Relief Rallies after FOMC Announcements as a Resolution of Uncertainty

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Abstract

We find substantial positive average stock returns after FOMC announcements accompanied by the release of the Summary of Economic Projections (SEP) and press conference by the Fed Chair. Both SEPs and press conferences contain new information that moves financial markets. We show that several measures of uncertainty are significantly higher on days of FOMC announcements accompanied by SEP and press conference than on announcement days without SEP and press conference. Controlling for changes in uncertainty measured by VIX changes, the positive unconditional mean returns after the FOMC announcements with SEP and press conference disappear. We also find that stocks correlated with market uncertainty shocks have higher returns on days of FOMC meetings with SEP and press conference. These results suggest that the positive post-announcement stock market returns are related to resolution of uncertainty.

JEL classification: E44; E52; E58; G14; G18

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> "The Federal Reserve's decision to hike rates gave investors room to breathe after months of will-they-won't-they agony. Wall Street's forecasts for a December hike came true and markets rallied. "We got a pop on the reduction of uncertainty," Brad McMillan, chief investment officer for Commonwealth Financial Network, told TheStreet."
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> TheStreet.com, December 16, 2015

1. Introduction

Market participants closely follow central bank announcements because these announcements move prices of financial assets.[1] Federal Reserve officials have made a concerted effort to communicate their assessment of the economic outlook and provide information about the future direction of policy. On November 20, 2007, the Federal Open Market Committee (FOMC) started publishing the Summary of Economic Projections (SEP) after every other FOMC meeting. The SEP includes Fed policymakers' projections for three major macroeconomic indicators: real GDP growth, unemployment rate, and inflation. Until 2010, the SEP was released with the FOMC minutes three weeks after the meeting. In 2011-2012, the SEP was released within two hours after the FOMC statement. Since then, it has been released simultaneously with the release of the statement. Beginning on January 25, 2012, the SEP has included the FOMC members' anonymous assessments of the appropriate monetary policy for the next few years and the longer term. These assessments, known as the "dot plots," are widely discussed by market participants.[2] The release of the SEP is followed by a press conference in which the Fed Chair explains the Fed's actions and answers questions. These releases make monetary policy actions more predictable and help form market expectations of the future path of policy.

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[1] Studies analyzing the effect of monetary announcements on financial markets include Bernanke and Kuttner (2005), Basistha and Kurov (2008), Wongswan (2009), and Kontonikas, MacDonald and Saggu (2013).

[2] For example, Feroli, Greenlaw, Hooper, Mishkin and Sufi (2016) state that the "dot plot" is the most important element of the Fed's "forward guidance." See Figure 2 at http://www.federalreserve.gov/monetarypolicy/fomcminutes20120125ep.htm for an example of the "dot plot."

We show that FOMC announcements with SEP and press conference give rise to significant positive average stock returns. These rallies are substantial: During the first hour after such announcements, the U.S. stock prices increase on average by approximately 49 basis points. These returns are not driven by good news about monetary policy or outliers. A trading strategy of buying the E-mini S&P 500 futures contracts five minutes before the FOMC announcements with SEP and press conference and closing the position 55 minutes after the announcement would have earned an annualized Sharpe ratio of 1.78.

We examine what drives the high average post-announcement returns. In classical asset pricing theory, positive expected excess returns represent compensation for systematic risk. However, recent literature shows that uncertainty also influences asset prices. For example, Bansal and Yaron (2004) show theoretically that the equity premium contains a component driven by fluctuations in economic uncertainty; a decline in uncertainty triggers a drop in the equity premium, which leads to an immediate increase in stock prices. Anderson, Ghysels and Juergens (2009) find that stock returns are related to economic uncertainty. Using a general equilibrium model capturing time-varying economic uncertainty, Bollerslev, Tauchen and Zhou (2009) argue that the market risk premium includes a premium for bearing volatility risk; when the market anticipates high volatility, there is a discount built into prices, resulting in higher expected returns.

Our results are consistent with these arguments. We show that market uncertainty, measured by the VIX index,[3] is high before FOMC announcements with SEP and press conference and then significantly decreases after the announcement, but there is no similar

[3] Studies using the VIX index as a proxy for market uncertainty include Chen and Clements (2007), Vahamaa and Aijo (2011), Lucca and Moench (2015), Agapova and Madura (2016), Amengual and Xiu (2018), and Fernandez-Perez, Frijns and Tourani-Rad (2017).

decline after FOMC announcements without SEP and press conference. We then conduct an analysis to relate the magnitude of the E-mini S&P 500 index positive unconditional average returns to the amount of uncertainty resolved around these FOMC announcements. We measure the amount of uncertainty resolved by changes in the VIX. Because the changes in VIX cannot be assumed to be exogenous, we use the two-stage least squares regression where the instrumental variable is the one-day lag of the VIX. We show that the positive unconditional stock returns after the FOMC announcements with SEP and press conference disappear after controlling for the change in VIX, supporting the conclusion that these returns are related to the resolution of uncertainty.

We complement this aggregate analysis by a disaggregated analysis of individual stocks. Building on Ang, Hodrick, Xing and Zhang (2006), Chang, Christoffersen and Jacobs (2013), and Cremers, Halling and Weinbaum (2015) who estimate models that include a volatility factor, we estimate a two-factor model and show that stocks that are more sensitive to volatility shocks have higher returns on FOMC announcement days with SEP and press conference. This finding is consistent with the hypothesis that the positive post-announcement stock returns are related to the resolution of uncertainty after the announcement.

There are two potential reasons for a greater uncertainty resolution after FOMC meetings followed by SEP releases. First, the information contained in the SEP and press conference helps reduce uncertainty. Second, since these meetings are followed by the press conferences where the Fed can explain its actions, the FOMC is likelier to introduce significant policy changes at these meetings.[4] The FOMC may also be more inclined to make important policy decisions at

[4] For example, the FOMC's decision to begin tapering asset purchases under the quantitative easing program in December 2013, the decision to initiate a lift-off from the zero bound in December 2015, and all subsequent decisions to increase the federal funds rate target range (in December 2016, March 2017, June 2017, December 2017, and March 2018) were made at meetings followed by SEP and press conference.

these meetings because investors pay more attention to the announcements followed by press conferences (Boguth, Gregoire and Martineau, 2018). This prospect of important decisions increases uncertainty before the FOMC meeting and leads a to greater uncertainty resolution after the meeting.

Our paper adds to the literature on the stock market uncertainty around FOMC meetings. Chen and Clements (2007) use daily data to show that the VIX falls on days with FOMC meetings. Vähämaa and Äijö (2011) confirm this finding with daily data and argue that it signifies the monetary policy decisions affecting the stock market uncertainty. Fernandez-Perez, Frijns and Tourani-Rad (2017) document a decrease in VIX on FOMC meeting days with intraday data and also attribute it to the resolution of market uncertainty. Amengual and Xiu (2018) model the term structure of variance in a general non-affine modeling framework and find that most of downward volatility jumps, measured by daily VIX changes, are associated with FOMC announcements and the Fed Chair speeches, which confirms the findings from the earlier studies: decreases in volatility are highly correlated with the monetary policy uncertainty resolution. In contrast to these previous studies that relate decreases in volatility to resolution of uncertainty following FOMC meetings in general, our paper focuses on the difference between FOMC meetings with and without SEP and press conference.

Other recent studies most closely related to our paper are Lucca and Moench (2015), Brusa, Savor and Wilson (2018), Savor and Wilson (2013), Cieslak, Morse and Vissing-Jorgensen (2018), and Boguth, Gregoire and Martineau (2018). Lucca and Moench (2015) find large positive average stock returns in the 24 hours before scheduled FOMC announcements. They find no significant return drift after the announcement and argue that the mismatch between the time when the news arrives and when the returns are earned makes it difficult to explain

these returns by asset pricing theory. In contrast, we find sizable positive average stock returns *after* the FOMC announcements accompanied by the SEP and press conference rather than before the announcements. This makes the uncertainty-based explanation more plausible. In our sample, there is no evidence of the pre-FOMC announcement drift found by Lucca and Moench (2015).

Brusa, Savor and Wilson (2017) show that the FOMC announcements are unique in generating positive average excess returns in the global stock markets in the two-day window surrounding scheduled FOMC meetings. Announcements from other central banks are not associated with such premia in either international or domestic stock markets.

Savor and Wilson (2013) show higher average returns on days of scheduled announcements about inflation, unemployment, and interest rates. They argue that these higher returns represent a premium that investors demand for bearing macroeconomic risk. They provide evidence that this risk premium increases in periods of high uncertainty about the state of the economy. However, they use daily data, which makes it difficult to conclusively show when the risk premium is earned. We use intraday data, which allows establishing a direct link between resolution of uncertainty and contemporaneous stock returns.

Cieslak et al. (2018) find that the equity premium in the U.S. and the rest of the world is earned entirely in even weeks of the FOMC meeting cycle. They conclude that the excess stock returns over the FOMC cycle are mainly caused by Fed's informal communication with the media and the financial sector. They find no evidence that the equity premium is related to public releases from the Federal Reserve. In contrast, we show that some of the FOMC-related equity premium is driven by public releases.

In a concurrent independent study, Boguth, Gregoire and Martineau (2018) analyze the economic consequences of the Fed's practice to hold press conferences after every other FOMC meeting. They provide evidence that this communication policy has unintended consequences. Concentration of investor attention on the meetings accompanied by press conferences reduces the frequency at which important monetary policy news is released to the public, which may reduce transparency and social welfare. We focus on significant positive stock returns immediately after FOMC announcements accompanied by the SEP and press conference. We provide evidence that these stock market moves are "relief rallies" driven by the resolution of uncertainty. Boguth et al. (2018) maintain that the press conferences attract investor attention but convey little new information to the market. In contrast, we show that both the SEPs and the press conferences contain information that influences interest rate expectations.

2. Sample Selection and Data

2.1. Sample Period

The SEPs contain policymakers' forecasts of three macroeconomic variables (real GDP growth, unemployment rate, and inflation) and a survey of their views of the appropriate levels of the federal funds target rate for the next three years and in the longer term. These materials are released after every other FOMC meeting, and their release is followed by the Fed Chair's press conference that consists of a briefing by the Chair and a Q&A session.[5] We examine a sample period from January 2012 to December 2016 that contains 40 FOMC announcements, including 21 announcements accompanied by the SEP and press conference.[6] The sample period begins in

[5] On June 13, 2018, the Fed Chairman Jerome Powell announced plans to hold press conferences after every FOMC meeting beginning in January 2019.

[6] In 2012, there were five FOMC announcements accompanied by the SEP and press conference; the FOMC statement was released at 12:30 p.m., and the SEP was released at 2:00 p.m. In each of the following years, there

January 2012 because that is when the FOMC started releasing individual members' assessments of the appropriate future levels of the federal funds target rate.

Plosser (2012) argues that adding the information about the appropriate future levels of the federal funds target rate was a major enhancement because it helps market participants establish a connection between expected economic conditions discussed in the SEP and future monetary policy, which conveys information about the Fed's reaction function.[7] Furthermore, by providing information about the full range of views of appropriate policy, the "dot plots" help investors quantify and therefore reduce uncertainty about the future monetary policy.

2.2. Data and Summary Statistics

We measure stock returns as continuously compounded (log) returns computed using five-minute data for the nearby E-mini S&P 500 index futures contracts. The nearby contract liquidity declines in its last few days of trading. Therefore, the next closest contract is used when its daily trading volume exceeds the nearby contract volume. Summary statistics for stock returns in two intraday windows around the FOMC announcements are shown in Panels A and B of Table 1. To highlight characteristics of FOMC announcements with SEP and press conference, the statistics are computed separately for FOMC meetings with and without SEP and press conference. The table also shows the average realized volatility and trading volume around the announcements. The realized variance is computed as the sum of squared five-minute returns because this measure represents a more accurate measure of ex-post return variation than the more traditional sample variance.[8]

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were four FOMC announcements with the SEP and press conference; the FOMC statement and the SEP were released simultaneously at 2:00 p.m. Before January 2013, press conferences started at 2:15 p.m. Since then, the press conferences were scheduled to start at 2:30 p.m., 30 minutes after the release of the FOMC statements.

[7] Kahn and Palmer (2016) use projections from the SEP to estimate the FOMC's implicit policy reaction function.

[8] See, for example, Andersen, Bollerslev, Diebold and Ebens (2001).

The average post-announcement return for FOMC announcements with SEP and press conference is 49 basis points. 17 out of 21 announcements with SEP and press conference were followed by positive stock returns in the hour following the announcement.[9] In contrast, the average return for announcements without SEP and press conference is close to zero, with positive and negative post-announcement returns approximately equally frequent. Based on a two-sample *t*-test, the difference between the mean returns in the two sub-samples is statistically significant. Wilcoxon rank sum test of the difference in medians produces a similar result.[10] Table 1 also shows that announcements with SEP and press conference are accompanied by higher post-announcement return variance and trading activity than announcements without SEP and press conference.

[Insert Table 1 here]

Figure 1 plots the kernel densities for post-announcement returns in the interval from five minutes before to 55 minutes after announcement on days with and without the SEP and press conference. The bandwidth in this kernel density estimation is selected using the Sheather and Jones (1991) method recommended by Jones, Marron and Sheather (1996). The return density associated with SEP and press conference (solid line) is located to the right with most of mass at positive values. This indicates that the positive average post-announcement returns for FOMC announcements with SEP and press conference are not caused by outliers.

[Insert Figure 1 here]

[9] To put this in perspective, if the probability of observing a positive return were 0.5, the probability of observing 17 or more positive returns in 21 independent episodes would be approximately 0.0036. During our sample period, the empirical probability of a positive E-mini S&P 500 return in the interval from 1:55 p.m. to 2:55 p.m. on non-FOMC announcement days is approximately 0.51.

[10] As mentioned in Section 1, the FOMC started publishing the SEP in the fall of 2007 along with the FOMC minutes. We examined average stock returns around the release of the FOMC minutes with SEP during the 2007-2010 period and found no statistically significant results.

Lucca and Moench (2015) document large positive stock returns in the 24 hours before scheduled FOMC announcements. They find that the one-year rolling average of pre-FOMC stock returns is positive for most of their 1980-2011 sample period. To see whether this pre-announcement drift exists in our sample, we calculate cumulative average returns in a window from 24 hours before to five minutes before the release of the FOMC statement. Panel C in Table 1 shows no evidence of positive average pre-announcement returns. FOMC announcements with SEP and press conference are associated with a lower pre-announcement trading volume but a similar level of realized volatility compared to other FOMC announcements.

3. Empirical Results

This section presents our main empirical results of positive unconditional average returns after FOMC announcements with SEP and press conference, reports robustness checks and shows economic significance of our findings.

3.1. Effect of FOMC Announcements on the Stock Market

Panel A of Figure 2 shows cumulative average stock returns in the interval from 12 hours before to two hours after announcements with SEP and press conference. The average returns are positive and statistically significant after the official release time, indicating that the stock market rallies after announcements with SEP and press conference. Within one hour after the announcement, the E-mini S&P 500 index futures prices increase by approximately 45 basis points on average. Panel B of Figure 2 shows that, in contrast to the positive average returns

earned after FOMC announcements with SEP and press conference, the cumulative average returns after other FOMC announcements are close to zero.[11]

[Insert Figure 2 here]

Kandel and Pearson (1995) show that different interpretations of information by individual traders cause an increase in trading volume around public announcements. Ross (1989) argues that price volatility is proportional to the rate of information flow. Therefore, FOMC announcements with the SEP and press conference should be associated with higher market volatility and trading activity. Figure 3 shows the average trading volume and volatility in the E-mini S&P 500 index futures market. Panel A shows that announcements with SEP and press conference trigger higher trading activity compared to other FOMC announcements. Panel B shows that volatility of the E-mini S&P 500 futures returns exhibits a similar pattern.

[Insert Figure 3 here]

A possible explanation for the positive average returns after the FOMC announcements with SEP and press conference is that these announcements tend to contain good news about future monetary policy. To test for this explanation, we first plot announcement stock returns against monetary surprises separately for FOMC announcements with and without SEP and press conference. The event window is from five minutes before to 55 minutes after the release of the FOMC statement. To measure monetary surprises, we use changes in the implied rates of Eurodollar futures contracts with 8-9 quarters to expiration.[12] This proxy for monetary shocks is highly correlated with the principal component measure of unconventional monetary surprises

[11] The dashed lines in Figure 2 represent 95% confidence interval computed by assuming that the average cumulative returns follow the asymptotic normal distribution. To alleviate the concern about the small sample, we use a bootstrap procedure to simulate the distribution of the average cumulative returns. The resulting mean standard errors are similar and available upon request.

[12] Kurov and Gu (2016) use a similar measure of monetary policy shocks during the 2009-2015 period. Hanson and Stein (2015) use the two-year Treasury yield as a measure of monetary policy shocks.

used in Wright (2012) and Glick and Leduc (2012). Figure 4 shows that the announcements with SEP and press conference exhibit a negative relation between returns and monetary surprises. However, even most announcements that result in upward revision of rate expectations are accompanied by positive stock returns. In contrast, returns after FOMC announcements without SEP and press conference are not related to monetary surprises, and the average stock return after such announcements is close to zero. Monetary surprises on days with SEP and press conference are often larger than those on days with other FOMC announcements.

[Insert Figure 4 here]

In addition to providing visual evidence, we regress post-announcement stock returns on monetary policy shocks. To examine whether the average return after the FOMC announcements with SEP and press conference is statistically different from that after the announcements without SEP and press conference, we estimate the following event study regression with OLS:

$$R_t = a_0 + b_0 D_t^{SEP} + c_0 \Delta i_t + e_t, \quad (1)$$

where R_t is the E-mini S&P 500 index futures contract return,[13] D_t^{SEP} is a dummy variable equal to one for announcements with SEP and press conference and zero otherwise, and Δi_t is the change in the rate of Eurodollar futures with 8-9 quarters to expiration. R_t and Δi_t are measured over intraday event windows around FOMC announcements starting five minutes before the announcement and ending 55 minutes and 100 minutes after the announcement; the wider window ends 100 minutes after the announcement because several FOMC announcements in our sample occurred at 2:15 pm and intraday VIX data used in subsequent analysis is not available after the 4 p.m. stock market close. The constant a_0 captures the average unconditional mean

[13] The results in Table 2 are almost identical when we use returns on the spot S&P 500 index.

returns earned after the announcements without SEP and press conference. The coefficient b_0 is the mean return differential for announcements with SEP and press conference.

Panel A of Table 2 reports estimates of a baseline regression without the SEP dummy. Consistent with previous literature, we show that the stock market significantly and negatively reacts to the monetary policy shocks. Using the 60-minute window, a hypothetical 25-basis-point decline in the expected short-term interest rate two years ahead is on average associated with a 1.08% increase in the stock market. Importantly, the intercept estimate that captures the unconditional mean return is positive and statistically significant, suggesting that the monetary policy shocks do not account for the positive average post-announcement returns.

[Insert Table 2 here]

To test for a shift in the intercept for FOMC announcements with SEP and press conference, we estimate equation (1). Panel B of Table 2 shows the results. The unconditional average return is close to zero for FOMC announcements without SEP and press conference but increases by about 46 basis points for announcements with SEP and press conference in the one-hour window. These estimates are consistent with the average post-announcement returns shown in Table 1. The jump in OLS R^2 from 40 percent in Panel A to 59 percent in Panel B implies that the model that accounts for a shift in the mean around FOMC announcements with SEP and press conference explains the post-announcement returns better than the baseline model.

To allow for a differential market response between announcements accompanied by SEP and press conference and those without SEP and press conference, we add a term that interacts the interest rate shocks with the SEP dummy and a term that interacts the interest rate shocks with a dummy that takes on value of 1 if the announcement was not accompanied by SEP and press conference and 0 otherwise. The regression then becomes:

$$R_t = a_0 + b_0 D_t^{SEP} + c_0(1 - D_t^{SEP})\Delta i_t + c_1 D_t^{SEP}\Delta i_t + e_t. \quad (2)$$

While the coefficient c_0 in the Panel B regression measures the average response to the interest rate shocks for all announcements, this regression measures the response separately for announcements accompanied by SEP and press conference (measured by c_1) and those without SEP and press conference (measured by c_0). Panel C of Table 2 shows the results. The positive average post-announcement returns still exist only after announcements with SEP and press conference. The other FOMC announcements do not show a significant response of the stock market to changes in interest rate expectations. This difference between SEP announcements and other FOMC announcements is likely due to two reasons. First, the monetary surprises are lower around announcements without SEP than announcements with SEP as shown in Figure 4. For example, in the (-5 min, +55 min) window, the standard deviations of the monetary surprises are 0.100 and 0.038 around SEP and other FOMC announcements, respectively. Since other FOMC announcements have smaller monetary surprises, they carry less relevant information. Second, investor attention may differ. Boguth et al. (2018) argue that investors pay less attention to the FOMC announcements without press conferences. DellaVigna and Pollet (2009) and Hirshleifer, Lim and Teoh (2009) show that investor inattention and distraction by extraneous news events increase underreaction of prices to earnings announcements. Chen, Liu, Lu and Tang (2016) and Benamar, Foucault and Vega (2018) provide evidence that when investors pay less attention to macroeconomic announcements, the market reaction to them is weaker.

3.2. Robustness Checks

This section reports robustness checks. Section 3.2.1 verifies that our results are not driven by outliers and performs a bootstrapping exercise. Section 3.2.2 tests the robustness of the results

presented in Table 2 to different measures of monetary shocks. Section 3.2.3 addresses potential endogeneity.

3.2.1. Sample Size

Our five-year sample period contains 40 FOMC announcements. To address a potential concern about the effect of a small sample on inferences, we conduct two robustness checks. First, to make sure that the OLS regression results in Table 2 are not driven by a small number of outliers, we use the weighted least squares procedure of Yohai (1987). This so-called MM estimator is robust in the presence of outliers. Table 2 shows that the robust regression results are essentially the same as the OLS results.[14]

Second, we perform a bootstrapping exercise similarly to Lucca and Moench (2015). We draw with replacement 1,000 samples of returns and interest rate shocks from policy announcements with and without SEP and press conference. Each random sample contains 21 FOMC announcements with SEP and press conference and 19 announcements without SEP and press conference. We then estimate equation (1) for each random sample and examine the empirical distribution of the coefficient estimates. Table 3 shows that the mean and standard deviation of the estimated coefficient of the SEP dummy are almost identical to the corresponding estimates in Table 2.

[Insert Table 3 here]

[14] We repeat the Table 2 analysis with the MacKinnon and White (1985) heteroskedasticity consistent covariance matrix that performs well in small samples. The statistical significance of the coefficients remains the same as in Table 2, providing further evidence that our results are robust to small sample size.

3.2.2. Alternative Measures of Monetary Shocks

In Table 2, we measured the monetary surprise as the change in the rate of Eurodollar futures with 8-9 quarters to expiration. In this section, we test robustness of the results to three other measures of monetary shocks. First, we use the rate of the nearby (one quarter to expiration) Eurodollar futures to measure news about current short-term interest rates. The results are similar to the results in Table 2, although the R^2 is lower. Second, following Rogers, Scotti and Wright (2018), we measure the monetary shocks using the price changes in the five-year U.S. Treasury futures. The results are again similar to those in Table 2. Third, we attempt to account for two dimensions of monetary policy: changes in the Fed's forward guidance, proxied by the change in the rate of Eurodollar futures with 4-5 quarters to expiration, and news about bond purchases under the quantitative easing programs, proxied by the change in the ten-year U.S. Treasury yield. When both of these policy factors are included in the model instead of the single monetary shock, the coefficient estimates of the SEP dummy are essentially unchanged.[15] We conclude that good news about monetary policy does not explain the positive average returns after FOMC announcements with SEP and press conference.

3.2.3. Endogeneity

Stock returns and monetary policy expectations are simultaneously affected by economic news. Furthermore, Rigobon and Sack (2003) show that monetary policy reacts to stock returns. Therefore, a possible criticism of the event study regression in equations (1) and (2) is that the coefficient estimates may be affected by endogeneity and omitted variable biases. Thornton (2014) proposes a way to measure the effect of monetary policy on asset prices that is unaffected by such biases. This approach is based on using daily data and estimating a time-series

[15] The results of these robustness checks are not tabulated for brevity but are available upon request.

regression for all days in the sample rather than only for the FOMC announcement days. Interest rate changes on non-FOMC days are used to control for the relation between expectations of monetary policy and asset returns due to incoming economic news. We implement this approach by estimating the following regression:

$$R_t = a_0 + a_1 D_t^{SEP} + a_2 D_t^{non\text{-}SEP} + a_3 D_t^{news} + b_0 \Delta i_t + b_1 \Delta i_t D_t^{SEP} + b_2 \Delta i_t D_t^{non\text{-}SEP} + e_t, \quad (3)$$

where R_t is the daily return on the S&P 500 index, D_t^{SEP} is a dummy variable for the FOMC announcement days with SEP and press conference, $D_t^{non\text{-}SEP}$ is a dummy variable for the FOMC announcement days without SEP and press conference, D_t^{news} is a dummy variable for days with Producer Price Index (PPI) and unemployment rate announcements, and Δi_t is the daily change in the rate of Eurodollar futures with 8-9 quarters to expiration.

This regression uses data for all days in the sample period. Coefficients a_1 and a_2 capture unconditional stock returns on FOMC announcement days with and without SEP and press conference, respectively. Coefficient a_3 represents additional return earned on days of PPI and unemployment rate announcements. A positive and significant estimate of this coefficient would indicate that the average stock returns on such days are higher as suggested by Savor and Wilson (2013).[16] Coefficient b_0 measures the "normal" relation between stock returns and interest rate changes. This relation is driven by the response of stock prices and monetary policy expectations to economic developments and possibly by the reaction of monetary policy to the stock market. Coefficients b_1 and b_2 capture the changes in this relation associated with monetary policy decisions on FOMC announcement days with and without SEP and press conference, respectively.

[16] PPI and unemployment rate announcements occur monthly. The corresponding dummy variable is equal to one on 120 days in our sample period.

The results reported in Table 4 are generally consistent with the intraday event study regression results in Table 2. The estimate of a_1 is 0.49% and statistically significant at 1% level, indicating higher unconditional stock returns on days of FOMC announcements with SEP and press conference. In contrast, the average stock returns on FOMC days without SEP and press conference, measured by a_2, are not statistically significant. The estimate of a_3 is positive but insignificant. There is a strong positive relation between stock returns and monetary policy expectations on days without FOMC announcements (represented by coefficient b_0). This suggests that, for example, good economic news simultaneously increases stock prices and the expected future short term interest rates. The negative and statistically significant estimate of b_1 represents the response of stock returns to monetary policy shocks on days of FOMC meetings with SEP and press conference. The sign and order of magnitude of this estimate (-9.29) match those of the corresponding estimate in Panel C of Table 2 (-4.62) although the Table 4 estimate is larger in absolute value, which may be due the different methodology (event study regression in Table 2 versus time-series regression in Table 4), different data frequency (intraday data in Table 2 versus daily data in Table 4), or an upward bias in the intraday event study estimate.

[Insert Table 4 here]

3.3. Economic Significance

The positive unconditional mean returns after the FOMC announcements with SEP and press conference are economically significant. Panel A of Table 5 shows that a strategy of buying the E-mini S&P 500 index futures contracts five minutes before the release of FOMC statements accompanied by the SEP and press conference and closing the position 55 minutes after the announcement would have earned a per-event Sharpe ratio of approximately 0.89 and an

annualized Sharpe ratio of approximately 1.78.[17] For comparison, Lucca and Moench (2015) report an annualized Sharpe ratio of 1.14 for a trading strategy designed to capture the pre-FOMC announcement drift.

[Insert Table 5 here]

4. Positive Returns after FOMC Announcements as a Resolution of Uncertainty

This section relates the positive unconditional average returns after FOMC announcements to changes in uncertainty. We proceed in three steps. In Section 4.1, we show that SEP and press conference contain market-moving information. In Section 4.2, we show that uncertainty decreases after the FOMC announcements with the SEP and press conference. In Section 4.3, we relate the magnitude of the positive unconditional average returns to the amount of uncertainty resolved around these FOMC announcements.

4.1. Information Content of SEP and Press Conference

Boguth et al. (2018) argue that post-meeting Fed Chair press conferences serve as a coordination device by focusing investor attention on FOMC meetings followed by press conference. To avoid shocking the markets, Fed policy makers prefer not to make important decisions when few investors are paying attention. Therefore, important FOMC announcements occur only after meetings accompanied by the press conference. Boguth et al. (2018) analyze realized volatility during the press conferences and conclude that the press conferences contain little new information. In contrast, this section presents three tests as evidence that SEP and press conference do convey information relevant to financial markets.

[17] Because there are currently four FOMC meetings accompanied by SEP and press conference per year, the annualized Sharpe ratio is computed as $\sqrt{4}$ times the per-event Sharpe ratio.

First, SEPs contain FOMC members' projections of three macroeconomic indicators: real GDP growth, unemployment rate, and inflation. For each SEP and each of the three economic indicators, we calculate the change in the median projection since the previous SEP. We then use the first principal component of these changes to proxy for the macroeconomic information contained in the SEP released on day *t*. We use an event study regression to test whether this variable explains some of the changes in interest rate futures prices after the SEP release. The dependent variable of the regression is the change in the 8-9 quarters ahead Eurodollar futures rate from five minutes before to 55 and 100 minutes after the SEP release. The results in Panel A of Table 6 show that economic projections included in the SEP contain new information influencing expectations of future interest rates.

[Insert Table 6 here]

Second, we test whether the SEP conveys new information about future monetary policy. We regress the change in the 8-9 quarters ahead Eurodollar futures rate on the change in the median projection of the federal funds rate for year $t + 2$ contained in the SEP. The results in Panel B of Table 6 provide evidence that expectations of future short-term interest rates embedded in Eurodollar futures prices adjust when meeting participants change their projections of the appropriate target level of the federal funds rate.

Third, we analyze the press conference transcripts to quantify the tone of the press conference and examine its effect on the interest rate futures. We use two lexicons to quantify the press conference tone. We begin with the lexicon provided by Bill McDonald.[18] In contrast to traditional dictionaries, this lexicon accounts for the distinct characteristics of financial terminology (Loughran and McDonald, 2011). For each press conference transcript, we count the

[18] The lexicon is available on Bill McDonald's website http://www3.nd.edu/~mcdonald/Word_Lists.html.

number of words considered positive by the lexicon and measure the press conference tone using the percentage of positive words in the transcripts.[19] We regress the change in the 8-9 quarters ahead Eurodollar futures rate in the event windows from five minutes before to 55 and 100 minutes after the beginning of the press conference on this tone variable. Panel C of Table 6 shows that there is a statistically significant relation between the press conference tone and expectations of future short-term interest rates. We then follow with the Sentiment and Emotion Lexicons compiled by the National Research Council Canada (NRC hereafter). Panel D of Table 6 reports the results. The results agree with Panel C although at a lower statistical significance level, which is not surprising since the Loughran and McDonald (2011) lexicon is designed specifically for financial texts (such as 10-K reports in Loughran and McDonald, 2011) whereas the NRC lexicon is designed for texts in general.[20]

Overall, the results in Table 6 suggest that both the SEPs and press conferences contain information that affects the interest rate futures market. Therefore, FOMC meetings accompanied by these communications are likely to be associated with increased uncertainty.

4.2. Uncertainty around FOMC Announcements

This section examines what happens to uncertainty around FOMC announcements. Since uncertainty can be measured in multiple ways, we use five measures to capture various types of uncertainty (VIX and S&P 500 options trading as measures of market uncertainty, and TYVIX,

[19] Garcia (2013) uses a similar methodology to examine the effect of news sentiment on the stock market.
[20] Sharpe, Sinha and Hollrah (2017) propose another word list in their analysis of the Federal Reserve Board Greenbooks tone. Applying this word list to the press conference transcripts does not yield significant results possibly for two reasons. First, because the Sharpe et al. (2017) word list is short (approximately 200 positive words and 100 negative words), it may be more appropriate for longer documents such as the Greenbook than for short texts such as the press conference transcripts because the longer tests may be of sufficient length to contain these selected words. Second, because the Sharpe et al. (2017) word list is designed specifically for the formal, written text in the Greenbook, it may not be appropriate for texts that capture oral language, which is the case especially in the Fed Chair's press conference Q&A session. Overall, a more comprehensive lexicon focused on financial texts, such as the McDonald lexicon, is more appropriate to measure the press conference tone.

interest rate options trading, and Google searches for "fed meeting" as measures of monetary policy uncertainty) to ensure that our results are not driven by one specific definition of uncertainty. Our analysis of these measures shows that uncertainty decreases after the FOMC announcements accompanied by SEP and press conference.

First, Ederington and Lee (1996) argue that the release of prescheduled news leads to the resolution of market uncertainty. VIX, derived from the prices of S&P 500 index options, has been widely used a measure of market uncertainty (for example, Chen and Clements (2007), Vahamaa and Aijo (2011), Lucca and Moench (2015), Agapova and Madura (2016), Amengual and Xiu (2018), and Fernandez-Perez, Frijns and Tourani-Rad (2017)). We examine the effect of the FOMC announcements on the VIX. Panel A of Figure 5 plots the average levels of VIX from 120 minutes before the FOMC announcements to 100 minutes after the announcements. Compared to policy announcements without SEP and press conference, FOMC announcements accompanied by SEP and press conference are associated with higher VIX before the announcement and a substantial decline after the announcement.[21] Panel B of Figure 5 plots the cumulative average changes. On average, VIX drops by more than five percent after FOMC announcements with SEP and press conference. The drop in the VIX after the announcement is substantially larger for announcements with SEP and press conference than for other FOMC announcements.

In addition to providing this visual evidence, we estimate a daily time-series regression of the VIX index log-change on a dummy variable for the FOMC announcement days with SEP and press conference and a dummy variable for the other FOMC announcement days while

[21] FOMC statements are released in the afternoon, whereas most scheduled macroeconomic announcements are released in the morning. Hence, the VIX changes around the FOMC announcements are not driven by macroeconomic announcements.

controlling for macroeconomic announcements with a dummy variable for days with Producer Price Index (PPI) and unemployment rate announcements. The first column of Table 7 reports the results. Consistent with Figure 5, the drop in the VIX after the announcement is statistically significant only for announcements with SEP and press conference. Both Figure 5 and Table 7 provide evidence that FOMC announcements with SEP and press conference resolve market uncertainty. As shown in Panel B of Table 5, ignoring transaction costs, selling VIX futures contracts five minutes before the FOMC announcement accompanied by the SEP and closing the position 55 minutes after the announcement would have earned an annualized Sharpe ratio of approximately 2.22.[22]

[Insert Figure 5 here]

[Insert Table 7 here]

Second, Beber and Brandt (2009) argue that in times of high uncertainty investors trade option contracts ahead of the release to hedge or speculate on the uncertainty. For example, investors may use index put options to hedge their equity portfolios. Panel A of Table 8 reports the average S&P 500 index option trading volumes on the day of the announcement.[23] FOMC announcement days with SEP and press conference are associated with higher trading volume in the option market than other FOMC announcement days. Panel B of Table 8 reports the changes in the S&P500 index option trading volume. The trading volume on the FOMC announcement days with SEP and press conference increases significantly relative to the average daily trading volume in the week before the FOMC meeting. There is no significant change in the option trading activity on FOMC announcement days without SEP and press conference. Consistent

[22] Fernandez-Perez et al. (2017) show that selling VIX futures at the start of the FOMC announcement day and closing the position at the end of the same day yields an annualized Sharpe ratio of 1.04.
[23] The option trading volume data is from the CBOE.

with Beber and Brandt (2009), this indicates that FOMC announcements with SEP and press conference resolve market uncertainty.

Third, the FOMC statements contain information about future monetary policy and have a direct effect on returns of Treasury securities. One can measure monetary policy uncertainty using implied volatilities of options on Treasury security futures.[24] Therefore, we use the CBOE/CBOT 10-year U.S. Treasury Note Volatility Index (TYVIX) derived from the prices of options on the 10-year U.S. Treasury futures as a measure of monetary policy uncertainty.[25] Figure 6 depicts the median daily TYVIX values around FOMC announcements with and without SEP and press conference. TYVIX is significantly higher before FOMC announcements with SEPs than FOMC announcements without SEP and press conference. In addition to providing this visual evidence, we estimate a daily time-series regression of the TYVIX index log-change on a dummy variable for the FOMC announcement days with SEP and press conference and a dummy variable for the other FOMC announcement days. The second column of Table 7 reports the results. Consistent with Figure 6, the drop in the TYVIX after the announcement is statistically significant only for announcements with SEP and press conference. Both Figure 6 and Table 7 provide evidence that FOMC announcements with SEP and press conference resolve monetary policy uncertainty.

[Insert Figure 6 here]

Fourth, investors may also trade interest rate options to hedge or speculate on the monetary policy uncertainty around FOMC announcements. The Eurodollar Mid-Curve options

[24] For example, Swanson and Williams (2014) use options on interest rate futures to measure monetary policy uncertainty.

[25] TYVIX uses the VIX methodology and represents the risk neutral expectation of volatility of 10-year Treasury note futures over the next 30 days.

offer such trading opportunities based on the mid-range of the yield curve.[26] Panel C of Table 8 reports changes in the Eurodollar Mid-Curve option volume on the announcement day relative to the average daily level in the week before the FOMC meeting. Relative to FOMC announcement days without SEP and press conference, announcements with SEP and press conference are associated with significantly greater abnormal trading volume in this market. As in the S&P500 index options, the trading activity in the Eurodollar Mid-Curve options is consistent with higher uncertainty associated with FOMC announcements accompanied by SEP and press conference.

[Insert Table 8 here]

Fifth, agents mitigate uncertainty about economic fundamentals by acquiring information (for example, Mele and Sangiorgi, 2015). Dzielinski (2012) provides evidence that internet search activity data from Google Trends captures investor uncertainty about the economy. Bontempi, Golinelli and Squadrani (2016) use the Google Trends search activity data to construct an index of macroeconomic uncertainty.[27] We use the Google Trends search volume index (SVI) for "fed meeting" to capture uncertainty associated with FOMC policy decisions and statements. This SVI represents search activity data aggregated across multiple related search queries, including 'next fed meeting,' 'fed reserve meeting,' 'fomc meeting,' 'fed meeting schedule,' etc. Google Trends allows extracting search volume data for different regions. We select the United States as the region.[28] Figure 7 shows the median SVI values around FOMC

[26] Eurodollar Mid-Curve options traded on the CME are short-term American-style options on Eurodollar futures with one, two, three, four, or five years to expiration. The Eurodollar Mid-Curve option trading volume data is from Bloomberg.

[27] Internet search activity has also been used as a measure of investor attention (for example, Da, Engelberg and Gao, 2011 and Boguth et al., 2018).

[28] Daily SVI data can be downloaded for a period of less than or equal to three months at a time. The SVI is scaled so that the maximum value of 100 represents the peak of search activity for the given search term during the selected period. We download daily SVI data for three-month periods with one-month overlaps. We then use the first three-month period as a base and add newer data two months at a time, using the median of the ratio of the overlapping SVI values to rescale the SVI in the newly added two-month period. After constructing the SVI for the entire sample period, we rescale it, so that the maximum value is 100.

announcements with and without SEP. The search volume increases in the days before the announcement, and it is significantly higher in the five days before the announcements with SEP and on the announcement day compared to announcement days without SEP. This finding is again consistent with higher uncertainty associated with FOMC meetings accompanied by SEP and press conference.

[Insert Figure 7 here]

4.3. Uncertainty-Based Explanation of Post-announcement Returns

Section 4.1 showed that the SEP and press conferences contain market-moving information. Section 4.2 showed that uncertainty decreases after the FOMC announcements accompanied by the SEP and press conference. In this section, we conduct analysis to relate the magnitude of the positive unconditional average returns on the S&P 500 index to the amount of uncertainty resolved around these FOMC announcements.

4.3.1. Controlling for Changes in VIX Index

Bansal and Yaron (2004) show theoretically that the equity premium contains a component driven by fluctuations in economic uncertainty; a decline in uncertainty triggers a drop in the equity premium, which leads to an immediate increase in stock prices.[29] Following this observation, we relate the positive unconditional mean returns after FOMC announcements with SEP and press conferences to changes in the VIX that can be viewed as a high-frequency proxy for the change in uncertainty. The time-series regression model in equation (3) then becomes:

$$R_t = a_0 + a_1 D_t^{SEP} + a_2 D_t^{non\text{-}SEP} + a_3 D_t^{news} + b_0 \Delta i_t + b_1 \Delta i_t D_t^{SEP} + b_2 \Delta i_t D_t^{non\text{-}SEP} + c_0 \Delta VIX_t + e_t, \quad (4)$$

[29] Caldara, Fuentes-Albero, Gilchrist and Zakrajšek (2016) provide empirical support for this prediction.

where ΔVIX_t is the first log difference of the daily VIX index, and the other variables are the same as in equation (3).

However, as Whaley (2009) notes, the causality between stock returns and VIX changes is bidirectional. For example, when expected market volatility increases, the required return on stocks rises, leading to a decline in the stock prices. When stock prices fall, the demand for portfolio insurance exerts upward pressure on prices of index put options, leading to an increase in the VIX. Due to such contemporaneous feedback from the stock market returns to the changes in VIX, the VIX change cannot be assumed to be exogenous. Therefore, we use the instrumental variable approach and estimate equation (4) with a two-stage least squares regression where the one-day lag of the VIX index is used as an instrument for the change in VIX; the Cragg and Donald (1993) test indicates that the one-day lag of the VIX index is a valid instrument for the change in VIX. In the first stage, the change in VIX is regressed on the lagged VIX and on the other explanatory variables in the model. In the second stage, the fitted value of the change in VIX from the first-stage regression is used in place of ΔVIX_t in equation (4).

The first column of Table 9 reports the estimation results. The coefficient of the SEP dummy is insignificant and the coefficient of the change in VIX is strongly significant. This indicates that the positive post-announcement unconditional average returns are related to the amount of uncertainty resolved around the FOMC announcements accompanied by the SEP and press conference. This finding is also consistent with Brusa, Savor and Wilson (2017) who argue that the Federal Reserve may possess private information due to its capabilities following from its researchers and proprietary data sources. Such information as well as the associated uncertainty generates risk premia on FOMC announcement days.

The OLS estimation results are shown for comparison in the second column of Table 9. These estimates are qualitatively similar to the two-stage least squares regression results, although the OLS estimate of the coefficient of the change in VIX is larger in absolute value, which is consistent with a bias caused by endogeneity of VIX changes and suggests that the instrumental variable approach is more appropriate.

[Insert Table 9 here]

4.3.2. Analysis of Disaggregated Returns

In addition to influencing stock returns though changes in the equity premium, innovations in aggregate volatility may be a cross-sectional risk factor. For example, Ang, Hodrick, Xing and Zhang (2006), Chang, Christoffersen and Jacobs (2013), and Cremers, Halling and Weinbaum (2015) use multifactor models that include a volatility factor and provide evidence that volatility risk is priced in the cross-section of stock returns. In this section, we analyze disaggregated data to test whether individual stock returns on FOMC days with SEP and press conference depend on the given stock's sensitivity to aggregate volatility innovations.

We use daily returns for 475 firms that were in the S&P 500 index on December 15, 2016 and have returns data for the entire sample period. For each of these stocks, we estimate the market beta and the VIX beta by regressing the daily stock's returns on market excess returns and log VIX changes using a rolling window of 126 trading days, an approximate length of half a year. Before estimating the market and VIX betas, we reverse the signs of the VIX changes to allow interpreting the VIX beta of a given stock as the average effect of a unit decrease in the VIX on the stock return, holding the market return constant. We normalize the betas using their sample means and standard deviations. We then estimate the following event study regression using pooled OLS:

$$R_{it} = a_0 + a_1\beta_{i,t-1}^{Mkt} + a_2\beta_{i,t-1}^{VIX} + \left(b_0 + b_1\beta_{i,t-1}^{Mkt} + b_2\beta_{i,t-1}^{VIX}\right)D_t^{SEP} + \left(c_0 + c_1\beta_{i,t-1}^{Mkt} + c_2\beta_{i,t-1}^{VIX}\right)\Delta i_t + e_{it}, \quad (5)$$

where R_{it} is the daily return of individual stocks in the S&P 500 index on FOMC announcement days, and $\beta_{i,t-1}^{Mkt}$ and $\beta_{i,t-1}^{VIX}$ are the 126-trading-day rolling market and VIX factor loadings one day before the FOMC announcement, respectively. As in equations (1) through (4), D_t^{SEP} is a dummy variable equal to one for FOMC announcements with SEP and press conference, and Δi_t is the change in the 8-9 quarters ahead Eurodollar futures rate computed over the window from five minutes before to 55 minutes after the release of the FOMC statement to control for interest rate shocks.

Equation (5) can be viewed as a version of the event study regression in equation (1). In contrast to equation (1) that models event window returns for the aggregate stock market, equation (5) allows the coefficients to vary depending on the given stock's sensitivity to the market return and VIX changes.[30] This is achieved by interacting the D_t^{SEP} dummy and the change in the 8-9 quarters ahead Eurodollar futures rate with the market and VIX betas. Our primary interest is in the coefficient b_2, which measures the relation between stock returns on days of FOMC announcements with SEP and press conference and the return sensitivity to volatility shocks. If significant amount of uncertainty is resolved on FOMC days with SEP and press conference and the aggregate volatility declines, stocks that are more sensitive to volatility shocks should have higher returns on such days, and b_2 should be positive.

Table 10 reports the results. The coefficient estimate of the interaction term between the VIX beta and the SEP dummy is positive and statistically significant. On average, a one-standard

[30] Kurov (2012) conducts a similar analysis conditioning the response of daily stock returns to monetary shocks on a given stock's sensitivity to cash flow and discount rate news.

deviation increase in the VIX beta leads to a seventeen-basis-point increase in the return on days of the FOMC announcements with SEP and press conference. This result from the disaggregated analysis is consistent with the results from the aggregate analysis in the above sections: the positive return after announcements with SEP and press conference is due to uncertainty resolution; once the uncertainty declines after the announcement, stock prices increase.

[Insert Table 10 here]

5. Conclusion

Our paper documents sizable positive unconditional stock returns after FOMC announcements accompanied by the SEP and press conference. On average, stock prices increase by approximately 0.5 percent in the one-hour interval around these announcements. A trading strategy consisting of buying stock index futures contracts five minutes before the announcement and closing the position 55 minutes after the announcement would have earned a large Sharpe ratio. The announcements with the SEP and press conference are also associated with higher trading volume, higher ex-post market volatility, and a larger decline in the VIX than announcements without SEP and press conference. When we use VIX changes to control for changes in uncertainty, the positive unconditional mean returns after the FOMC announcements with SEP and press conference disappear. We also find that stocks correlated with market uncertainty shocks have higher returns on days of FOMC meetings with SEP and press conference. These findings suggest that the stock market positive post-announcement moves are “relief rallies” related to resolution of uncertainty.

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Table 1
Summary statistics

	All Announcements (N=40)	Announcements without SEP (N=19)	Announcements with SEP (N=21)	Difference (with SEP – without SEP)
Panel A. (-5 min, +55 min) window				
Mean return	0.244***	-0.023	0.485***	0.507***
Median return	0.233	0.012	0.477	0.465[a]
St. deviation of returns	0.523	0.340	0.549	
Number of positive returns	28	11	17	
Mean realized volatility	2.43	2.11	2.71	0.70*[,c]
Mean trading volume	380,047	339,986	416,293	76,307*[,c]
Panel B. (-5 min, +100 min) window				
Mean return	0.238**	-0.069	0.516***	0.586***
Median return	0.190	0.089	0.491	0.402[b]
St. deviation of returns	0.731	0.579	0.754	
Number of positive returns	27	11	16	
Mean realized volatility	2.20	1.91	2.46	0.55*[,c]
Mean trading volume	588,829	534,811	637,702	102,891*[,c]
Panel C. (-24 hour, -5 min) window				
Mean return	0.025	0.018	0.031	-0.013
Median return	-0.056	-0.046	-0.070	0.024
St. deviation of returns	0.430	0.451	0.421	
Number of positive returns	14	8	6	
Mean realized volatility	0.67	0.71	0.63	-0.08
Mean trading volume	1,369,154	1,509,574	1,242,108	-267,465***[,a]

This table reports summary statistics for the E-mini S&P 500 index futures. The event windows are from five minutes before to 55 minutes after the release of the FOMC statement (Panel A) and from five minutes before to 100 minutes after the release of the FOMC statement (Panel B). Panel C reports pre-announcement returns from 24 hours to five minutes before the announcement. Realized volatility is computed as the square root of the sum of squared five-minute returns. For comparison purposes, the realized volatility in Panels A and B is scaled to reflect the standard deviation of 24-hour returns. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively, based on a two-sample *t*-test. a, b, and c indicate that the Wilcoxon rank sum test of the difference in medians is significant at the 1%, 5%, and 10% levels, respectively.

Table 2
Event study regression controlling for monetary policy surprises

	(-5 min, +55 min) window		(-5 min, +100 min) window	
	OLS	Robust Regression	OLS	Robust Regression
Panel A. Base model				
Intercept (a_0)	0.22 (0.06)***	0.26 (0.06)***	0.22 (0.10)**	0.26 (0.10)***
Monetary surprise (b_1)	-4.33 (0.71)***	-4.65 (0.74)***	-3.50 (0.87)***	-3.86 (1.09)***
R^2	0.40	0.36	0.18	0.23
Panel B. Model with intercept dummy				
Intercept (a_0)	-0.02 (0.08)	0.05 (0.07)	-0.07 (0.14)	0.02 (0.13)
SEP dummy (b_0)	0.46 (0.11)***	0.39 (0.09)***	0.55 (0.19)***	0.45 (0.18)**
Monetary surprise (c_0)	-4.08 (0.57)***	-4.38 (0.62)***	-3.27 (0.92)***	-3.62 (1.02)***
R^2	0.59	0.49	0.32	0.29
Panel C. Model with intercept and slope dummies				
Intercept (a_0)	-0.02 (0.08)	0.04 (0.07)	-0.07 (0.11)	-0.07 (0.13)
SEP dummy (b_0)	0.46 (0.10)***	0.40 (0.09)***	0.53 (0.16)***	0.53 (0.18)***
Surprise non-SEP (c_0)	0.03 (2.48)	-2.35 (1.93)	7.13 (3.66)*	7.13 (3.39)**
Surprise SEP (c_1)	-4.62 (0.47)***	-4.62 (0.65)***	-4.28 (0.71)***	-4.28 (1.06)***
R^2	0.64	0.50	0.47	0.35

Panel A reports estimates for the following model: $R_t = a_0 + b_1 \Delta i_t + e_t$, Panel B reports estimates for the following model: $R_t = a_0 + b_0 D_t^{SEP} + c_0 \Delta i_t + e_t$, and Panel C reports estimates for the following model: $R_t = a_0 + b_0 D_t^{SEP} + c_0 (1 - D_t^{SEP}) \Delta i_t + c_1 D_t^{SEP} \Delta i_t + e_t$, where R_t is the return of the E-mini S&P 500 futures, D_t^{SEP} is a dummy variable equal to one for FOMC announcements with SEP and press conference, and Δi_t is the change in the 8-9 quarters ahead Eurodollar futures rate. The event windows used to compute returns and rate changes are from five minutes before to 55 minutes after the release of the FOMC statement and from five minutes before to 100 minutes after the release of the FOMC statement. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference. The regressions are estimated using (1) OLS with the White (1980) heteroskedasticity consistent covariance matrix and (2) Yohai (1987) MM weighted least squares procedure robust to outliers. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 3
Empirical distribution of the estimated SEP dummy coefficient

	(-5 min, +55 min) window		(-5 min, +100 min) window	
	Mean	Standard Deviation	Mean	Standard Deviation
Panel A. Model with intercept dummy				
SEP dummy (b_0)	0.46	0.11	0.54	0.20
Panel B. Model with intercept and slope dummies				
SEP dummy (b_0)	0.45	0.10	0.52	0.17

Panel A reports means and standard deviations of the estimated SEP dummy coefficient for the following model: $R_t = a_0 + b_0 D_t^{SEP} + c_0 \Delta i_t + e_t$, and Panel B reports means and standard deviations of the estimated SEP dummy coefficient for the following model: $R_t = a_0 + b_0 D_t^{SEP} + c_0 (1 - D_t^{SEP}) \Delta i_t + c_1 D_t^{SEP} \Delta i_t + e_t$, where R_t is the return of the E-mini S&P 500 futures, D_t^{SEP} is a dummy variable equal to one for FOMC announcements with SEP and press conference, and Δi_t is the change in the 8-9 quarters ahead Eurodollar futures rate. The event windows used to compute returns and rate changes are from five minutes before to 55 minutes after the release of the FOMC statement and from five minutes before to 100 minutes after the release of the FOMC statement. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference. The means and standard deviations are estimated using the bootstrapping exercise described in Section 3.2.1.

Table 4
Daily time series regression

Intercept (a_0)	0.04 (0.02)*
SEP dummy (a_1)	0.49 (0.17)***
Non-SEP dummy (a_2)	-0.23 (0.15)
Macroeconomic news dummy (a_3)	0.05 (0.08)
Rate change (b_0)	5.14 (0.51)***
Rate change × SEP dummy (b_1)	-9.29 (1.70)***
Rate change × Non-SEP dummy (b_2)	1.91 (3.26)
N	1,254
R^2	0.091

The table reports estimates for the following model:
$R_t = a_0 + a_1 D_t^{SEP} + a_2 D_t^{non\text{-}SEP} + a_3 D_t^{news} + b_0 \Delta i_t + b_1 \Delta i_t D_t^{SEP} + b_2 \Delta i_t D_t^{non\text{-}SEP} + e_t$, where R_t is the daily return on the S&P 500 index, D_t^{SEP} is a dummy variable for the FOMC announcement days with SEP and press conference, $D_t^{non\text{-}SEP}$ is a dummy variable for the other FOMC announcement days, D_t^{news} is a dummy variable for days with Producer Price Index (PPI) and unemployment rate announcements, and Δi_t is the daily change in the rate of Eurodollar futures with 8-9 quarters to expiration. The sample period is from January 2012 through December 2016. The regression is estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 5
Sharpe ratios

	(-5 min, +55 min) window		(-5 min, +100 min) window	
	Sharpe Ratio	Annualized Sharpe Ratio	Sharpe Ratio	Annualized Sharpe Ratio
Panel A. E-mini S&P 500 Index Futures				
All announcements	0.47	1.33	0.33	0.93
Announcements with SEP	0.89	1.78	0.68	1.37
Announcements without SEP	-0.07	-0.14	-0.12	-0.24
Panel B. VIX Futures				
All announcements	0.65	1.85	0.38	1.08
Announcements with SEP	1.11	2.22	0.91	1.82
Announcements without SEP	0.19	0.38	-0.07	-0.14

Panel A reports the Sharpe ratio of the following trading strategy: buy the E-mini S&P 500 index futures contracts five minutes before the release of the FOMC statement and close the position 55 or 100 minutes after the release. Panel B reports the Sharpe ratio of the following trading strategy: sell the VIX futures contracts five minutes before the release of the FOMC statement and close the position 55 or 100 minutes after the release. The Sharpe ratio is computed by dividing the sample mean return by the sample standard deviation. The annualized Sharpe ratio is computed as $\sqrt{4}$ times the per-event Sharpe ratio. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

Table 6
Information content of the SEP and press conference

	(-5 min, +55 min) window	(-5 min, +100 min) window
Panel A. Effect of macroeconomic projections on interest rate futures		
Intercept	-0.009 (0.020)	-0.011 (0.024)
Economy	0.028 (0.014)*	0.037 (0.017)**
N	21	21
R^2	0.079	0.102
Panel B. Effect of federal funds target rate projections on interest rate futures		
Intercept	-0.017 (0.021)	-0.023 (0.024)
ΔFFR	0.078 (0.033)**	0.105 (0.040)**
N	20	20
R^2	0.124	0.160
Panel C. Effect of press conference tone on interest rate futures analyzed using the McDonald lexicon		
Intercept	0.112 (0.041)**	0.113 (0.044)**
Tone	-0.090 (0.032)**	-0.088 (0.034)**
N	21	21
R^2	0.149	0.111
Panel D. Effect of press conference tone on interest rate futures analyzed using the National Research Council Canada Sentiment and Emotion Lexicons		
Intercept	0.245 (0.126)*	0.279 (0.136)*
Tone	-0.036 (0.018)*	-0.040 (0.020)*
N	21	21
R^2	0.107	0.105

Panel A reports estimates for the following model: $\Delta i_t = a_0 + a_1 Economy_t + e_t$, where Δi_t is the change in the 8-9 quarters ahead Eurodollar futures rate and $Economy_t$ is the first principal component of changes in median projections of real GDP growth, inflation, and unemployment contained in the SEP. Panel B reports estimates for the following model: $\Delta i_t = a_0 + a_1 \Delta FFR_t + e_t$, where ΔFFR_t is the change in the median projection of the federal funds rate for year $t + 2$ contained in the SEP. Panels C and D report estimates for the following model: $\Delta i_t = a_0 + a_1 Tone_t + e_t$, where $Tone_t$ is the tone measured using the McDonald lexicon and the National Research Council Canada Sentiment and Emotion Lexicons, respectively. The sample period is from January 2012 through December 2016. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 7
Daily time series regression for uncertainty measures

	VIX	TYVIX
Intercept (a_0)	0.18 (0.20)	0.30 (0.12)**
SEP dummy (a_1)	-7.26 (1.59)***	-5.98 (1.32)***
Non-SEP dummy (a_2)	1.65 (1.41)	-0.61 (0.59)
Macroeconomic news dummy (a_3)	-1.37 (0.72)*	-2.20 (0.60)***
N	1,257	1,257
R^2	0.019	0.044

The table reports estimates for the following model:
$U_t = a_0 + a_1 D_t^{SEP} + a_2 D_t^{non\text{-}SEP} + a_3 D_t^{news} + e_t$, where U_t is the daily log difference of the VIX index and the TYVIX index multiplied by 100 in the first and second columns, respectively, D_t^{SEP} is a dummy variable for the FOMC announcement days with SEP and press conference, $D_t^{non\text{-}SEP}$ is a dummy variable for the other FOMC announcement days, and D_t^{news} is a dummy variable for days with Producer Price Index (PPI) and unemployment rate announcements. The sample period is from January 2012 through December 2016. The regression is estimated using OLS regression with the Newey-West (1987) standard errors. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 8
Option trading volume on FOMC announcement days

	Announcements without SEP (N=19)	Announcements with SEP (N=21)	Difference (with SEP – without SEP)
Panel A. S&P 500 index option average volumes			
Total volume	823,952	1,116,826	292,874***,a
Put option volume	499,578	692,484	192,906***,a
Call option volume	324,374	424,342	99,967**,b
Panel B. S&P 500 index option average abnormal volumes			
Total volume	-30,520	190,246***	220,766***,a
Put option volume	-34,004	120,216***	154,220***,a
Call option volume	3,484	70,030**	66,546*,c
Panel C. Eurodollar Mid-Curve option average abnormal volumes			
1 year Mid-Curve	91,980***	206,276***	114,296***,a

Panel A reports the S&P 500 index option trading volume on FOMC announcement days. Panel B reports the changes in the S&P 500 index option trading volume on the announcement day relative to the average daily level in the week before the FOMC meeting (days *t-6* through *t-2* relative to the announcement day). Panel C reports the changes in the Eurodollar Mid-Curve option volume on the announcement day relative to the average daily level in the week before the FOMC meeting (days *t-6* through *t-2* relative to the announcement day). The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively, based on a *t*-test; a, b, and c indicate that the Wilcoxon rank sum test of the difference in medians is significant at the 1%, 5%, and 10% levels, respectively.

Table 9
Daily time series regression results controlling for VIX changes

	2SLS	OLS
Intercept (a_0)	0.05 (0.01)***	0.05 (0.01)***
SEP dummy (a_1)	0.08 (0.14)	-0.15 (0.10)
Non-SEP dummy (a_2)	-0.13 (0.11)	-0.06 (0.10)
Macroeconomic news dummy (a_3)	-0.04 (0.06)	-0.09 (0.05)*
Rate change (b_0)	2.73 (0.73)***	1.33 (0.39)***
Rate change × SEP dummy (b_1)	-5.79 (1.35)***	-3.76 (0.99)***
Rate change × Non-SEP dummy (b_2)	1.85 (1.77)	1.82 (1.52)
Change in VIX (c_0)	-5.63 (1.21)***	-8.88 (0.29)***
N	1,257	1,257
R^2	0.61	0.70

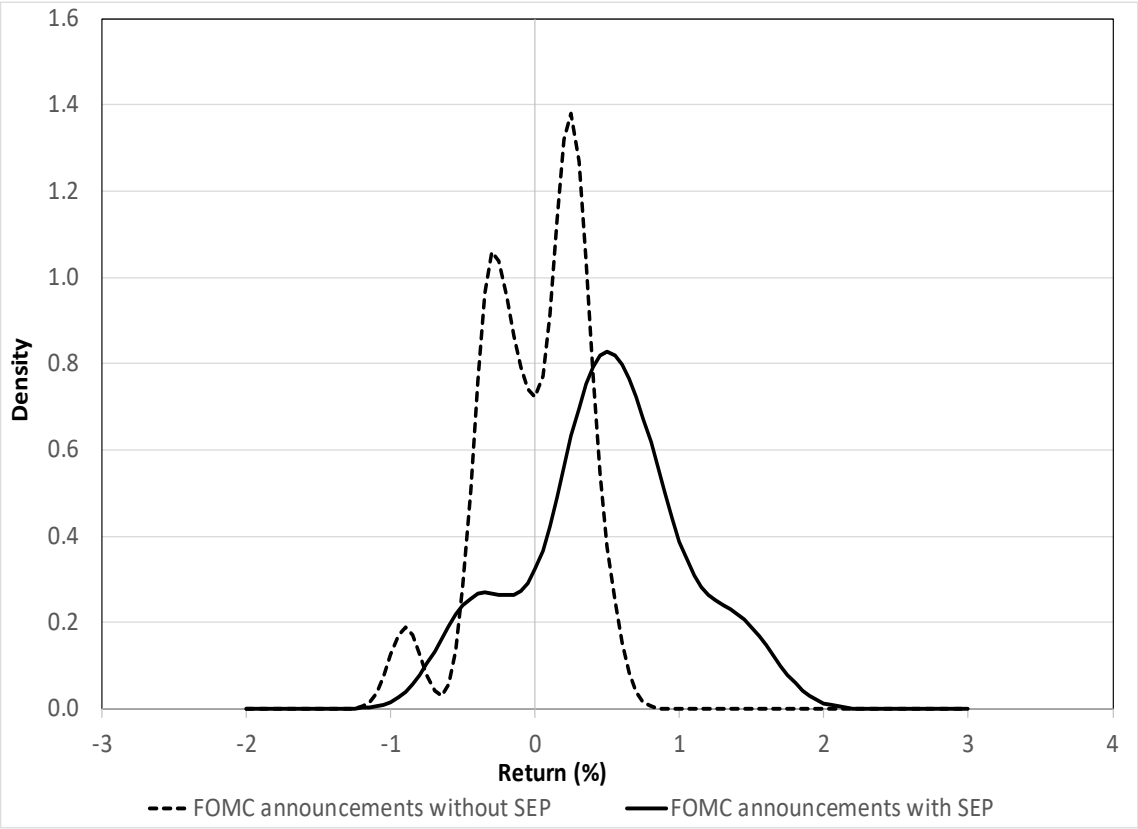
The table reports estimates for the following model:
$R_t = a_0 + a_1 D_t^{SEP} + a_2 D_t^{non\text{-}SEP} + a_3 D_t^{news} + b_0 \Delta i_t + b_1 \Delta i_t D_t^{SEP} + b_2 \Delta i_t D_t^{non\text{-}SEP} + \mathrm{c}_0 \Delta VIX_t + e_t$,
where R_t is the daily return on the S&P 500 index, D_t^{SEP} is a dummy variable for the FOMC announcement days with SEP and press conference, $D_t^{non\text{-}SEP}$ is a dummy variable for the other FOMC announcement days, D_t^{news} is a dummy variable for days with Producer Price Index (PPI) and unemployment rate announcements, Δi_t is the daily change in the rate of Eurodollar futures with 8-9 quarters to expiration, and ΔVIX_t is the daily log difference of the VIX index. The sample period is from January 2012 through December 2016. The regression is estimated using two-stage least squares regression with Newey-West (1987) standard errors and OLS with the Newey-West (1987) standard errors in the first and second columns, respectively. The instrumental variable in the two-stage least squares regression is the one-day lag of the VIX index. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Table 10
Event study regression for daily disaggregated stock returns

Intercept (a_0)	-0.26 (0.02)***
Market beta (a_1)	0.03 (0.03)
VIX beta (a_2)	-0.07 (0.03)**
SEP dummy (b_0)	0.77 (0.03)***
SEP dummy×Market beta (b_1)	0.13 (0.04)***
SEP dummy×VIX beta (b_2)	0.17 (0.04)***
Monetary surprise (c_0)	-4.36 (0.17)***
Monetary surprise × Market beta (c_1)	-0.53 (0.27)**
Monetary surprise × VIX beta (c_2)	0.32 (0.27)
N	19,000
R^2	0.09

The table reports estimates for the following model: $R_{it} = a_0 + a_1\beta_{i,t-1}^{Mkt} + a_2\beta_{i,t-1}^{VIX} + \left(b_0 + b_1\beta_{i,t-1}^{Mkt} + b_2\beta_{i,t-1}^{VIX}\right)D_t^{SEP} + \left(c_0 + c_1\beta_{i,t-1}^{Mkt} + c_2\beta_{i,t-1}^{VIX}\right)\Delta i_t + e_{it}$, where R_{it} is the daily return of individual stocks in the S&P 500 index on FOMC announcement days, Δi_t is the change in the 8-9 quarters ahead Eurodollar futures rate computed over the window from five minutes before to 55 minutes after the release of the FOMC statement, D_t^{SEP} is a dummy variable equal to one for FOMC announcements with SEP and press conference, and $\beta_{i,t-1}^{Mkt}$ and $\beta_{i,t-1}^{VIX}$ are the 126-trading-day rolling market and VIX betas one day before FOMC announcement, respectively. The market and VIX betas are estimated by regressing returns of stocks in the S&P 500 index on daily market excess returns and daily log-changes in the VIX index on a 126-trading-day rolling basis. The betas are normalized using their sample means and standard deviations. The sample period is from January 2012 through December 2016. The regression is estimated using pooled OLS. Panel-corrected standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

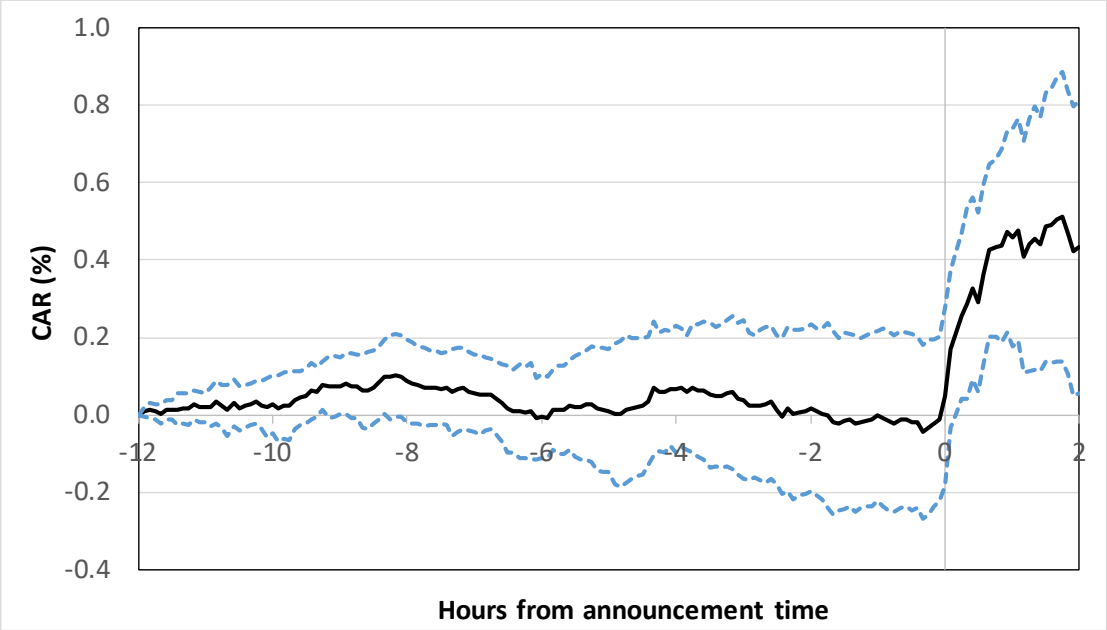
Figure 1. Kernel densities of post-announcement returns



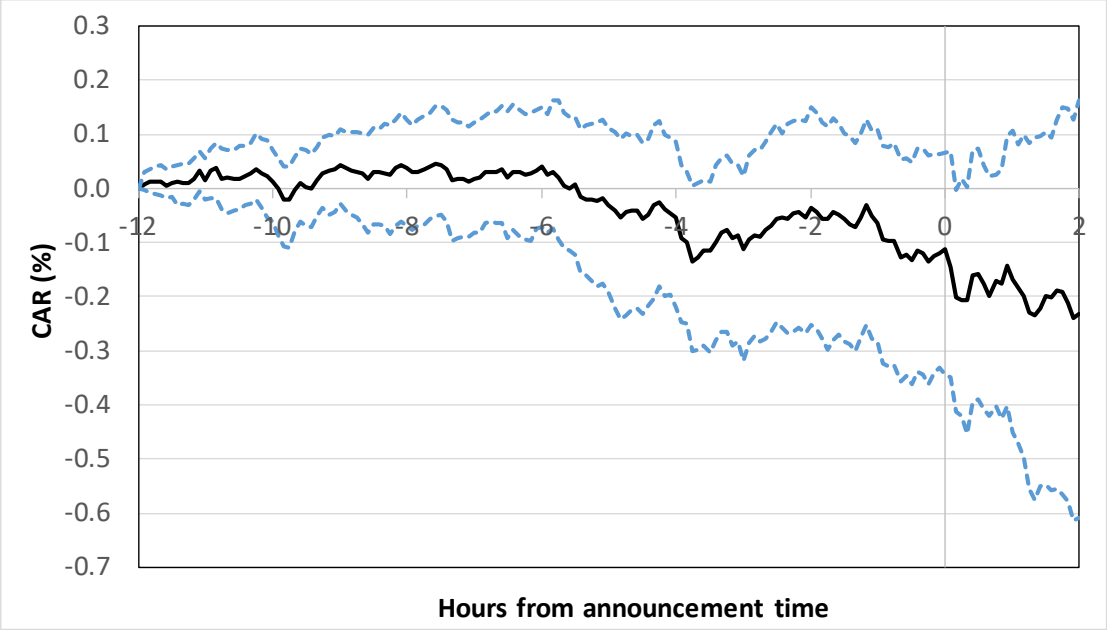
This figure plots kernel densities of continuously compounded returns of the E-mini S&P 500 futures. The bandwidth is selected using the Sheather and Jones (1991) method. The event window is from five minutes before to 55 minutes after the release of the FOMC statement. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

Figure 2. Cumulative average returns

Panel A. FOMC announcements with SEP



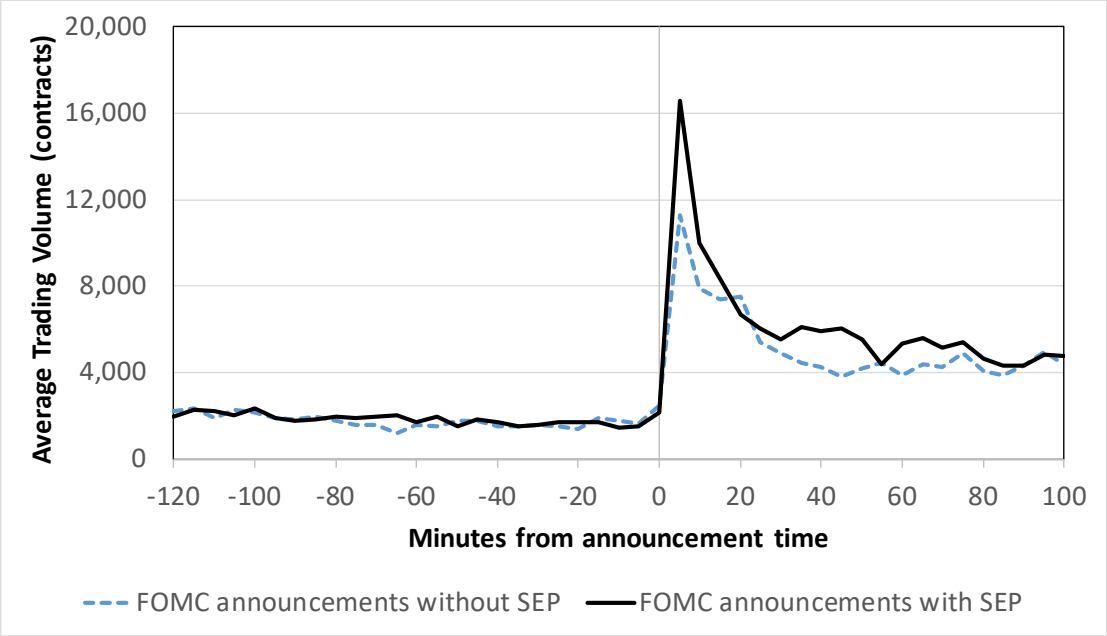
Panel B. FOMC announcements without SEP



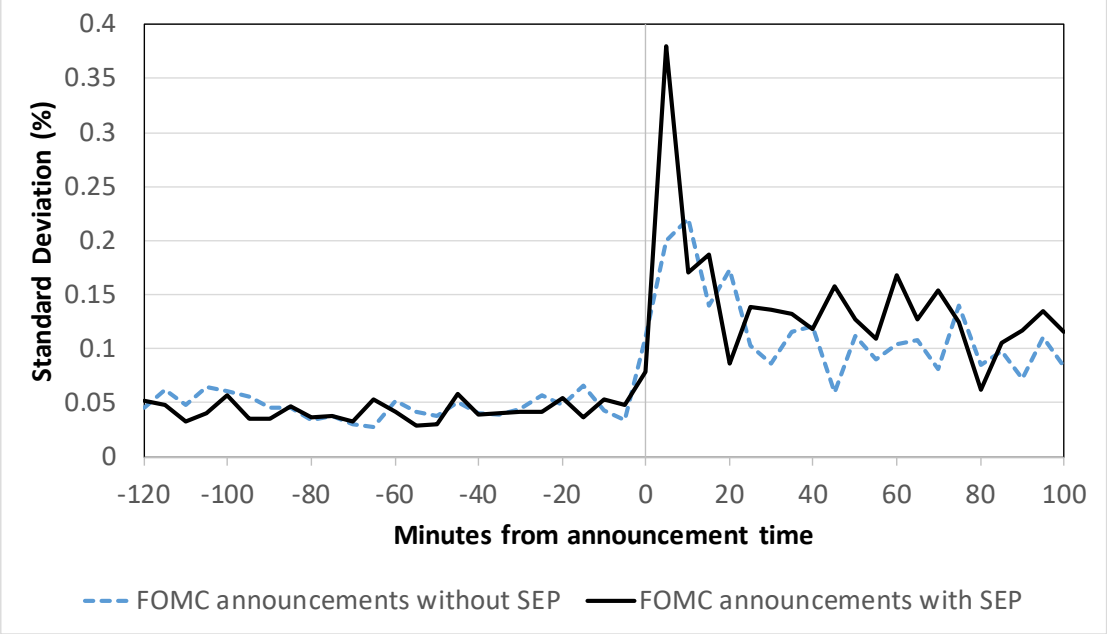
This figure shows the average cumulative returns of the E-mini S&P futures around the FOMC announcements. The event window is from twelve hours before to two hours after the release of FOMC statements. The solid lines in Panels A and B are for the cumulative average returns on policy days with and without SEP and press conference, respectively. The dashed lines represent 95% confidence intervals computed by assuming that the average cumulative returns follow the asymptotic normal distribution. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

Figure 3. Trading volume and return volatility

Panel A. Average trading volume

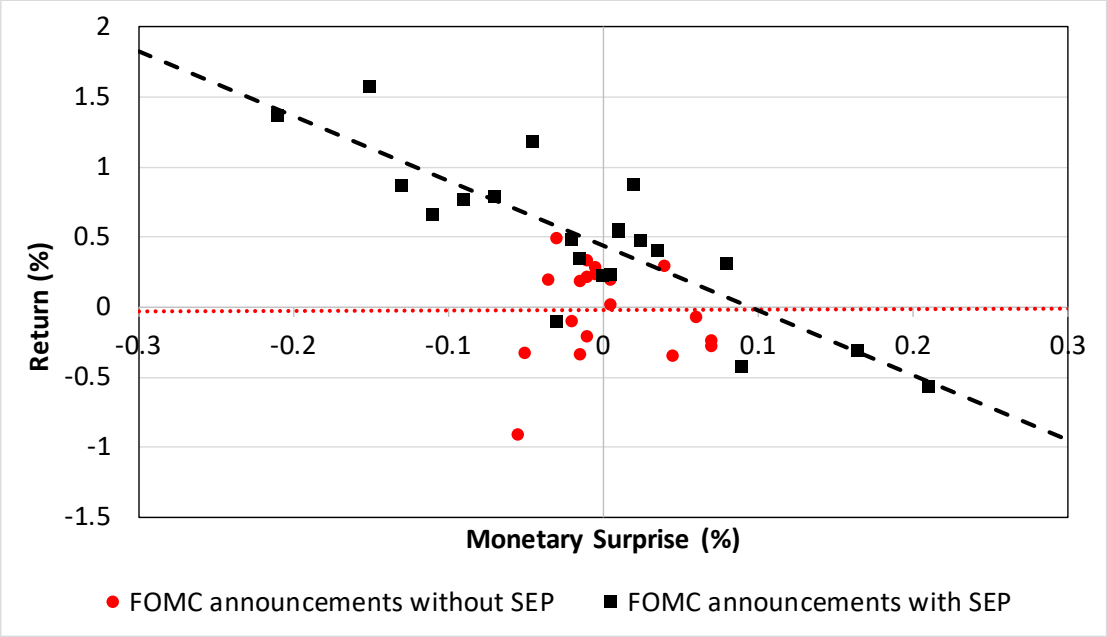


Panel B. Standard deviation of returns



Panel A shows the average per-minute trading volume of the E-mini S&P 500 futures. Panel B shows the standard deviation of five-minute returns of the E-mini S&P 500 futures. The event window is from 120 minutes before to 100 minutes after the release of FOMC statements. The solid and dashed lines represent policy announcements with and without SEP and press conference, respectively. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

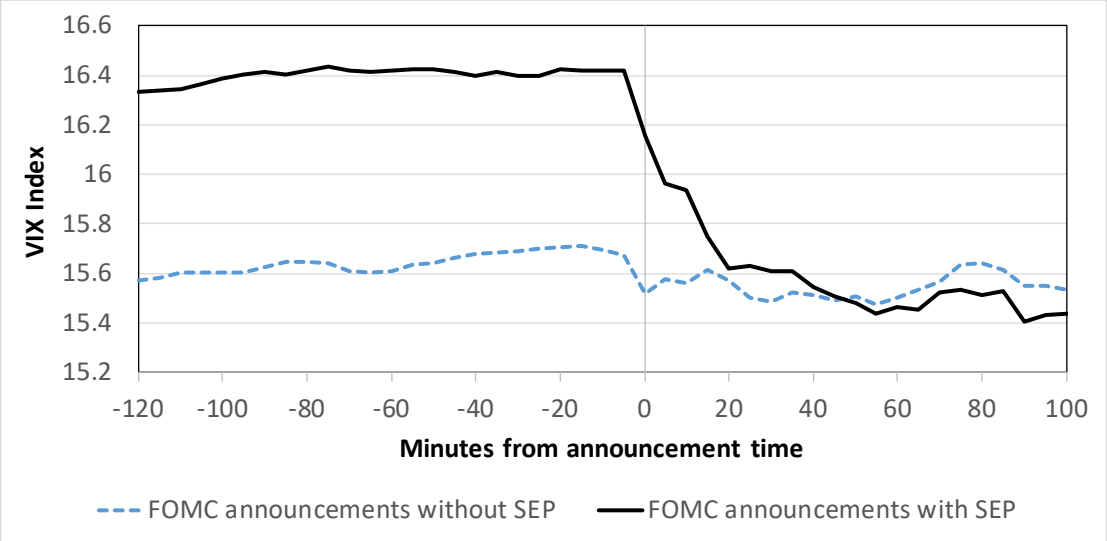
Figure 4. Monetary surprises and post-announcement stock returns



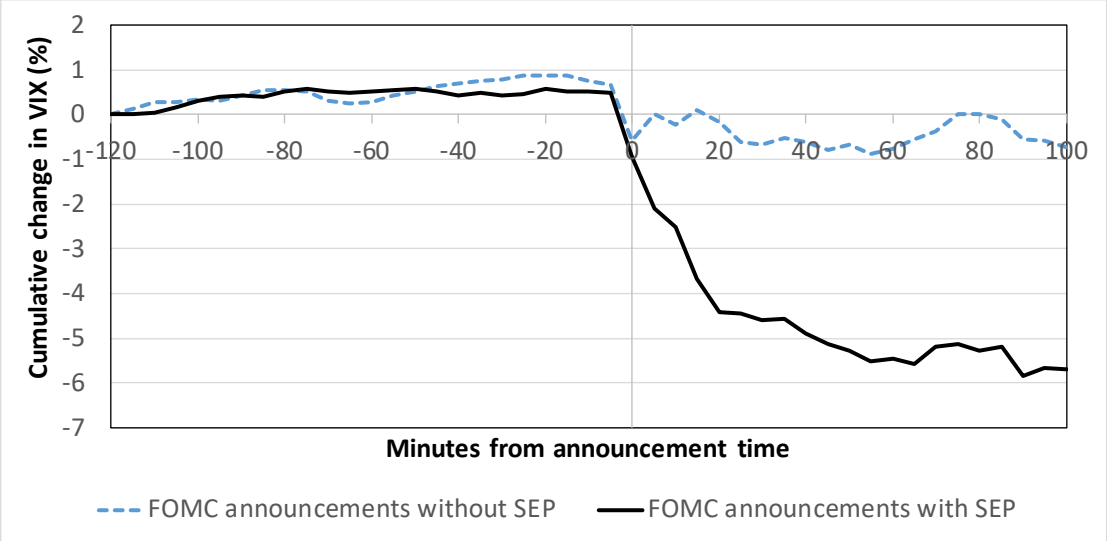
This figure plots post-announcement returns of the E-mini S&P 500 futures against monetary surprises. The event window is from five minutes before to 55 minutes after the release of the FOMC statement. The monetary surprise is computed as the change in the 8-9 quarters ahead Eurodollar futures rate. The dashed and dotted lines represent the regression lines for the FOMC announcements with and without SEP and press conference, respectively. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

Figure 5. Implied volatility

Panel A. Average VIX levels

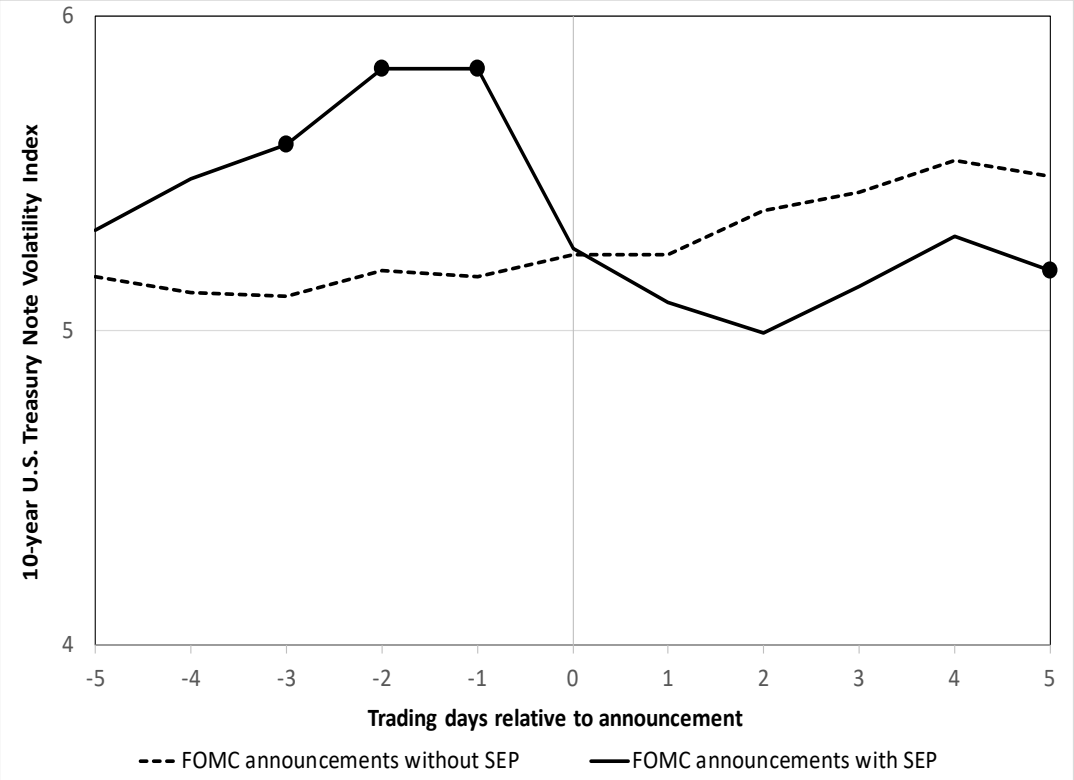


Panel B. Cumulative average changes in VIX



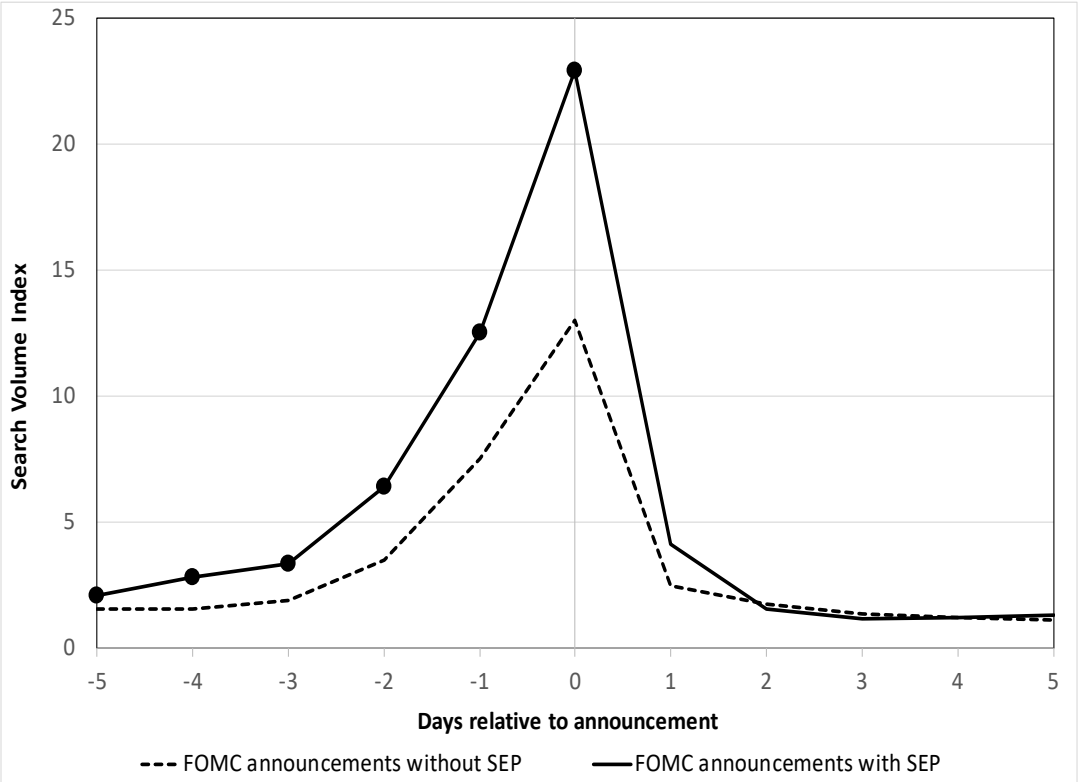
Panel A shows average levels of VIX around the FOMC announcements. Panel B shows cumulative average changes in the natural log of VIX. The event window is from 120 minutes before to 100 minutes after the release of FOMC statements. The solid line represents policy announcements with SEP and press conference. The dashed line represents policy announcements without SEP and press conference. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

Figure 6. CBOE/CBOT 10-year U.S. Treasury Note Volatility Index



The figure shows median daily values of CBOE/CBOT 10-year U.S. Treasury Note Volatility Index. The solid line represents policy announcements with SEP and press conference. The dashed line represents policy announcements without SEP and press conference. Solid circles indicate that the Wilcoxon rank sum test of the difference in medians between the samples with and without the SEP is significant at the 10% level. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.

Figure 7. Google search volume



The figure shows median daily values of the Google search volume index for the search term "fed meeting." The solid and dashed lines represent policy announcements with and without SEP and press conference, respectively. Solid circles indicate that the Wilcoxon rank sum test of the difference in medians between the samples with and without SEP is significant at the 5% level. The sample period is from January 2012 through December 2016 and contains 40 FOMC announcements, including 21 announcements with SEP and press conference.