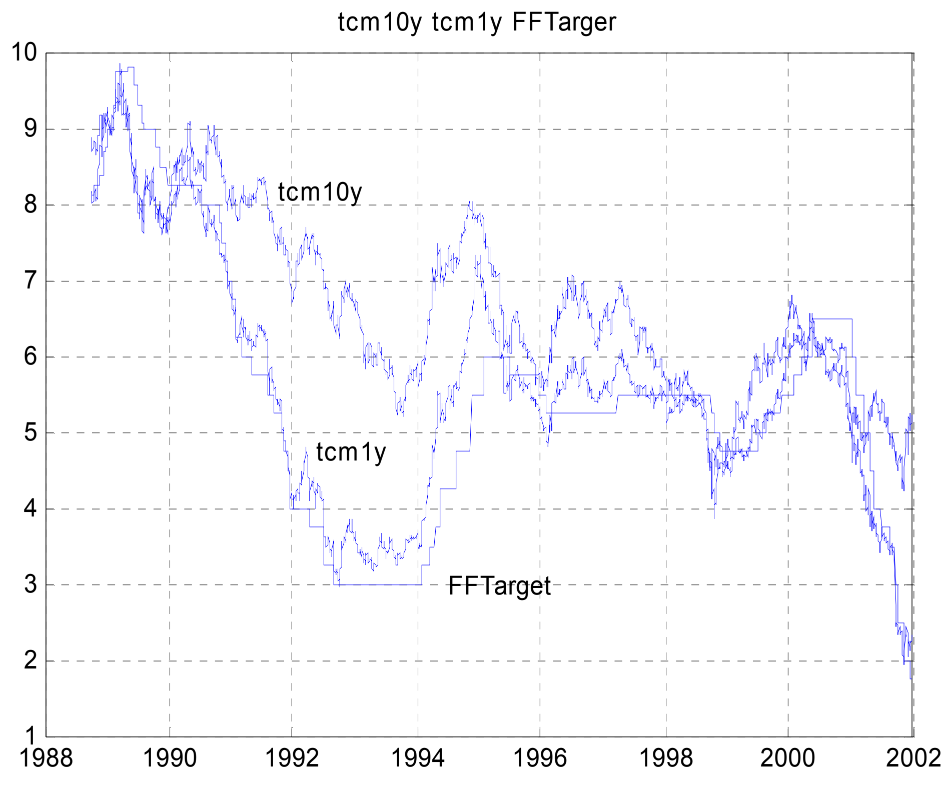
Comparison

Rigobon and Sack's general specification nests our factor model. We followed the standard practice in finance of separating risk into systematic risk—common factors—and security specific risk—diversifiable risk. This restriction makes the factor model fully identified when we adopt R&S's heteroskedasticity specification for event day shocks.

Section 2: Data

Our factor model specifies that the change in security prices depends on the monetary policy surprise, a common information shock, and an idiosyncratic shock that is security specific. In principle the monetary policy surprise should affect all security prices from the shortest maturity bond to infinitely lived equity prices. We use data on yields and equity returns for the period from 10/88 (when Fed Funds Futures began trading on the CBOE) through 12/01 (the latest CRSP data.) We also look at a subsample starting in 2/94. when the FOMC began to pursue a much more transparent policy regime that made it easier for market participants to forecast policy (Target) changes. They announced changes in the Target immediately and in 1997 announced the "intended federal funds rate" and in 1999 started announcing an "intended bias" toward changing the Target or keeping it the same. Arguably the most important move to transparency was limiting Target changes to FOMC meeting dates except in very unusual events. Prior to 1994 most of the Target changes took place between meetings. Agents had to guess when the Target would change as well as by how much.

Event studies examine the response of Treasury yields to their definition of a monetary policy shock. We use the same yield data which comes from the Federal Reserve Board's web site. We chose yields for constant maturity treasury bonds with maturities of 10years, 7years, 5years, 3years, 1years, and 3months. Figure 1 shows the Fed Funds Target and the one and 10year yields. The yields and Target are measured at annual percentage rates.

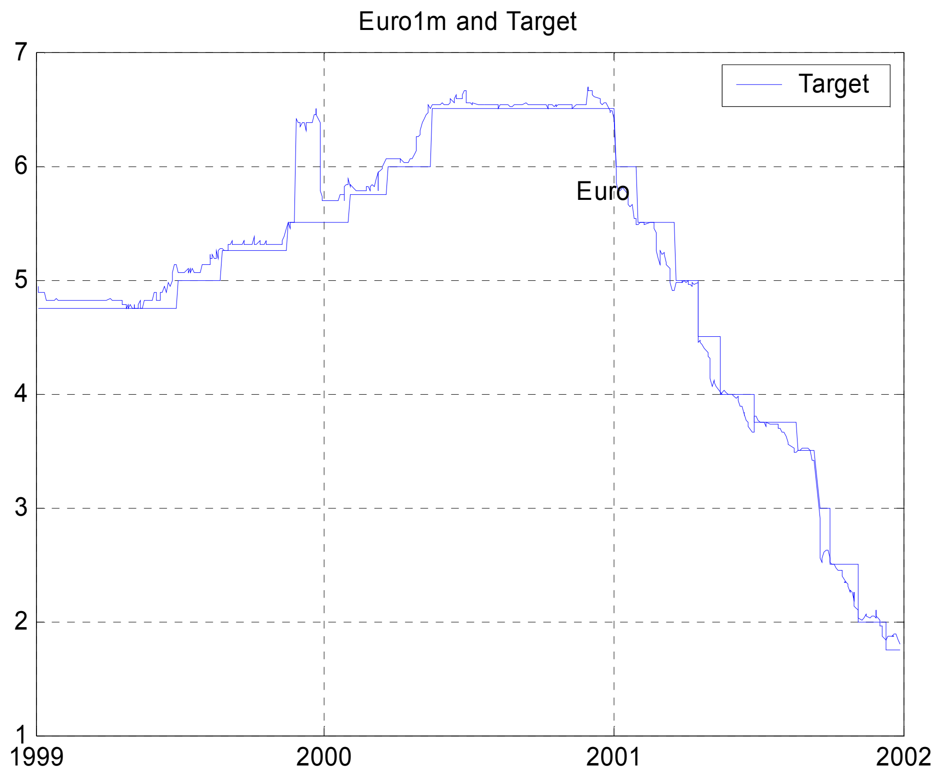


The yields generally move with the Target, but there are significant departures even in the one-year yield.

Event studies define the monetary shock as the change in a short maturity yield—Cochrane and Piazzesi use the 30-day Eurodollar rate and Bernanke and Kuttner, Kuttner and Poole and Raasche use the Fed Funds Futures rate—on the event day[5]. We try both as short maturity yields. The Eurodollar rate comes from the Federal Reserve Board's web site. We follow Cochrane and Piazzesi and lead the Eurodollar data by one day to compensate for the plus six hour time differential from New York to London. The Fed Funds Futures data come from Datastream[6].

Figure 2 shows the 30-day Eurodollar rate and the Fed Funds Target for 99 through 01. Cochrane and Piazzesi have a similar picture for 2001.

Figure 2



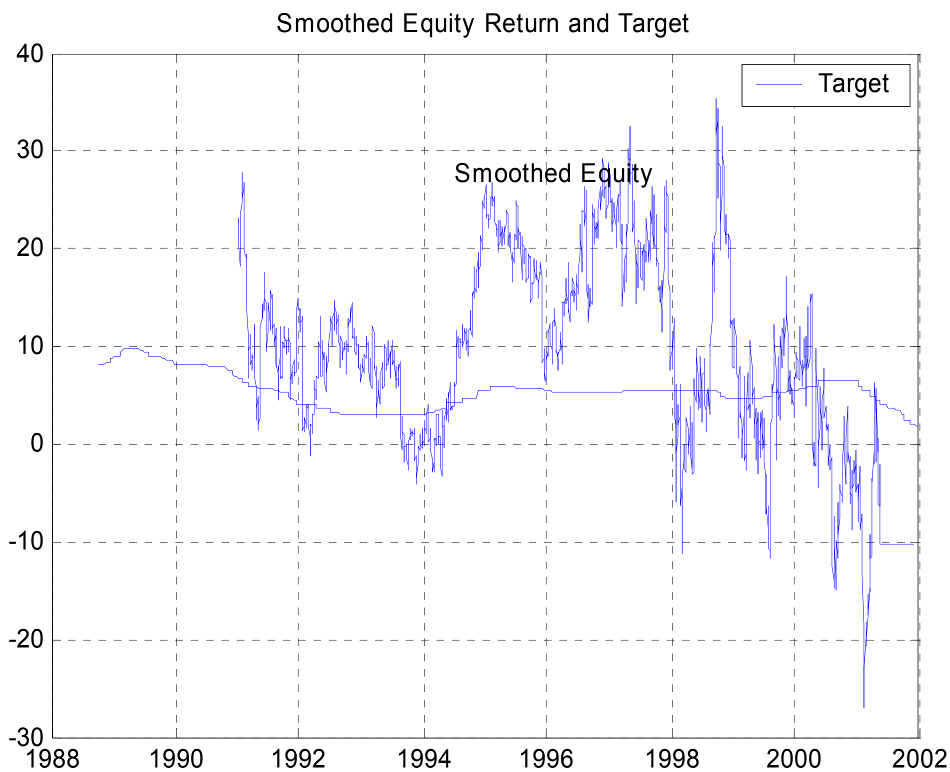
Notice the Euro seems to anticipate most of the increases the Target during 1999 and the first half of 2000, and then most of the decreases in 2001. Cochrane and Piazzesi use this impressive visual evidence to justify identifying the monetary policy surprise as the change in the 30-day Euro rate. One should also notice considerable movements in the Euro rate that seem unrelated the Fed Funds rate.

[5] Cochrane and Piazzesi use an event window.

[6] Kuttner weights the change in futures rate as follows, $\frac{n}{n-\tau}\Delta i_t$, where n is the number of days in the month and τ the number of days plus one that elapsed in the current month before the current day t. We use Kuttner's weighted change.

Financial journalists frequently attribute changes in stock prices to changes in Federal Reserve policy, or no changes in policy when the market expected a change. The recent papers by Bernanke and Kuttner and Rigobon and Sack document a strong reaction in equity markets. We include the return on the value-weighted NYSE from CRSP. The return is calculated as the log difference of the value-weighted index including distributions. The return is a daily return. Figure 2 shows the smoothed (one-year moving average) daily return measured as annual percentage rate and the target.

Figure 2



We smoothed the data for the picture. We use daily return for estimation. The daily return is extremely volatile. The standard deviation of the daily equity return of, 0.9 is half the standard deviation of the three-month annualized Treasury yield of 1.8.

Table 2.1 gives descriptive statistics for the full sample period. We use every trading day between October 1988 and the end of 2001 when trades occurred on both the NYSE and the Bond market. The only exception is that we excluded September 17, 2001. On September 17 the NYSE reopened after being closed for a week following the 9/11 attacks and Fed reduced the target rate. Table 2.2 gives the descriptive statistics for the sub-sample from 1994-2001.

Table 2.1

Descriptive statistics of changes in yields in basis points, percentage equity returns and monetary shocks in basis points: 1988 to 2001.

Asset	Std dev		Cov-CP		Cov-K	
	Policy	Non-Policy	Policy	Non-Policy	Policy	Non-Policy
3 mth yield, change	7.718	5.392	57.988	7.723	50.809	7.366
1 yr yield, change	7.707	5.546	55.749	10.388	49.917	8.491
3 yr yield, change	7.200	6.328	38.774	11.458	32.134	7.302
5 yr yield, change	7.216	6.313	32.294	10.150	24.507	6.640
7 yr yield, change	6.747	6.148	24.974	9.375	19.267	5.577
10 yr yield, change	6.306	5.864	18.756	8.312	13.499	4.963
Equity return	0.857	0.852	-3.727	-0.217	-2.765	0.017
Coch-Pia shock	10.561	7.203	-	-	-	-
Kuttner shock	9.933	6.499	-	-	-	-
Number of days	144	3161	-	-	-	-

The first two columns give the standard deviations of the variables on event and nonevent days. In general the event days—FOMC meeting days or Target change days—have larger standard deviations. The only exception is the equity return in 94 sub-sample. More news arrives on event days. The last two rows show the standard deviation of the change in the shortest maturity interest rate—the 30 day Eurodollar, and the Fed Funds Futures rate. Event studies define these variables on event days as the monetary shock. The standard deviation of these variables is much larger on event days. But notice that the standard deviation is large on nonevent days. Information arrives everyday that changes yields.

Table 2.2

Descriptive statistics of changes in yields in basis points, percentage equity returns and monetary shocks in basis points: 1994 to 2001.

Asset	Std dev		Cov-CP		Cov-K	
	Policy	Non-Policy	Policy	Non-Policy	Policy	Non-Policy
3 mth yield, change	6.902	5.689	45.157	7.300	33.478	7.429
1 yr yield, change	6.302	5.393	38.912	7.684	25.550	6.841
3 yr yield, change	6.812	6.366	22.184	7.866	8.921	6.253
5 yr yield, change	7.238	6.422	14.882	6.779	1.445	5.603
10 yr yield, change	6.251	6.083	-1.269	4.767	-10.478	3.806
Equity return	0.931	0.932	-5.943	0.002	-4.649	0.286
Coch-Pia shock	10.953	5.167	-	-	-	-
Kuttner shock	9.468	4.542				
Number of days	67	1904	-	-	-	-

The remaining columns give the covariance between changes in a short maturity yield and changes in longer maturity yields and the equity return.[7] The covariance is much larger on event days than nonevent days.

The statistics for the two samples look fairly similar except for the covariances. In the 94 sub-sample the covariance between the change in the 10year yield and the short maturity rate is negative. In the full sample it is positive.

Section 3: Results

This section presents the results from three models—the factor model, the event studies model, and R&S's model—for two sample periods with two measures of the shortest rate—twelve combinations. Two robust results stand out: (1) allowing for a common information shock is important, and (2) monetary policy surprises have a strong impact on equity returns that has received very little attention.

[7] These are proportional to the response coefficients in event studies.

Tables 3.1 through 3.4 present the estimates of the factor model. Tables 3.5 and 3.6 compare the security market response coefficient for the factor model, the event studies model, and R&S's model. Table 3.7 gives the estimates for the multivariate factor model.

A digression: Units

Most papers in this literature focus on the effect of monetary surprises on the yield curve. They use annual yields on various maturities as the dependent variable[8]. Bernanke and Kuttner's recent (2003) event study paper is one of the first to look at equity market returns. They look only at equity returns. We look at bond and equity data. We use daily returns to make the bond and stock data comparable. The daily return is the natural measure in the equity market since there is no yield to maturity. The daily return is,

$$r(s)_t = \Delta \ln(vwindd)_t \tag{3.1}$$

where *vwindd* is the value weight NYSE index including distributions in our data set.

To calculate the daily return on bonds from the yield data use the fact that the annual yield, $y(n)_t$, on day t for a discount bond with n years of maturity remaining is,

$$y(n)_t \equiv -\tfrac{1}{n} \ln p(n)_t \tag{3.2}$$

the negative of the log of the price, *p*, divided by the maturity. So the daily difference in the log of the prices, the daily return, is the negative of the daily difference in the yield multiplied by the maturity,

$$\Delta p(n)_t \equiv r(n)_t = -n\Delta y(n)_t \tag{3.3}$$

Results

Bivariate Models

The event studies model is just identified so a single equation approach gives efficient estimates. R&S use a single equation instrumental variable estimator to estimate the identified parameters in their model. In this sub-section we present estimates of the bivariate version of the factor model

$$\begin{aligned} r(i)_t &= \sigma_m m_t + \sigma_s s_t \\ r(j)_t &= \alpha_j m_t + \beta_j s_t + \sigma_j e(j)_t \end{aligned} \tag{3.4}$$

where $r(i)$ is the daily return on the Fed Funds Futures contract or on the 30-day Eurodollar and $r(j)$ is the daily return on a constant maturity Treasury bond or the value weighted NYSE index.

Table 3.1 shows the estimates of the bivariate model where $r(i)$ is the return on the Fed Funds futures contract[9].

[8] The yield data on the FRB's web site are percentage annual rates.

[9] For those of you who actually look at tables you noticed negative standard errors. Please change them in your head to positive. This happened because importing text with () into Excel translates to minus. Also divide all the cells by 10 to get responses measured in %.

Table 3.1 Bivariate Models with Fed Funds Futures
Sample Period 1988-2001

Asset	slope Common Shock	slope Money Shock	sigma Ido Shock	sigma Common Shock	sigma Money Shock
r(3mth)	-0.28775	-1.389	-1.31475	1.59175	1.93625
se	0.0635	0.22125	0.05375	-0.189	-0.34425
r(1yr)	-1.322	-5.37	-5.381	1.59675	1.9255
se	0.208	0.998	0.141	-0.1815	-0.332
r(3yr)	-3.363	-10.014	-18.687	1.62875	1.854
se	0.588	3.048	0.381	-0.20825	-0.39925
r(5yr)	-5.045	-14.655	-31.205	1.65025	1.73525
se	0.82	5.41	0.585	-0.21025	-0.419
r(10yr)	-7.62	-14.96	-58.22	1.63	1.8025
se	1.22	9.71	1.08	-0.216	-0.42925
r(equity)	-0.4	-36.1	84.2	1.55375	2.0975
se	-2.2	-13.1	-2	-0.22025	-0.35

The first column gives the response coefficients for the common shock. The common shock is significant and important for the bonds of all maturities. A positive common shock reduces the bond price (the return is negative) and the decline is larger the longer the maturity. The common shock is not important in the bivariate model for equities.

The second column gives the response coefficients for a monetary policy shock. A positive monetary policy shock (a surprise increase in the Target) reduces the price of bonds of all maturities and equities. The response for 10 year bonds is insignificant, but the response in the equity market is very large and significant. A 25 basis point monetary policy surprise leads to a 90 basis point change in the daily return on equities.

Table 3.2 gives the estimates of the bivariate factor model for the subsample starting in 94.

Table 3.2 Bivariate Models with Fed Funds Futures
Sample Period 1994-2001

Asset	slope Common Shock	slope Money Shock	sigma Idio Shock	sigma Common Shock	sigma Money Shock
r(3mth)	-0.416	-0.8595	-1.37025	1.14275	2.0135
se	0.11425	0.3045	0.07	0.16575	0.4905
r(1yr)	-1.536	-2.261	-5.205	1.14325	2.001
se	0.362	1.283	0.177	0.166	0.4955
r(3yr)	-4.185	-0.654	-18.699	1.13725	2.00025
se	0.894	4.356	0.498	0.16725	0.48975
r(5yr)	-6.26	2.63	-31.63	1.1385	1.90875
se	1.21	9.17	0.785	0.167	0.49625
r(10yr)	-8.36	17.34	-60.19	1.1345	2.09225
se	1.49	16.19	1.46	0.1675	0.42575
r(equity)	2.2	-56.3	90.9	0.99075	2.2015
se	-4.7	-17.5	-2.6	0.18075	0.45375

The overall results are fairly similar for the subsample where some believe that there was a different data generating process because Fed policy was more transparent. The major difference is the impact of monetary policy shocks on long maturity bond returns. Now surprises affect only short maturity bonds. The responses for bonds with maturities over a year are insignificant. Common shocks still have large and significant effects everywhere except the equity market. And the equity market response it very large and significant.

Tables 3 and 5 in the Appendix give the estimates of the factor model when the shortest maturity is the 30-day Eurodollar contract. Those tables are in bond yields and equity returns, so it is harder to make direct comparisons. The results, however, are very similar. Table 7 in the appendix shows the *p* values for the tests of the over-identifying restrictions. The bivariate model has only one over-identifying restriction (no idiosyncratic shock in the short maturity return). The model is not rejected for any of the bond equations. The equity model would be rejected at the 1% level, but not at the 5% level. Common shocks between equity and bond markets don't seem to have much in common.

Model Comparisons

Our factor model, R&S simultaneous equation model, and the event study models all provide estimates of the main parameter of interest—the response of a security market return to a monetary shock. Tables 3.5 and 3.6 show the estimates and their standard errors for the three models.

We estimated the event studies models with OLS using only observations on event days. We estimated R&S's model using the instrumental variable estimator they use. We chose a paired sample—event days and the day preceding the event day for nonevent days—as they did. Recall their sample selection technique ignores 90% of the nonevent days. And their estimates are sensitive to the choice of the nonevent day.

Table 3.5 Model Comparisons
Effects of monetary shocks on security returns
Sample: 1988-2001

Asset	Euro Factor	Euro Event	Euro Rig-Sack	Futures Factor	Futures Event	Futures Rig-Sack
r(3mth)	-1.4695	-1.136	-1.699	-1.389	-0.997	-1.23675
se	0.204	0.09425	0.20775	0.22125	0.0945	0.15025
r(1yr)	-5.518	-4.242	-5.719	-5.37	-3.896	-4.271
se	0.963	0.379	0.715	0.998	0.38	0.534
r(3yr)	-10.326	-8.127	-10.188	-10.014	-7.245	-7.479
se	3.144	1.149	1.905	3.048	1.209	1.602
r(5yr)	-16.095	-10.685	-14.375	-14.655	-12.4	-9.63
se	5.335	1.905	3.115	5.41	2.85	2.605
r(10yr)	-16.94	-12.37	-16.44	-14.96	-9.86	-8.12
se	10.62	3.54	5.77	15.41	3.75	5
r(equity)	-41.7	-28.3	-40.2	-36.1	-23.5	-34.2
se	12	5.2	9.8	13.1	5.7	8.8

The coefficient estimates are fairly similar. The event study models, which omit common shocks get smaller (in absolute value) response coefficients as one would expect if common shocks are important.

The major differences, however, are in the estimates of the standard errors. And these have important economic implications for how we should think about the impact of monetary policy. In the event study models a positive monetary surprise of one percent reduces the daily return on the 10 year bond return by 1.23% (increases the annual yield by 0.12%) which is hard to reconcile with economic theory. Cochrane and Piazzesi call this a puzzle. The factor model solves the puzzle—when one allows for a common shock the impact of a monetary shock on the price of a 10 year bond is insignificant. The R&S results are in between—if one uses the change in the Eurodollar rate then the R&S estimator finds a significant response for 10 year bonds. But, if one uses the Fed Funds Futures rate, the response is insignificant.

Notice that all of the models show that equity returns have a large and significant response to monetary policy surprises. A one percent money surprise lowers the daily return by 2% to 4% depending on the model.

Table 3.6 shows the 1994-2001 sub-sample.

Table 3.6 Model Comparisons
Effects of monetary shocks on security returns
Sample: 1994-2001

	Euro			Futures		
Asset	Factor	Event	Rig-Sack	Factor	Event	Rig-Sack
r(3mth)	-0.966	-0.90075	-0.87425	-0.8595	-0.7525	-0.8245
se	0.273	0.15	0.1845	0.3045	0.1565	0.186
r(1yr)	-3.207	-3.107	-2.849	-2.261	-2.281	-2.042
se	1.55	0.685	0.692	1.452	0.707	0.699
r(3yr)	-4.374	-5.16	-4.074	-0.654	-2.388	-1.356
se	4.65	2.055	2.076	4.356	2.121	2.097
r(5yr)	-7.395	-5.385	-3.945	2.63	-0.615	0.89
se	9.145	3.495	3.46	9.17	3.62	3.525
r(10yr)	5.93	1	4.93	17.34	9.78	14.07
se	17.33	6.69	7.03	16.19	6.74	7.06
r(equity)	-67.1	-50.5	-57	-56.3	-45.7	-53
se	12.8	8.7	10.3	17.5	9.1	10.4

In the sub-sample when policy is more transparent none of the models show significant responses for bond prices with maturities longer than three years. The action is at the short end of the term structure and in equities.

Multivariate Model

In the multivariate model we impose all of the model's over-identifying restrictions. The model specifies that the (demeaned) vector of six bond market returns plus the equity return respond to two systematic factors—a common information shock and the monetary surprise shock—plus security specific idiosyncratic shocks. We estimate 20 parameters using over 3000 observations and impose 36 over-identifying restrictions. This is the most stringent test of the model and the data strongly reject the model. This is a disappointing but not unusual result. Most models that try to simultaneously explain stock and bond data are rejected, eg, see Campbell and Viceria (2000), or ??. We are working—with some success—on a three factor model.

Even though the test of the over-identifying restrictions indicates some misspecification the parameter estimates are worth examining and are very interesting. Table 3.9 shows the estimates from the full sample,

Table 3.9
Multivariate Results of the effects of monetary policy shocks on bond and equity returns
Sample 1988-2001

Euro results

The value of the objective function is 320.73
Overidentifying restriction test p-value is 2.1781e-047
With degrees of freedom = 36.000

Fed Funds Futures

The value of the objective function is 295.76
Overidentifying restriction test p-value is 1.4682e-042
With degrees of freedom = 36.000

		Euro results Estimate	Euro results se	Fed Funds Futures Estimate	Fed Funds Futures se
short	(common)	-0.06526	-0.01018	-0.05213	-0.00736
	(money)	-0.67457	-0.09733	-0.67918	-0.0688
3mth	(common)	-0.38428	-0.03147	-0.3575	-0.03199
	(money)	-1.03395	0.118683	-3.7576	0.13289
1yr	(common)	-3.7576	-0.13408	-3.6462	-0.13674
	(money)	-2.7636	-0.61691	-3.4727	-0.73527
3yr	(common)	-16.0203	-0.39444	-15.7653	-0.39534
	(money)	-0.41748	-2.41206	-2.49102	-2.6469
5yr	(common)	-28.32	-0.60995	-28.1015	-0.6083
	(money)	5.1265	-4.6336	0.43443	-5.045
10yr	(common)	-51.561	-1.1696	-51.737	-1.161
	(money)	18.873	-9.0381	11.57	-9.3839
equity	(common)	-10.174	2.0526	-12.312	2.079
	(money)	-19.752	10.336	-24.57	9.4523
3mth	(idio)	0.721225	0.039775	0.6999	0.03874
1yr	(idio)	1.5971	0.060323	1.6301	0.055779
3yr	(idio)	4.1406	0.097272	4.128	0.098103
5yr	(idio)	3.93385	0.23938	4.0055	0.234535
10yr	(idio)	15.467	0.48771	15.266	0.50239
equity	(idio)	0.76137	0.019377	0.76671	0.019407

All of the bond and the equity returns respond strongly and significantly to the common shock. The common shock is a level shock for the term structure. The response to a money shock resembles a textbook description—a positive shock causes short (out to a year) maturity yields to rise (bond prices and returns fall). Intermediate maturity yields—3 to 5 years do nothing—and the long yield actually falls (bond price increases.)

In the model that uses Eurodollars as the shortest maturity bond (column 1) a one percent monetary policy shock causes the daily return on a 10year bond to rise by 1.8% (the yield to fall by 0.18%). Equity returns move in the opposite direction by almost the same magnitude. And the responses are significant.

Conclusions

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Appendix

Table 3:

Effects of monetary shocks on Treasury yields in basis points and equity returns in percentages, using Cochrane and Piazzesi shocks, 1994 to 2001: stardard errors based on GMM are in parentheses.

Asset	Common SD (σ_s)	Money SD (σ_m)	Common shock (β)	Money shock (α)	Idiosyn. SD (σ_e)	Test[a] (pv)
3 mth	5.161	9.572	1.409	3.864	5.503	0.003
	(0.617)	(2.500)	(0.554)	(1.092)	(0.287)	(0.955)
1 yr	5.163	9.579	1.485	3.207	5.180	0.001
	(0.617)	(2.470)	(0.428)	(1.117)	(0.165)	(0.972)
3 yr	5.176	9.300	1.533	1.458	6.192	0.106
	(0.620)	(2.441)	(0.357)	(1.550)	(0.158)	(0.744)
5 yr	5.176	8.684	1.321	1.479	6.303	0.593
	(0.621)	(2.486)	(0.292)	(1.829)	(0.155)	(0.441)
10 yr	5.167	9.456	0.923	-0.593	6.014	0.011
	(0.622)	(2.311)	(0.155)	(1.733)	(0.144)	(0.916)
Equity	4.594	10.196	-0.053	-0.671	0.896	7.664
	(0.660)	(2.240)	(0.050)	(0.128)	(0.026)	(0.006)

(a) Test for the number of overidentifying restrictions, based on one overidentifying restriction, with p-value in parentheses.