The Costs of Scheduling FOMC Meetings*

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Abstract

Using a set of liquid high-frequency options on a broad market index, we study the behavior of economic uncertainty around U.S. monetary policy announcements. We find a remarkable pattern from a week before to a day after announcement days. Uncertainty increases on the first two days of the blackout period, and then gradually resolves as we near the meeting day, with a sizable jump at the announcement time. We show that this pattern can be explained by uncertainty about tail events. FOMC meetings command a premium for being exposed to the possibility of such events. Our results are amplified on days with press conferences indicating that markets seek for opportunities to categorize the importance of meetings, and we show that unexpected decisions trigger a large resolution of uncertainty. We accredit this reaction to news provided by the Fed being unexpectedly good in recent decades.

Keywords: Macroeconomic News Announcements, Monetary Policy Decisions, FOMC, Stock Market Uncertainty, Jump Risks, High-Frequency Options Data, Fed Put

JEL: E44, E52, G12, G18

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I. Introduction

The Federal reserve states the reduction of financial and economic uncertainty as one of its objectives to push the mandate of promoting a strong and healthy U.S. economy. The concept of uncertainty is not readily measurable, and whether the Fed adheres to its mandate can only be approximated. One approach to assess the Fed's effectiveness in addressing uncertainty is the use of aggregate stock market options. Option prices depend on the market's economic outlook and thus directly encompass uncertainty. The empirical literature studying uncertainty in the context of monetary policy has focused on the reaction of the VIX on FOMC announcements. The VIX consists of a portfolio of out-of-the-money (OTM) option prices that captures the 30-day forward-looking conditional volatility on the S&P 500.

This paper makes use of high-frequency option quotes and starts by documenting a systematic pattern of VIX-type uncertainty around FOMC announcements. At the start of the one week blackout period, in which committee members must refrain from disclosing information publicly, uncertainty is already significantly below the previous 30-day average (control group). Throughout the next trading days, however, uncertainty follows a steady upward trend with levels rising 2% above the pre-meeting control group. This large increase in uncertainty is accompanied by negative stock returns. The upward trend in uncertainty and the downward trend in stock markets are reversed two days *ahead* of the scheduled announcement days – a finding previously documented by Lucca and Moench (2015) and Hu, Pan, Wang, and Zhu (2019). At the day of the FOMC announcement, uncertainty levels exhibit a steep drop of approximately -5% but quickly recover thereafter to similar levels as at the start of the blackout period.

Because the Fed's policy decisions impact the economy through monetary and non-monetary channels, both of which may trigger large stock market reactions, we account for the impact of tail risk in the systematic pattern. Our analysis reveals that the fear of large stock market movements drives the increase in uncertainty in the week ahead of the meeting. Furthermore, most of the resolution of uncertainty at the actual announcement is attributable to a decrease in tail uncertainty. We observe that the reduction of the remainder of uncertainty is relatively small, with a share of about 85% due to the prospect of tail events. After the meeting, when the

fear of large and sudden movements has mostly left the market, levels are similar to our base analysis in which we do not account for tail uncertainty. How can we interpret those findings? The fact that tail uncertainty explains the increase ahead of the meeting and the sudden resolution at announcement time, and that levels after the meeting are similar implies that the Fed induces uncertainty, by the mere scheduling of a meeting. From a short-term perspective, the Fed's effect on uncertainty is rather marginal when taking the uncertainty buildup into account. Drawing from the conclusions of Kelly, Pastor, and Veronesi (2016) that options spanning political events are systematically more expensive due to the nature of such events, we find similar evidence of an FOMC premium.

To understand the pattern we document, we condition on various meeting characteristics that have previously been found to enhance or outright drive the results of FOMC announcements on uncertainty. We find that unexpected monetary policy news, as well as scheduled press conferences, show the desired effects of resolving uncertainty. For both types of meetings, however, uncertainty sharply rises as we approach the announcement date, increasing the prices of insurance from the options market and conversely uncertainty about the future trajectory of the economy. Especially press conferences increase uncertainty levels significantly throughout the blackout period, indicating that the market's belief is that major decisions may only be undertaken on days with a scheduled press conference. Interestingly, we find that across the meetings labeled either a surprise or a press conference, uncertainty resolves below control group levels, with a prolonged depression on the post-meeting day. In light of this, Cieslak and Vissing-Jorgensen (2018) and Cieslak, Morse, and Vissing-Jorgensen (2019) have argued that news from the Fed has been unexpectedly favorable in the period from 1994 onward. Whenever the Fed's decisions came in part unexpected, or large decisions were accompanied by an explanatory press conference, we confirm the authors' ideas with convincing evidence on uncertainty from the options market.

As a placebo test we also analyze the impact of 19 unscheduled phone conferences between 2004 and 2017. In contrast to a severe reduction in uncertainty one might expect, we observe significantly elevated levels of uncertainty leading up to the conference, with a further upward drift as the conference date approaches. On the day thereafter we do observe a large resolution of uncertainty of about -7%. This

reduction is small, however, when compared to the elevation of +28% ahead of the meeting. The Fed arguably failed to fully soothe the market, even in times where it saw the need to step in aside from its regular schedule.

We hypothesize that a long-term VIX-equivalent measure for a horizon of a year better captures the influence of FOMC announcements on economic uncertainty. Long-term options are not subject to a single FOMC meeting only, but condense information on the economic outlook, monetary policy decisions, and indications on the future course of monetary policy made in each individual FOMC announcement. The blackout-period pattern for long-term uncertainty is similar to that of short-term uncertainty. Again, we find a strong influence of tail uncertainty induced by the meeting. After accounting for this, we observe a steady decrease in long-term uncertainty over the blackout period. Our classification for press conferences shows that they do create large uncertainty ahead of the meeting, but further reveals that levels one day after the announcement are not different from our base analysis. This is in sharp contrast to surprising monetary policy decisions, which generate only little reaction on the announcement days but depress long-term uncertainty levels significantly the day after.

We are the first to tackle the empirical identification problems of FOMC meetings by using a large and liquid panel of high-frequency option quotes. The prices of options depend on forward-looking information and can be used to extract the market‘s perception about the future course of the economy. Thus, they can be combined to a model-free instrument with which we gauge uncertainty over different horizons. Our data set differs from those of former studies as they use high-frequency (futures) data on the VIX. Although the VIX is also calculated from observable option prices and designed to gauge the 30-day conditional variance, it is recognized that its calculation method can cause significant errors. Specifically, the CBOE omits all further OTM options once two consecutive bids equal zero. Andersen, Bondarenko, and Gonzalez-Perez (2015) show that high-frequency VIX quotes jump due to these shifts in the strike range. This is a particularly important issue around macroeconomic announcement days, when trading activity increases, and a large amount of new information enters the market.[1] We also account for intraday effects, which may

[1]See also Ying (2018) who documents large shifts in open interest around FOMC announcements.

arise deterministically over a trading day. We compare the dynamics of uncertainty around FOMC meetings with the thirty days before the blackout period starts. Another advantage of our data set is that we can estimate economic uncertainty over multiple horizons, which we make use of when examining long-term uncertainty.

Our paper contributes to the most resent research that analyzes the impact of monetary policy on financial markets. Lucca and Moench (2015) find evidence that most of the equity risk premium is realized in the 24-hour window before FOMC announcements. Cieslak, Morse, and Vissing-Jorgensen (2019) further show that this pre-FOMC announcement drift is part of a broader bi-weekly cycle. They explain their findings through information leakage or the Fed's stance to act as needed in case of a market downturn, which effectively caps the downside risk in stock markets (Cieslak and Vissing-Jorgensen, 2018). Hu, Pan, Wang, and Zhu (2019) rationalize the pre-announcement drift with a reduction in uncertainty. They use intraday changes on the VIX provided by the CBOE and show that the VIX is indeed reduced on the days leading up to the announcement. Our analysis deviates in several ways. First, we infer uncertainty directly from option prices. This not only reduces potential identification errors but also allows to analyze the behavior of uncertainty over several time horizons. We show that the documented reduction in uncertainty follows an elevation at the start of the blackout period, and that most of this reduction is merely the meeting premium. We further contribute by showing that tail expectations are elevated due to FOMC meetings and can explain much of the dynamics of short-term uncertainty.

The effects of monetary policy decisions are notoriously difficult to estimate as multiple economic mechanisms may interact. One promising endeavor is the use of a high-frequency window, typically 60–120 minutes surrounding the target time, which should isolate how the market reacts to news from the announcement. Nakamura and Steinsson (2018) argue that high-frequency jumps in target measures, such as the federal funds futures rate, or uncertainty measures, should adequately represent the underlying market mechanisms and shift in sentiment. The estimated shocks are often input for vector-autoregressive models (VAR) that analyze the impact of monetary policy announcements on the economy. Models that explicitly use the VIX to asses the effect of FOMC announcements include Bekaert, Hoerova, and Lo Duca (2013) or Savor and Wilson (2013). We show that disregarding levels ahead

of the meetings, and regarding only the change in target measures hides the fact that expectation measures drawn from option prices may be elevated in advance to announcements that have a) widely recognized importance, and b) a pre-scheduled day and time. Kelly, Pastor, and Veronesi (2016) identify an option price premium associated with political events falling in the lifespan of option contracts. We find a similar buildup in option prices a few days before FOMC announcements, which we cannot attribute to other scheduled macroeconomic announcements.

Lastly, our paper has some direct policy implications as we show that the resolution of uncertainty previously documented in the literature is in fact driven by an upward trend *ahead* of FOMC announcements. Most of the reduction is an uncertainty premium associated with Fed meetings. We argue that the regularly scheduled meetings do not help in adhering to the Fed's objective of decreasing economic uncertainty. At the same time, even when the Fed sees the need to intervene in between two meetings, effects on market uncertainty are modest at best. The reluctance to decide on big policy shifts is evident, and the committee rather waits until the next meeting before intervening "too much" today. The results on press conferences tell a similar tale. The market seeks the opportunity to categorize a Fed meeting as important or not. Ever since the introduction of press conferences, the market assumes that bigger decisions may only occur when the committee subsequently explains its decisions. Therefore, we observe largely elevated levels of uncertainty ahead of these meetings, and that most of the reduction associated with these meetings is the FOMC uncertainty premium. We conjecture that the tight schedule of eight meetings per year may be too strict, and the meetings too closely spaced, should individual intervention bring about significant and immediate results on aggregate uncertainty.

II. Data

A. Option Data

The use of high-frequency option data allows us to robustly estimate economic uncertainty across multiple horizons and strike ranges. We can therefore isolate short- from long-term uncertainty, and tail or up- and downside, from overall uncertainty.

For this we obtain minute-by-minute S&P 500 option quote data for the time period from January 2004 to December 2017. The data is taken from the CBOE datashop. We omit the first two quotes of each trading day to avoid staleness and missing quotes. Our sample consists of 3,524 trading days, with an average of 235 OTM call and 784 OTM put quotes per minute, totaling 410,149 option quotes each day.

To remedy the limitation that the S&P 500 is not directly traded and that prices may be poorly recorded especially in a high-frequency setting, we infer S_t from put-call parity and confirm the validity through comparison with traded S&P 500 futures obtained from the CME group.[2] In this, we follow Andersen, Bondarenko, and Gonzalez-Perez (2015).[3] Our data filters follow the same study closely, with slight adaptions as detailed in Appendix A. We report average open interest and relative bid-ask spreads per minute for Non-FOMC and FOMC days in Table I.

Open interest is high across the time and moneyness domain even intra-day, which alleviates concerns of old prices and lack of trading. Moneyness is defined as

$$m = log(K/F) \times (IV^{ATM}\sqrt{\tau})^{-1},$$

which is convenient when isolating measures of tail expectations. We observe a U-shaped pattern in open interest, showing that the bulk of outstanding contracts is in OTM put and call options. Interestingly, deep-OTM puts ($m < -2.5$) show the highest average open interest, indicating a liquid secondary market. Generally, there is little variation for different times to maturity. Open interest for FOMC and non-FOMC days differs little, with a slight drop for FOMC announcement days, a finding previously documented by Ying (2018), which the author attributes to a reduction of investor disagreement following FOMC releases.

Relative bid-ask spreads show a similar U-shaped pattern as m varies. ATM contracts have the tightest spreads, which increases significantly as we move further out of the money. Estimating tail expectations is notoriously difficult. Still, a prolonged effect on tail measures as a result of FOMC announcements should be a signal of

[2] In the early sample, S&P 500 futures suffered from illiquidity. A natural choice in our framework is thus to use ATM options to infer the price of the underlying.

[3] The authors provide a detailed analysis of the behavior of option-implied volatility for very high frequencies.

changing tail risks. The bid-ask-spreads on FOMC days are comparable in size. We conclude that high-frequency option quotes are sufficiently liquid also on FOMC announcement days.[4]

B. FOMC News Announcements

The Federal Open Market Committee has scheduled 8 meetings per year since 1994, in which not only monetary policy, but also the economic outlook is discussed. The announcements have typically been released at 2:15 p.m. Since the introduction of press conferences, dissemination times have varied between 12:30 p.m. and 2:15 p.m.. Currently, the FOMC statements are released at 2:00 p.m. and the press conference is held at 2:30 p.m. As we start our analysis in 2004, we are left with a total of 112 meetings, 28 of which have been accompanied by a press conferences. We extend this sample of scheduled meetings by 18 unscheduled phone conferences. A list of all FOMC meetings considered in this study is provided in Table B1.

III. Empirical Analysis

The focus of our empirical analysis lies on understanding how economic uncertainty behaves around monetary policy announcements, when taking into account the evolution preceding the time of dissemination. The times of announcement of scheduled FOMC meetings are known in advance. It would be frivolous to assume that uncertainty for a future time period is only affected by intraday meeting jumps. Rather, changes leading up to an announcement have to be taken into account. To this end we rely on VIX-like measures to approximate economic uncertainty in reference to Bloom (2009). Formally, uncertainty about future states of the economy may be extracted as the expected quadratic variation from option prices on a broad market index:

$$\mathbb{E}_t^{\mathbb{Q}}\left[\mathrm{QV}_t^{t+\tau}\right] = 2e^{\int_t^{t+\tau} r_s ds}\left(\int_0^{\infty} \frac{O_t^{\tau}(K)}{K^2} dK\right), \tag{1}$$

[4]High-frequency liquidity measures compare well to measures for the end-of-day option panel.

with risk-free rate r, option prices O at strike K and time to maturity τ. We abstract from the methodology proposed by the CBOE in several ways. First, we calculate these VIX-like measures ourselves, using a granular grid of minute-by-minute option quotes. For higher frequencies, the cutoff rule imposed by the CBOE may lead to random biases in the estimation, as uncovered by Andersen, Bondarenko, and Gonzalez-Perez (2015). Second, we fill in option prices at unobserved strike prices to approximate the integral by a sum of finer differences. We employ a kernel smoothing technique across adjusted log-moneyness, time to maturity and a put-call identifier. Note that we do not extrapolate outside the extreme strike points observed in the market and thus refrain from making any statement about the underlying distribution in unobserved regions. And third, we estimate the measure not only for a constant maturity of one month, but also for longer horizons, to identify distinct effects across the term structure of economic uncertainty. This is particularly important in light of the stark focus on the short-end in recent research on uncertainty.

A. Empirical Design

As we wish to contrast the real effects of FOMC announcements on economic uncertainty, we base our analyses on difference-in-difference estimators. These estimators allow us to a) purge our uncertainty measures from deterministic intraday effects, which may skew results,[5] and b) figure out abnormal effects, by a simple comparison with average uncertainty levels ahead of the announcements. The diff-in-diff approach is inspired by Bollerslev, Li, and Xue (2018). We split our sample into treatment days, which encompasses the day of the FOMC announcement, $\mathcal{F}$, the one week before, and one day thereafter. The remainder is labeled as non-treatment. We use the week before the actual announcement as part of our treatment group to assure that uncertainty levels from which we calculate abnormal deviations include only information that has been provided by the Fed directly. During this week, committee members must not make public comment about the meeting's content. This assures that we indeed condition on all Fed-given news, such that deviations from these baseline levels must be a consequence of learning about the news that has already been in the market, other macroeconomic news, or leakage by committee

[5] See Bollerslev, Li, and Xue (2018) and Andersen, Thyrsgaard, and Todorov (2019)

members and close aids. We also include the day following FOMC announcements to identify persistence of the meeting shocks. Should we see a direct reversal to pre-meeting uncertainty levels, we argue that attributing a "real" effect of resolving uncertainty is debatable at best.

For each day (d) and time (t) combination in each set of treatment days $\mathcal{T}_j$, centered around the jth FOMC announcement $\mathcal{F}_j$, we subtract the 30-day average before the blackout period,

$$\widetilde{\mathcal{U}}_{d\in\mathcal{T}_j}(t) = log\ \left[\mathcal{U}_{d\in\mathcal{T}_j}(t)\right] - \frac{1}{30}\sum_{i=8}^{37} log\ \left[\mathcal{U}_{F_j-i}(t)\right]. \tag{2}$$

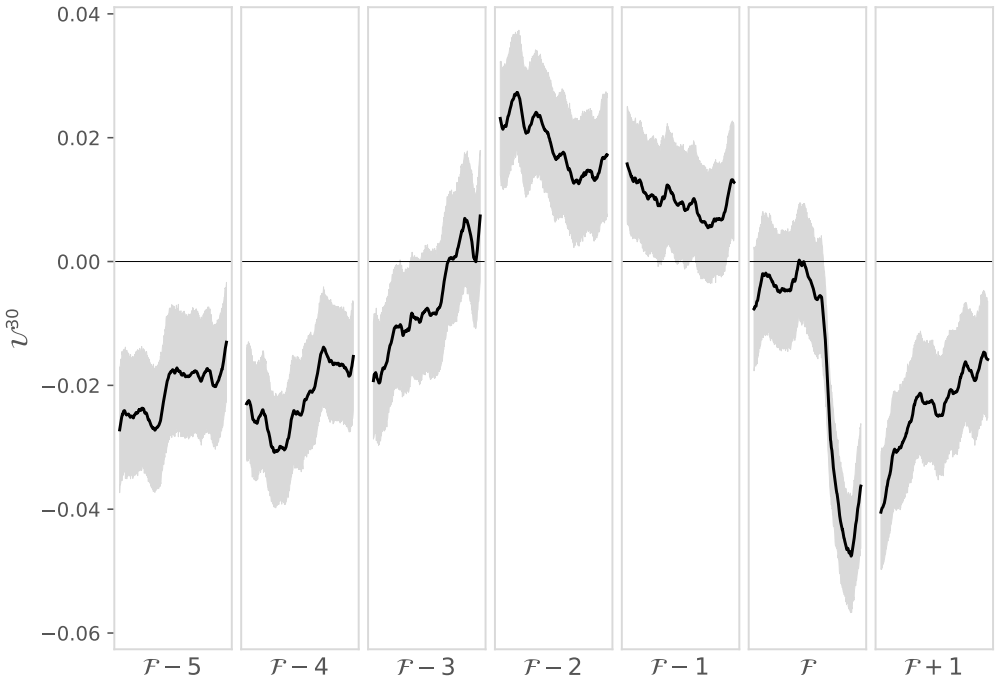
For the most common announcement time of 2:00 pm, we would thus subtract the 30-day average from 38 to 8 days before the announcement, sampled at 2:00 pm daily to obtain our desired estimator.

We keep the control group constant for the days in each set of treatment days $\mathcal{T}_j$. This approach assures consistent comparisons of pre-meeting uncertainty levels and makes sure that any deterministic intraday patterns are being accounted for. The resulting estimates are convenient, as they assume stationarity, similar to first-differencing, and can be interpreted as relative changes in uncertainty compared to a predefined pre-announcement control group.

B. Patterns in Short-Term Uncertainty

The first part of our analysis will focus on using a measure of short-term economic uncertainty, specifically with a horizon of one month. This instrument has been used in numerous studies to identify the real effects of FOMC announcements on how uncertain the aggregate market sees the future. The idea is that, if policy decisions and discussions of the market outlook have an influence on uncertainty about future states of the economy, we should see a long-lasting drop in a carefully selected portfolio of index options, which mimics the conditional risk-neutral expectation of future volatility for a fixed horizon. The average evolution of short-term uncertainty in the blackout period, on the announcement day and the day thereafter ($\widetilde{\mathcal{U}}^{30}$) is displayed in Figure 1. We identify **four phases** of a remarkable and consistent pattern in the seven days considered here:

Figure 1. $\mathcal{U}^{30}$



Note. The figure shows the evolution of the relative $\widetilde{\mathcal{U}}^{30}$ averaged across all announcement days. Measures are shown as 30-minute averages. 99% confidence intervals are bootstrapped from the sample of announcement days.

1. At the start of the blackout period on days $\mathcal{F}-5$ through $\mathcal{F}-3$ we see an increase in uncertainty levels. Uncertainty rises from levels about 2% below the control group on day $\mathcal{F}-5$ to levels more than 2% *above* the control group at the start of day $\mathcal{F}-2$. This increase in uncertainty during the blackout period is significant and to the best of our knowledge, we are the first to document it. A possible explanation may be in the FOMC cycle examined by Cieslak, Morse, and Vissing-Jorgensen (2019), since FOMC announcements have typically been made on a Wednesday in the sample we consider. The blackout period buildup observed here would thus occur during the week preceding an announcement and the weekend-gap in between. The authors have found an association of odd weeks from the last FOMC meeting and poor returns.

2. The second phase we see replicates the findings by Hu, Pan, Wang, and Zhu (2019), who document a reduction of uncertainty *before* FOMC announcements, which they argue serves as an explanation for the pre-FOMC announcement drift. When only considering days $\mathcal{F}-2$ up to the time of the announcement on day $\mathcal{F}$, the pre-meeting resolution of uncertainty is remarkable. A drop from +2% to -1% at the start of the announcement day may indeed explain the 49 basis point return documented by Lucca and Moench (2015) associated with an average meeting. We extend this picture and find that 100% of this pre-meeting reduction is associated with the blackout period buildup discussed in phase 1. If a risk-based explanation should explain the pre-FOMC announcement drift, the same explanation should serve for phase 1. We therefore expect to see abnormally poor returns on days $\mathcal{F}-4$ and $\mathcal{F}-3$.

3. The intraday drop directly associated with the meeting is large and amounts to about 4.5% compared to control group levels. Other studies have identified this reduction and have offered multiple explanations. For one, Gu, Kurov, and Wolfe (2018) find that this high-frequency reduction in uncertainty exclusively happens on announcement days with a subsequent press conference where the Fed explains its decisions. From a high-frequency view the shock to economic uncertainty induced by FOMC announcements is remarkable. The drop amounts to about 4%, depressing uncertainty levels by the same amount when compared to pre-meeting levels. Compared to levels at the start of the blackout period the drop is more modest, but still significant.

4. The apparent resolution of uncertainty in phase 3 is rather short-lived when considering short-term uncertainty. A mere consideration of high-frequency shocks, as proposed by new advances in the VAR literature, is ill advice. Many possible reasons for this exist. Consider a world in which the Fed is the only source of information on the future trajectory of the economy. An investor with a time horizon of less than the spacing between two scheduled FOMC meetings will thus not concern herself with future Fed announcements, which should bring uncertainty levels back to their long-run mean. We observe a similar pattern for short-term uncertainty. Once the meeting concludes, levels revert back to levels at the start of the blackout period and pre-meeting levels.

We cannot confirm many of the recent findings in the literature that the FOMC has

a lasting and notable effect on levels of uncertainty. Rather we find a distinct pattern around FOMC announcement days, with a buildup induced by the announcements, a downward drift thereafter and a jump at the announcement time. On the day following the announcement however, we find levels to revert back to previous levels, indicating that while the Fed induces uncertainty about upcoming decisions, which may materially change the economic landscape, it does not live up to its mandate of substantially lowering levels of economic uncertainty.

C. Possible Explanations

The above discussion of how short-term uncertainty behaves around FOMC announcements leads us to examine four possible explanations. We first study whether uncertainty about tail events may explain parts of the pattern we find. We further condition on whether monetary policy decisions made in the meeting came as a surprise to market participants, and in how far a press conference following FOMC announcements makes a difference. Lastly, we use unscheduled telephone conferences by the committee to understand what happens to economic uncertainty whenever the market is not informed about a possible decision taking place in advance, but the Fed still sees a need to step in.

To more formally assess how different meeting characteristics and the influence of tail uncertainty relate to the above pattern, we employ a set of dummy regressions. For this, we set individual dummies corresponding to each day in a set of treatment days $\mathcal{T}_j$. For the announcement day $\mathcal{F}_j$ we set two dummies, PRE and POST, to distinguish between what happens before and after the actual announcement is made. This simultaneously allows us to quantify the associated jump in uncertainty measures $\widetilde{\mathcal{U}}$, which we denote as JUMP and which is mathematically defined as the difference between coefficients to dummies POST and PRE. This formulation is neatly summarized in the following regression setup:

$$\widetilde{\mathcal{U}}_d = a + B' D_t(1 + F_t) + C' X_t + \varepsilon_t, \quad \text{with} \tag{3}$$

$$D_t = [-5, \ldots, -1, \text{PRE}, \text{POST}, 1]' \quad \text{and} \tag{4}$$

$$b_{JUMP} = b_{POST} - b_{PRE}, \tag{5}$$

where B is a vector of coefficients to dummies in vector D_t, C a vector of coefficients to possible control variables in X_t, and F_t an auxiliary vector of whether a respective meeting has characteristic f. Through the interactions with F_t we focus on additional signals from characteristic f above and beyond information from "regular" meetings. Table II shows the corresponding results, along with the base case given in Figure 1, for which we have set $F_t = X_t = \emptyset$.

Can Tail Uncertainty Explain the Pattern? To understand the influence of tail uncertainty, we separately identify short-term expectations of tail variation following Bollerslev, Todorov, and Xu (2015). Formally, we estimate left (LU) and right (RU) tail uncertainty,

$$LU_t = \int_t^{t+\tau} \int_{-\infty}^{-k_t} x^2 \nu_s(dx) ds, \qquad RU_t = \int_t^{t+\tau} \int_{k_t}^{\infty} x^2 \nu_s(dx) ds, \tag{6}$$

by assuming the jump compensator $\nu_s(dx)$,

$$\nu_t(dx) = \left(\phi_t^+ \times e^{-\alpha_t^+ x} \mathbf{1}_{\{x>0\}} + \phi_t^- \times e^{\alpha_t^- x} \mathbf{1}_{\{x<0\}} \right), \tag{7}$$

where $\phi^{\pm}$ governs the level of tail uncertainty, $\alpha^{\pm}$ the decay of the tail, and x the jump-size. Bollerslev and Todorov (2014) show how, given that log-prices of deep-OTM put (call) options increase (decrease) linearly in the log-moneyness as time to maturity approaches zero, both parameters can be consistently estimated through least absolute deviation. As we are interested in the impact of very large asset price movements on uncertainty, we only consider jumps that are larger than a time-varying cutoff $k_t = 7 \times IV^{ATM} \sqrt{\tau}$.[6] To focus exclusively on information about tail uncertainty, we exclude options for which $-2.5 < m < 1$ in the parameter estimation. The procedure proposed by Bollerslev, Todorov, and Xu (2015) sorts the options by m regardless of their time to maturity, while demanding strict convexity in option mid prices. This effectively discards otherwise valid option quotes from the sample and mixes the inherently unique information from options maturing at different points in time to come up with single values for $\alpha_t^{\pm}$ and $\phi_t^{\pm}$ at time t. In contrast, we seek to retain as much information on the tails as possible and estimate the parameters for each time to maturity τ individually. In the next step we calculate

[6] For a hypothetical option with 30 days to maturity at an ATM IV level of 20%, this corresponds to expecting annualized jumps of around 40%.

LU and RU for each τ, and take the median at time t to obtain robust minutely tail uncertainty proxies. We include the information from options with $\tau \leq 45$ days, explicitly incorporating very short-term options, which have often been discarded in previous studies, but are particularly informative about tail uncertainty.

The second column of Table II shows the results when using $X_t = [\widetilde{LJV}_t, \widetilde{RJV}_t]'$ and $\widetilde{\mathcal{U}} = \text{VIX}^{30}$ in the dummy regression across all 112 scheduled meetings considered here. In contrast to the regression where we do not account for the influence of changing tail uncertainty, levels at the start of the blackout period change significantly less. The first phase of the pattern, the blackout period buildup, is driven almost exclusively by expectations of tail variation. Investors seem to disagree more in the week leading up to FOMC announcements, with both left and right tail variation surging. Phase two of the pattern resembles the base case, but the overall downward drift is more severe. Uncertainty levels drop significantly on the two days before and the first half of the announcement days (measured by coefficient PRE). Interestingly, levels compared to the control group are much lower when accounting for tail disagreement, falling below the levels in the thirty days before the blackout period. Following the line of reasoning in Hu, Pan, Wang, and Zhu (2019), the pre-FOMC announcement drift is better explained by short-term uncertainty reductions purged from tail influence. The high disagreement in the tails hides these effects. The large jump of -4.81% we observed in the base case now shrunk to less than -0.5%. Phase three, the high-frequency jump, is solely driven by vanishing tail disagreement. The uncertainty recovery of phase four is equally pronounced here, reverting back to levels at the start of the blackout period. In summary, it remains unexplained as to why uncertainty levels plummet in the days before announcements, but go back to average levels less than a day thereafter.

The Impact of Press Conferences. We next condition on whether a press conference was held after an announcement. Since 2011 the FOMC has relied on press conferences to explain their decisions. This in turn has led the Fed to make big decisions only on days with a scheduled press conferences, which ultimately led to a policy shift to always hold press conferences after meetings starting in 2019 – a practice used by the European Central Bank for years. We indeed find similar effects on days with press conferences in column IV of Table II as we did for monetary policy surprises. From the start of the blackout period until the end of the day after

FOMC announcements, we find an almost uniform reduction in uncertainty from more than 8% to almost −4%. Our findings are similar to those of Gu, Kurov, and Wolfe (2018) who find a resolution of uncertainty on press conference days and days of the release of a statement of economic projection only. Since announcement days with press conferences almost surely hold valuable information provided by the Fed, short-term uncertainty levels are significantly elevated in advance. We again find a reduction in uncertainty before the actual announcement is made and the press conference is held. In the model by Laarits (2019) this is explained by how market participants learn how to interpret the upcoming meeting. In the model setup, they do so by aggregating news that had already been in the market. As the meeting ensues, these participants gradually learn about the meeting's content, which speeds up the pace at which uncertainty resolves. We see a similar pattern in the data. As the meeting's conclusion approaches, uncertainty reduction starts to pick up with the largest drop at the time of the announcement. We do however find that uncertainty levels reduce below the pre-meeting averages, a finding that cannot hold in the world of **?** for an uncertainty horizon which does not encapsulate a secondary meeting. Likewise, it remains unclear whether the Fed meets its objective of lowering economic uncertainty even when a press conference is held. While uncertainty levels are depressed below pre-meeting levels, they significantly rise at first. The price of insurance against volatility in the market increases, simply due to the possibility of material policy stance changes. About two thirds of the overall uncertainty reduction is just this premium leaving the market.

What Happens on Days of Monetary Policy Surprises? Many researchers have argued that days on which the Fed announces decisions unexpected by the market, represent a monetary policy shock as required by VAR models. We therefore wish to understand how uncertainty behaves on these days. For this, we have classified the 112 meetings in our sample to be either a meeting of monetary policy surprise (Sur) or of no monetary policy surprise. A list of all classifications is given in Table B1. We measure surprises with the methodology proposed in Bernanke and Kuttner (2005), by taking the unexpected changes in federal fund futures rates on announcement days. Column III of Table II shows the results.

Days with monetary policy surprises follow a vastly different pattern. At first we find that uncertainty elevates significantly from days −5 to −3. Afterwards, we

see an almost monotonic decrease in uncertainty until after the announcement day. Merely day -1 shows a slight elevation from the day before. On the day after the announcement, uncertainty levels increase in a similar fashion as for the base case. However, levels are actually significantly below both control group and pre-blackout period levels, speaking in favor of a "true" resolution of uncertainty whenever the monetary policy aspect of FOMC announcements was not expected by the market in advance.

The days with monetary policy surprises have historically been favorable for the stock market and the overall economy through rate cuts, an accommodating policy, and improving outlooks. The notion of unexpectedly good news has been thoroughly examined by Cieslak and Vissing-Jorgensen (2018). The authors find convincing evidence that through their promise to act, the Fed has improved stock returns and the economic outlook as stated by consumers. Our finding, that monetary policy surprises have a lasting effect on economic uncertainty even in the short-term speak in favor of this story. Not only do we find that uncertainty is depressed below pre-meeting levels, but we also find a significant elevation at the start of the blackout period. From peak to trough this corresponds to a resolution of uncertainty of about 12%. Whenever things heated up in financial markets, the Fed's promise to be there was fulfilled and uncertainty resolved. On days without monetary policy surprises, however, we find no such resolving effects.

A possible explanation may be that on these days the realized Fed decision was more accomodative than expected, which is plausible when considering that most surprise meetings occurred during or in the aftermath of the financial crisis. At the end of our sample, the content of most meetings with a press conference was also "surprising" to the market.

Unscheduled Meetings. We have seen that it is questionable at best, whether the FOMC should regularly schedule meetings. We therefore ask, whether effects of unscheduled telephone conferences show a clearer picture of the usefulness of Fed intervention. These unscheduled meetings occur whenever highly negative news require action in between two scheduled meetings. This has been the case in the financial crisis of 2008, and the fiscal cliff debates of 2011 and 2013. The last column of Table II shows the results. Note that we have not conditioned on the exact time of the phone conference, as it is hard to gauge when exactly market participants

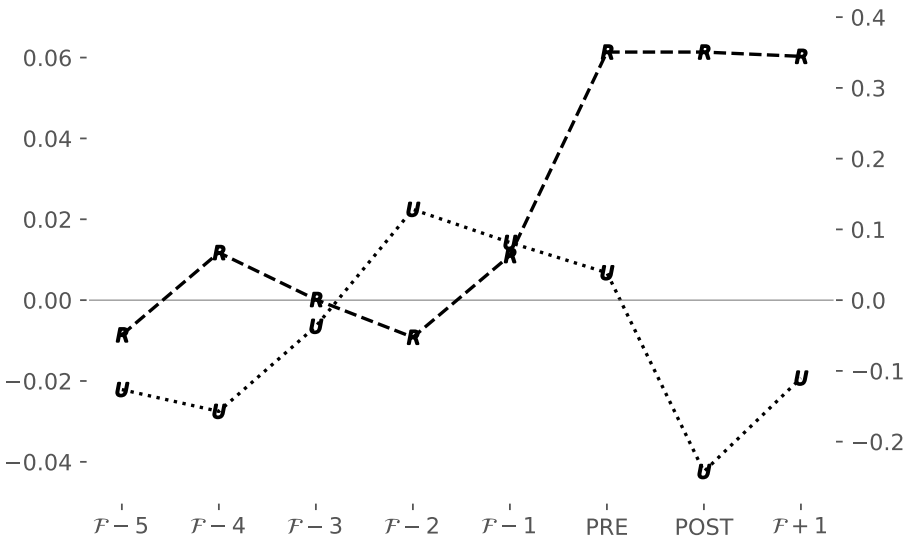
may have gotten to know about its contents. Rather, we look at the business week before, the conference day itself, and the day thereafter. Should the conference relieve uncertainty this would correspond to a reduction on either the conference day, the day after, or both. Interestingly, uncertainty is highly elevated in the week leading up to Fed intervention in the form of phone conferences. The elevation is at around $+18\%$ at the start of the period considered and reaches its peak on day -1 at $+28\%$ compared to the thirty day previous time-of-day-specific averages. The reduction of uncertainty from day 0 to $+1$ is large in absolute terms at about -6.5%, but modest when compared to the elevation we see, which has led to an intervention in the first place. In times of heightened uncertainty, which warrant the Fed to intervene, a mere accommodative stance in monetary policy or discussion of an improving economic outlook are insufficient to bring relief to the market. Interventions in single meetings, scheduled or not, are simply not large enough to bring about the desired effects and shift in sentiment. The Fed may rather wait and see in how far market forces, together with policy aid decided in the last meeting, create calm. In subsequent meetings, the course of the Fed is then adjusted to accommodate financial markets in view of intermeeting evolution.

FOMC Cycle and Fed Put Effects. We ask in how far the observed uncertainty pattern relates to changes in cumulative returns around FOMC announcements. Return patterns have previously been documented, for example in the study of Lucca and Moench (2015), who find that cumulative returns increase substantially over the 24-hour window *ahead* of FOMC announcement. Cieslak and Vissing-Jorgensen (2018) show that low intermeeting returns can predict target rate changes and argue that the Fed keeps a close eye on the stock market development in between scheduled meetings. Combining these effects, Cieslak, Morse, and Vissing-Jorgensen (2019) find a broader cycle of stock returns around FOMC announcement weeks. In this cycle, odd weeks from the last FOMC announcement (counting this week itself as "0") show poor or negative returns on average, even weeks significantly positive returns.

Figure 2 shows simple average cumulative returns from end of day $d-1$ to end of d, and average abnormal uncertainty across d. We can confirm the finding of a pre-announcement drift, with returns from day -1 to the announcement day of about 28 basis points. At the same time, we find that in the days leading up to the announcement, average uncertainty follows a downward drift, which may explain

the large returns we observe over the same time period. We argue that while the pre-announcement drift may be driven by a resolution of uncertainty, as proposed by Hu, Pan, Wang, and Zhu (2019), the steep drop in uncertainty at the time after the announcement should warrant even larger realized returns, when following the same logic. From Lucca and Moench (2015) we know that post-announcement returns are virtually zero, such that we see no effects of this sort here.

Figure 2. Returns vs. Uncertainty



Note. The figure shows short-term uncertainty on treatment days (left axis, letter "U") vs. cumulative returns (right axis, letter "R", in basis points). Note that we observe returns at the end of each day only, thus we see no change in cumulative returns from PRE to POST.

In general we observe a perfectly asymmetrical comovement between uncertainty and returns before the announcement is made. For a reduction in uncertainty, a rise in cumulative returns follows, and vice versa. This relationship breaks down after the announcement, however, where we first see a steep reduction in uncertainty, followed by a recovery, but close to no changes in returns. A case can be made for the Fed put narrative of Cieslak and Vissing-Jorgensen (2018). Using option-implied empirics we find an inverse relationship between uncertainty and returns *ahead* of announcements, and close to no relation thereafter. While the Fed has had mixed

success in decreasing economic uncertainty, it has managed to drive a large portion of average stock returns since 1994. No matter the concern in the market, and the empirical extent as to which it has been relieved, index returns have continued to rise, or, as seen on day $\mathcal{F}+1$, not fallen significantly in an increasingly uncertain view of the future.

With Wednesday as the most common day of dissemination by the committee, days $\mathcal{F}-5$ to $\mathcal{F}-3$ fall into the odd week right *before* the next meeting, with changes from $\mathcal{F}-3$ to $\mathcal{F}-2$ primarily driven by weekend effects, while all other days are part of the even announcement week. We indeed find that odd week returns are low, and find the large return increases documented in Cieslak, Morse, and Vissing-Jorgensen (2019) only for the announcement day itself. At least for this portion of the broader FOMC cycle, we find that one day, the day of dissemination by the committee, drives close to all return effects, while the picture is much more diverse for short-term uncertainty measures.

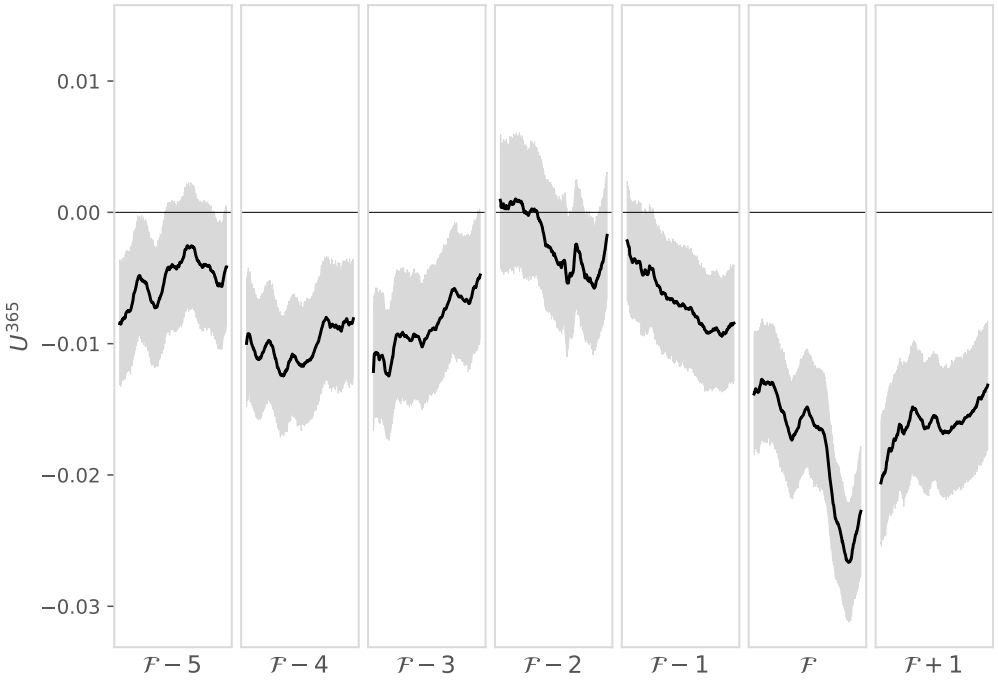
Returns and uncertainty comove negatively before FOMC announcements. However, this comovement is lowest for the largest changes in uncertainty on the announcement day and for the day thereafter. We thus find only weak evidence for a risk-based explanation of cycle and pre-announcement returns.

Policy implications. We have argued that the Fed has at best modest effects on short-term uncertainty. Scheduled meetings are best complemented by a press conference, detailing the decided actions. At the same time, the promise to explain has led to the belief that major decisions may only be undertaken on days with a scheduled press conference. Consequently, market participants see the future as more uncertain, driving the prices of insurance in the options market up. A promising step has been the shift to schedule press conferences for every other meeting, but for every single meeting. Still, the meetings induce uncertainty as shown here, and spark volatility as evidenced by Bollerslev, Li, and Xue (2018). Even if Fed intervention is warranted, as evidenced by our subset of unscheduled phone conferences, the tight meeting schedule has created an environment in favor of small and modest policy shifts as opposed to large scale and sudden intervention. Committee members rather wait to see the effects of smaller policy changes to not overshoot their objectives and worsen the problems. As additional meetings are just a few weeks away, any decision may be reverted, adapted, or complemented in a short period of time.

D. A Case for Long-Term Uncertainty

Relying on options with longer time-to-maturity allows us to extract expectations about uncertainty for an annual horizon. We argue that longer-term uncertainty is more suitable to learn about the effects of monetary policy announcements on the economy. Key drivers that can be tackled by the Fed's policy are not transitory, and may react rather sluggishly and over the long-run. As shown earlier, FOMC announcements are associated with a sudden increase in tail risk before dissemination and a resolution soon after. This tail influence is naturally smaller for long-term uncertainty, limiting the possible contamination by tail disagreement. Figure 3 displays the behavior around FOMC announcements.

Figure 3. $\mathcal{U}^{365}$



Note. The figure shows the evolution of the relative $\widetilde{\mathcal{U}}^{365}$ averaged across all announcement days. Measures are shown as 30-minute averages. 99% confidence intervals are bootstrapped from the sample of announcement days.

We observe a similar uncertainty pattern in our long-term measure. Relative levels again start at about 1% below the control group at the beginning of the blackout period. However, the linear upward trend in phase one is not as strong as for short-term uncertainty. There is close to no change on $\mathcal{F}-4$ but an increase from -1.25% to -0.5% on $\mathcal{F}-3$. Nevertheless, levels are somewhat above, but significantly different from, the control group at the start of phase two, mainly due to a sharp increase over the weekend ($\mathcal{F}-3$ to $\mathcal{F}-2$). Two days before the actual meeting, levels start to decrease steadily to approximately -1.5% until the day of the FOMC announcement. Again, we observe a strong average intraday drop of more than 1% after the Fed announces their decision but the resolution is rather short-lived as next days' levels are approximately -1.5% below the control group. In contrast to short-term uncertainty, we see levels that are below levels at the start of the blackout period.

We wish to understand what drives the pattern in uncertainty and apply the same conditioning analysis as above. The regression results are given in Table III. The base case regression underlines the above findings. We generally observe depressed levels during the blackout period, and at first an increasing, but later a decreasing trend. Levels jump downwards at the FOMC announcement but reverse the next day to -1.5%. When we account for the influence of tail uncertainty, a similar picture emerges. Yet, the fear of large negative or positive price movements does have a pronounced effect on longer-term uncertainty as well. While levels increase until $\mathcal{F}-2$ in the base case, we see a continuous downward trend when we account for the tails. The jump from PRE to POST announcement levels is zero in this case. Interestingly, the POST levels in the base case and here are almost identical. This speaks in favor of the fact that the Fed induces tail uncertainty, which is in turn resolved by the announcement – a finding robust across the term structure of uncertainty. We also note the similar levels on the next day $\mathcal{F}+1$, which indicates that jump risk has indeed no effect on the estimates **after** the announcement.

Press conferences also have a substantial impact long-term uncertainty. Throughout the first days of the blackout period, uncertainty is about 1% higher compared to the control group. Levels decrease over the week and fall slightly below the control group as the announcement approaches. The -3.5% decrease from PRE to POST is the largest we observe for long-term uncertainty. Levels slightly revert the day after the announcement and are still below the control group. However, they are

not different from the base case. This indicates that press conferences, intended to provide the market with more detailed information about the Fed's decision, create strong reactions upfront and at the announcement but do not aid in lowering long-term uncertainty persistently. Again, we argue that the Fed induces uncertainty in the market through pre-scheduled meetings, even more when the scheduled meeting is accompanied by a press conference. The promise to rationalize its decision has led to the belief that major decisions may only be undertaken on days with a press conference.

Conditioning on monetary policy surprises yields further insight. We observe that the estimate is very erratic over the course of the blackout period. However, at the day of the announcement, levels do not change dramatically. The PRE and POST coefficient are of same magnitude (about -2.5). This is puzzling given that the decision of the Fed has been surprising for the interest rate market and indicates that markets learn about the possible content of the meeting ahead of time. The level one day after the meeting further decreases to -3.55, the lowest we observe in our classification. The negative drift after the actual announcement shows that financial markets need time to process surprising decisions and that these decisions have been accommodating in general.

The results for unscheduled meetings are qualitatively in line with the results for short-term uncertainty but as expected lower in magnitude. Levels are highly elevated in the days before the meeting and steeply increase one day before and at the day of the conference call. In contrast to short-term uncertainty, the drop from 12% to 11.2% above the control group is marginal. Consequently, longer-term uncertainty hardly reacts to unscheduled FOMC meetings and is highly above pre-meeting levels. This finding is hard to reconcile with a tight schedule of eight meetings per year.

Our analysis of patterns in long-term uncertainty reveals lesser impact of pre-meeting changes. We conjecture that it is beneficial to focus on a longer-term uncertainty measures, which better aligns with the objectives of the Fed, and arguably does a better job at filtering out short-term disagreement of whether an ensuing meeting continues the unexpectedly accomodative stance of the Fed.

IV. Conclusion

Option prices provide aggregate expectations about the future course of the economy. We study the behavior of uncertainty inferred from option prices around FOMC announcements to gauge the Fed's effectiveness in stabilizing financial markets. We document that uncertainty is already depressed at the start of the blackout period before it starts to increase *ahead* of the announcement time. The rise of uncertainty is accompanied by negative stock market returns. However, two days before the FOMC announces their decisions on monetary policy issues, and discusses the economic outlook, both trends are quickly reversed. Stock markets tend to go up significantly while uncertainty decreases, a finding that has previously been recognized in the literature. When the FOMC announces its decision, uncertainty drops sharply by almost 5% compared to average levels of thirty days before the blackout week. The day after the FOMC announcements no major stock market moves can be seen. Uncertainty, in contrast, increases again to approximately the same levels as at the start of the blackout period (-2%).

We emphasize that most of the pattern can be explained by the evolution of tail risk. Our regression results indicate that the increase in uncertainty to levels above its control group and most of the resolution around the actual FOMC meeting is attributable to the fear of large stock market movements. Once the meeting concludes and the jump risk is eliminated levels are similar to our baseline analysis. Although the overall trend in uncertainty is decreasing, we highlight the fact that FOMC announcements themselves cause uncertainty by uncovering possible material information.

FOMC announcements with press conferences cause even more fear of such events but are also responsible for large resolutions of uncertainty. Whenever decisions by the Fed are explained by the board, levels drop persistently to almost 4% below our control group. Surprising decisions, as measured by a change in Fed fund futures, have the lowest post-decision levels, which we interpret that most surprising decisions were of accommodative nature in the sample considered. We estimate longer-term uncertainty of one year as we wish to naturally dampen the effect of single meetings and the jump risk associated with it. Purging uncertainty from the influence of tail uncertainty, we can confirm the decreasing trend in uncertainty, but also highlight

the effect of FOMC-induced fear of jumps. Almost all of the intraday change in long-term uncertainty at FOMC announcement can be explained by tail risk.

Our findings have important policy implications. A strict schedule of eight meetings per year may do more harm than help, as we see a persistent pattern of high elevation in uncertainty leading up to these meetings. At the same time, the fine structure with which the committee has met since 1994 has led to a form of "inertia", in that large decisions are postponed to subsequent meetings, to get a sense of how the market may react to monetary policy intervention in the meantime. Direct market-action by the Fed has been perceived as "too little, too late" by the market – a notion we back by uncovering how unscheduled meetings affect stock market uncertainty.

Table I. Option Sample Characteristics

	Non-FOMC			FOMC		
	≤ 15	≤ 90	≤ 365	≤ 15	≤ 90	≤ 365
Panel A: Open Interest						
$m < -2.5$	567	510	593	511	503	568
$-2.5 \leq m < -1.0$	385	486	404	350	460	393
$-1.0 \leq m < 1.0$	237	330	331	208	312	323
$m > 1.0$	379	355	416	356	350	424
Panel B: Bid-Ask Spread						
$m < -2.5$	0.53	0.39	0.35	0.51	0.41	0.37
$-2.5 \leq m < -1.0$	0.19	0.12	0.09	0.16	0.13	0.10
$-1.0 \leq m < 1.0$	0.10	0.07	0.06	0.09	0.08	0.06
$m > 1.0$	0.60	0.53	0.46	0.57	0.53	0.47

Note. This table shows 1-minute average Open Interest (Panel A) and Bid-Ask-Spread (Panel B) for our option sample on FOMC and Non-FOMC days. m corresponds to the adjusted log-moneyness and $15, 90$ and 365 to the options maturity.

Table II. 30-Day VIX Regression

	Base	Tails	PC	Sur	Unsch
-5	−0.0221	−0.0093	0.0851	0.0077	0.1672
	[-0.026; -0.019]	[-0.010; -0.008]	[0.079; 0.092]	[0.001; 0.014]	[0.157; 0.176]
-4	−0.0275	−0.0023	0.0711	0.0225	0.1907
	[-0.031; -0.024]	[-0.003; -0.001]	[0.065; 0.078]	[0.016; 0.027]	[0.181; 0.199]
-3	−0.0065	0.0010	0.0967	0.0432	0.1730
	[-0.010; -0.002]	[-0.000; 0.002]	[0.090; 0.103]	[0.035; 0.051]	[0.163; 0.185]
-2	0.0224	−0.0055	0.0846	−0.0054	0.1831
	[0.019; 0.026]	[-0.007; -0.004]	[0.077; 0.091]	[-0.014; 0.004]	[0.171; 0.196]
-1	0.0143	−0.0186	0.0665	0.0257	0.2864
	[0.011; 0.017]	[-0.020; -0.017]	[0.060; 0.073]	[0.019; 0.033]	[0.273; 0.298]
PRE	0.0068	−0.0334	0.0496	−0.0219	0.2861
	[0.003; 0.011]	[-0.035; -0.032]	[0.039; 0.058]	[-0.031; -0.012]	[0.270; 0.301]
POST	−0.0424	−0.0370	−0.0387	−0.0796	0.2861
	[-0.047; -0.036]	[-0.039; -0.035]	[-0.049; -0.028]	[-0.093; -0.066]	[0.270; 0.301]
JUMP	−0.0491	−0.0062	−0.0884	−0.0609	
	[-0.054; -0.042]	[-0.009; -0.003]	[-0.101; -0.073]	[-0.077; -0.042]	
1	−0.0193	−0.0154	−0.0369	−0.0565	0.2139
	[-0.022; -0.016]	[-0.019; -0.012]	[-0.044; -0.030]	[-0.063; -0.050]	[0.199; 0.230]

Note. This table shows estimates for our dummy regression as given in Equation (3). The dependent variable is diff-in-diff estimate for 30-day uncertainty. Tail includes tail uncertainty measures as control variables, PC are meetings with scheduled press conference, Sur denotes meetings with monetary policy suprises, and Unsch are unscheduled conference calls. The 99 percent confidence intervall is given in parenthesis and obtained via bootstrapping.

Table III. 365-Day VIX Regression

	Base	Tail	PC	Sur	Unsch
-5	−0.0071	−0.0020	0.0151	−0.0081	0.0619
	[-0.008; -0.008]	[-0.003; -0.001]	[0.012; 0.018]	[-0.012; -0.004]	[0.056; 0.067]
-4	−0.0112	−0.0014	0.0146	0.0044	0.0833
	[-0.011; -0.011]	[-0.002; -0.000]	[0.012; 0.018]	[0.001; 0.008]	[0.079; 0.088]
-3	−0.0101	−0.0085	0.0111	0.0251	0.0739
	[-0.010; -0.010]	[-0.010; -0.007]	[0.008; 0.015]	[0.021; 0.030]	[0.070; 0.079]
-2	−0.0008	−0.0108	0.0088	−0.0082	0.0719
	[-0.001; -0.001]	[-0.012; -0.010]	[0.005; 0.012]	[-0.013; -0.003]	[0.067; 0.077]
-1	−0.0061	−0.0173	−0.0019	0.0034	0.1097
	[-0.006; -0.006]	[-0.018; -0.016]	[-0.005; 0.001]	[-0.001; 0.007]	[0.104; 0.115]
PRE	−0.0119	−0.0256	−0.0035	−0.0209	0.1201
	[-0.011; -0.011]	[-0.027; -0.024]	[-0.008; 0.000]	[-0.026; -0.016]	[0.115; 0.125]
POST	−0.0274	−0.0248	−0.0383	−0.0264	0.1201
	[-0.026; -0.026]	[-0.027; -0.023]	[-0.043; -0.033]	[-0.033; -0.019]	[0.115; 0.125]
JUMP	−0.0155	−0.0001	−0.0349	−0.0089	
	[-0.016; -0.016]	[-0.003; 0.002]	[-0.041; -0.030]	[-0.016; 0.001]	
1	−0.0141	−0.0125	−0.0169	−0.0333	0.1122
	[-0.015; -0.015]	[-0.014; -0.011]	[-0.020; -0.013]	[-0.037; -0.029]	[0.105; 0.119]

Note. This table shows estimates for our dummy regression as given in Equation (3). The dependent variable is diff-in-diff estimate for 365-day uncertainty. Tail includes tail uncertainty measures as control variables, PC are meetings with scheduled press conference, Sur denotes meetings with monetary policy suprises, and Unsch are unscheduled conference calls. The 99 percent confidence intervall is given in parenthesis and obtained via bootstrapping.

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Appendix

A Data Filter Procedure

To assure a robust inference from our high-frequency options sample, we perform a series of data filters. For our sample from January, 2004 through December, 2017, we are left with a total of 410,148 OTM option quotes per day.

The specific data filters used are the following:

- Retain only options for which the bid and ask prices are above 0.
- The ask is above the bid, and the ratio of ask to bid is at most 5.
- Open interest for all contracts it non-zero.
- All option quotes have to adhere to standard no arbitrage bounds. That is,
- The implied volatility can be calculated and is non-extreme (we set a cutoff at 400%, which explicitly incorporates very deep OTM short-term options, but discards those with obvious recording flaws).
- The put and call prices are non-convex, that is, the price difference of two options with consecutive strikes, such that $K_1 < K_2$, is ≥ 0 for calls and ≤ 0 for puts. This is to assure no arbitrage between contracts. If any two contracts violate this condition, the one closer ATM is retained.
- We require at least one quote update per trading day, or trades in the contract to avoid stale quotes.
- For each date-expiry combination for puts and calls, we require three quotes.

Despite being fairly restrictive, these data filters leave us with enough option quotes for our analyses.

B FOMC Meetings

Table B1. Overview of FOMC Meetings

	Rate Cut %	Surprise	News Type	Press Conference
28-Jan-2004	-	-	MP	-
16-Mar-2004	-	-	MP	-
04-May-2004	-	Yes	ECON	-
30-Jun-2004	-	Yes	ECON	-
10-Aug-2004	-	Yes	MP	-
21-Sep-2004	-	Yes	MP	-
10-Nov-2004	-	-	MP	-
14-Dec-2004	-	-	ECON	-
02-Feb-2005	-	-	ECON	-
22-Mar-2005	-	-	MP	-
03-May-2005	-	-	ECON	-
30-Jun-2005	-	-	ECON	-
09-Aug-2005	-	-	MP	-
20-Sep-2005	-	Yes	ECON	-
01-Nov-2005	-	Yes	MP	-
13-Dec-2005	-	-	ECON	-
31-Jan-2006	-	-	ECON	-
28-Mar-2006	-	-	MP	-
10-May-2006	-	Yes	ECON	-
29-Jun-2006	-	Yes	MP	-
08-Aug-2006	-	Yes	MP	-
20-Sep-2006	-	-	ECON	-
25-Oct-2006	-	-	ECON	-
12-Dec-2006	-	-	ECON	-
31-Jan-2007	-	-	MP	-
21-Mar-2007	-	-	MP	-
09-May-2007	-	-	ECON	-
28-Jun-2007	-	-	ECON	-

Table B1. Overview of FOMC Meetings

	Rate Cut %	Surprise	News Type	Press Conference
07-Aug-2007	-	Yes	ECON	-
18-Sep-2007	-0.50	Yes	MP	-
31-Oct-2007	-0.25	-	ECON	-
11-Dec-2007	-0.25	Yes	ECON	-
30-Jan-2008	-0.50	-	ECON	-
18-Mar-2008	-0.75	Yes	MP	-
30-Apr-2008	-0.25	Yes	ECON	-
25-Jun-2008	-	Yes	ECON	-
05-Aug-2008	-	Yes	MP	-
16-Sep-2008	-	Yes	ECON	-
29-Oct-2008	-0.50	Yes	MP	-
16-Dec-2008	-1.00	Yes	MP	-
28-Jan-2009	-	-	MP	-
18-Mar-2009	-	Yes	MP	-
29-Apr-2009	-	-	MP	-
24-Jun-2009	-	Yes	ECON	-
12-Aug-2009	-	Yes	ECON	-
23-Sep-2009	-	-	MP	-
04-Nov-2009	-	-	ECON	-
16-Dec-2009	-	Yes	ECON	-
27-Jan-2010	-	Yes	ECON	-
16-Mar-2010	-	-	MP	-
28-Apr-2010	-	-	MP	-
23-Jun-2010	-	-	MP	-
10-Aug-2010	-	-	MP	-
21-Sep-2010	-	-	ECON	-
03-Nov-2010	-	Yes	MP	-
14-Dec-2010	-	-	ECON	-
26-Jan-2011	-	-	ECON	-
15-Mar-2011	-	-	ECON	-

Table B1. Overview of FOMC Meetings

	Rate Cut %	Surprise	News Type	Press Conference
27-Apr-2011	-	-	ECON	2:15
22-Jun-2011	-	Yes	ECON	2:15
09-Aug-2011	-	-	MP	-
21-Sep-2011	-	Yes	MP	-
02-Nov-2011	-	-	MP	2:15
13-Dec-2011	-	Yes	MP	-
25-Jan-2012	-	-	MP	2:15
13-Mar-2012	-	Yes	MP	-
25-Apr-2012	-	-	MP	2:15
20-Jun-2012	-	-	MP	2:15
01-Aug-2012	-	Yes	MP	-
13-Sep-2012	-	Yes	MP	2:15
24-Oct-2012	-	-	ECON	-
12-Dec-2012	-	-	ECON	2:30
30-Jan-2013	-	-	MP	-
20-Mar-2013	-	-	MP	2:30
01-May-2013	-	Yes	MP	-
19-Jun-2013	-	Yes	MP	2:30
31-Jul-2013	-	-	ECON	-
18-Sep-2013	-	-	MP	2:30
30-Oct-2013	-	-	MP	-
18-Dec-2013	-	Yes	MP	2:30
29-Jan-2014	-	-	MP	-
19-Mar-2014	-	-	MP	2:30
30-Apr-2014	-	-	MP	-
18-Jun-2014	-	-	MP	2:30
30-Jul-2014	-	-	ECON	-
17-Sep-2014	-	-	MP	2:30
29-Oct-2014	-	-	MP	-
17-Dec-2014	-	Yes	MP	2:30

Table B1. Overview of FOMC Meetings

	Rate Cut %	Surprise	News Type	Press Conference
28-Jan-2015	-	-	MP	-
18-Mar-2015	-	Yes	ECON	2:30
29-Apr-2015	-	-	ECON	-
17-Jun-2015	-	-	ECON	2:30
29-Jul-2015	-	-	MP	-
17-Sep-2015	-	Yes	MP	2:30
28-Oct-2015	-	-	MP	-
16-Dec-2015	-	Yes	MP	2:30
27-Jan-2016	-	-	MP	-
16-Mar-2016	-	Yes	MP	2:30
27-Apr-2016	-	-	ECON	-
15-Jun-2016	-	-	ECON	2:30
27-Jul-2016	-	-	ECON	-
21-Sep-2016	-	Yes	MP	2:30
02-Nov-2016	-	Yes	MP	-
14-Dec-2016	-	-	MP	2:30
01-Feb-2017	-	Yes	ECON	-
15-Mar-2017	-	Yes	MP	2:30
03-May-2017	-	-	ECON	-
14-Jun-2017	-	Yes	MP	2:30
26-Jul-2017	-	-	MP	-
20-Sep-2017	-	-	MP	2:30
01-Nov-2017	-	Yes	MP	-
13-Dec-2017	-	Yes	ECON	2:30

Note. This table gives an overview of all FOMC meetings and their classification.