THE
ECONOMIC
JOURNAL

The Economic Journal, **132** (*May*), 1290–1308 https://doi.org/10.1093/ej/ueab086
Advance Access Publication Date: 3 November 2021

MARKET-BASED MONETARY POLICY UNCERTAINTY*

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Uncertainty about future policy rates plays a crucial role for the transmission of monetary policy to financial markets. We demonstrate this using event studies of FOMC announcements and a new model-free uncertainty measure based on derivatives. Over the 'FOMC uncertainty cycle' announcements systematically resolve uncertainty, which then gradually ramps up again. Changes in monetary policy uncertainty around FOMC announcements—often due to forward guidance—have pronounced effects on asset prices that are distinct from the effects of conventional policy surprises. The level of uncertainty determines the magnitude of financial market reactions to surprises about the path of policy rates.

In order to better understand the transmission of monetary policy to financial markets, a large literature has studied the effects of changes in expected policy rates in event studies of Federal Open Market Committee (FOMC) announcements with high-frequency data.[1] However, the role of second moments and uncertainty has received much less attention in this context. In this paper, we use a market-based measure of uncertainty about future short-term interest rates to document new findings about the drivers of policy uncertainty and the effects of uncertainty on asset prices.

The paper makes three main contributions. First, we introduce a new uncertainty measure based on prices of Eurodollar futures and options, the market-based conditional volatility of the future short-term interest rate. The measure is model-free, derived from prices of highly liquid interest rate derivatives, and available at a daily frequency for a long sample period. This allows us to use event studies to investigate changes in short-rate uncertainty around FOMC announcements, when changes in this uncertainty are primarily driven by changes in monetary policy uncertainty.

Second, we document the underlying drivers of changes in monetary policy uncertainty, including an 'FOMC uncertainty cycle'. On average, FOMC announcements cause uncertainty to fall, in line with a systematic resolution of uncertainty. Over the first two weeks after the announcement, uncertainty then gradually ramps up again. We investigate other events as potential drivers of uncertainty, such as macroeconomic news releases and speeches by FOMC participants, and none can match the impact of FOMC announcements on short-rate uncertainty.

Beyond this pattern over the FOMC cycle, monetary policy uncertainty exhibits substantial variation across FOMC announcements and systematically responds to specific Fed policy actions. In particular, forward guidance announcements typically lower uncertainty: FOMC meetings that are followed by the release of a Summary of Economic Projections and a press

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This paper was received on 7 July 2020 and accepted on 26 October 2021. The Editor was Francesco Lippi.

The data and codes for this paper are available on the Journal repository. They were checked for their ability to reproduce the results presented in the paper. The replication package for this paper is available at the following address: https://zenodo.org/record/5566246.

We thank Ruslan Bikbov, Mike Chernov, Rodrigo Sekkel and seminar participants at various seminars and conferences for their helpful comments; Brent Bundick, John Rogers and Eric Swanson for sharing their uncertainty measures; and Shannon Sledz, Patrick Shultz and Simon Zhu for excellent research assistance.

[1] See, e.g., Cook and Hahn (1989), Kuttner (2001), Bernanke and Kuttner (2005), Gürkaynak *et al.* (2005a), Hanson and Stein (2015) or Nakamura and Steinsson (2018).

conference lead to larger declines in uncertainty than other FOMC meetings over the same period (since 2012). A narrative analysis reveals that the most pronounced changes in policy uncertainty result from changes in the forward guidance language in the FOMC statement. While policy actions often move expectations and uncertainty about future policy rates in the same direction, the effects on uncertainty are a separate dimension of FOMC announcements. For example, some forward guidance announcements, such as the introduction of calendar-based guidance in August 2011, only caused a modestly dovish policy surprise as conventionally measured, but substantially lowered uncertainty. While Gürkaynak *et al.* (2005a) emphasised the need to distinguish between surprises in *current* and *expected future* policy rates, our results imply that another relevant distinction is between changes in the *level* of the expected policy path and in the *uncertainty* around this future path.

Our findings—which are robust to the choice of sample period, the exclusion of influential observations and different horizons for uncertainty—can be interpreted through the lens of a simple short-rate model with deterministic jumps at FOMC announcement dates. Uncertainty tends to sharply decline around announcements and then gradually increase due to the changing number of FOMC jumps contributing to conditional volatility. Further variation in policy uncertainty is due to changes in beliefs about the volatility of future jumps, likely due to forward guidance by the Fed.[2]

The third contribution of the paper is to document an uncertainty channel for the transmission of FOMC actions to financial markets: changes in policy uncertainty have significant effects on asset prices that are distinct from the effects of shifts in expectations, i.e., from the effects of conventional measures of the policy surprise.[3] An increase in uncertainty around FOMC announcements raises nominal and real long-term interest rates, has a negative effect on the stock market—lowering S&P 500 returns and increasing the VIX—and causes the Dollar to appreciate. An event study of unconventional monetary policy announcements shows that balance sheet policies and forward guidance substantially lower perceived monetary policy uncertainty, contributing to their effectiveness in easing financial conditions. The uncertainty channel appears to be particularly powerful when the zero lower bound constrains the policy rate and the main lever for forward guidance announcements is to affect second moments. The direction of the estimated effects on asset prices is consistent with a risk-based explanation: in standard asset-pricing models, higher uncertainty raises risk premia, leading to higher real and nominal yields and lower stock prices.[4]

Our evidence on the uncertainty channel may help explain the puzzling large responses of long-term interest rates and other asset prices to Fed policy surprises that previous studies have documented; see, for example, Hanson and Stein (2015). Changes in the expected policy path are positively related to uncertainty: hawkish policy surprises are associated with smaller-than-average declines in uncertainty (or even increases) while dovish surprises are associated with larger declines. Since first-moment surprises are positively correlated with second-moment changes, and uncertainty has pronounced effects on asset prices, leaving out uncertainty in the common event-study regressions may cause an upward bias in the estimated effects of monetary policy surprises. We avoid this problem by accounting for the effects of monetary policy uncertainty on asset prices.

[2] Additional evidence indicates the presence of substantial FOMC jump risk premia.
[3] While we focus on transmission to US financial markets in this paper, in follow-up work Lakdawala *et al.* (2021) showed that this effect spills over to international bond and equity markets in both advanced and emerging economies.
[4] Additional evidence about the response of term premia to changes in uncertainty supports this explanation.

Finally, the level of short-rate uncertainty also matters for the transmission of policy actions to financial markets: at high levels of uncertainty, monetary policy surprises have much more muted effects on asset prices than when uncertainty is low. This empirical pattern is consistent with a signal-extraction logic that investors put higher weight on signals from the Fed when they are more confident about the expected policy path.[5]

The paper is most closely related to the literature that uses market-based measures of second moments to study the role of risk and uncertainty in the transmission of monetary policy to financial markets. In an early contribution, Swanson (2006) documented that option-based short-rate uncertainty declines between 1989 and 2003, and that starting in 1994 it tends to fall around FOMC announcements, a fact he attributed to increased Fed transparency. We extend the evidence on the resolution of uncertainty and explain this pattern with FOMC jumps. Bundick *et al.* (2017) estimated positive effects of changes in short-rate uncertainty on term premia around FOMC announcements. We establish that changes in policy uncertainty affect a broad range of asset prices, including real and nominal bonds, stocks and exchange rates and provide a risk-based explanation that is consistent with such term premium effects.[6] De Pooter *et al.* (2021) also found that the response of long-term yields to monetary policy surprises depends on the level of short-rate uncertainty, and proposed an explanation based on the bond inventory management of primary dealers. Our results show that this level effect is present in all asset price responses, and we propose a more general explanation based on signal-extraction logic and investors' confidence about the future policy rate path. Finally, Kroencke *et al.* (2021) documented an 'FOMC risk shift' as a separate dimension of FOMC announcement effects. They identified this risk shift by changes in risk spreads and the VIX that are orthogonal to the conventional (first-moment) policy surprise, and showed that this measure is correlated with stock returns. They hypothesised an 'uncertainty channel' of policy announcements for which we provide direct evidence.[7]

A quickly growing literature measures policy uncertainty using different text-based or model-based approaches. In a landmark contribution, Baker *et al.* (2016) proposed a methodology to measure policy uncertainty based on newspaper coverage. Husted *et al.* (2020) leveraged this methodology to create an index of monetary policy uncertainty. Using state-of-the-art time series methods, Fernández-Villaverde *et al.* (2015) and Creal and Wu (2017) estimated fiscal and monetary policy rules, respectively, and measured policy uncertainty as the stochastic volatility of the rules' innovations. Each of these methods has its own unique advantages. What distinguishes our market-based measure is that it has a very clear economic interpretation as the conditional volatility of the future short rate, and that it is available at a daily frequency, which is crucial when using event studies to investigate the role of uncertainty in financial markets.

[5] This finding dovetails existing evidence that during periods of high uncertainty, monetary policy shocks have more muted effects on the macroeconomy (Aastveit *et al.*, 2017; Tillmann, 2020).

[6] In contrast to Bundick *et al.* (2017), our event-study regressions control for conventional policy surprises, which is important due to their correlation with changes in uncertainty.

[7] In older work, Ederington and Lee (1996) and Beber and Brandt (2006) documented declines in option-implied interest rate volatility around macroeconomic announcements. We show that the resolution of uncertainty on FOMC days is much more pronounced than on macro announcement days. Other papers that also use market-based measures of short-rate uncertainty and investigate the effects of monetary policy include Neely (2005), Emmons *et al.* (2006) and Chang and Feunou (2013). Bundick and Herriford (2017) showed that short-rate uncertainty has declined since the FOMC started releasing its Survey of Economic Projections. In subsequent work, Chatterjee *et al.* (2020) found a reduction of swaption implied volatility around FOMC announcements. Lucca and Moench (2015) and Mueller *et al.* (2017) documented profitable trading strategies around FOMC meetings, related to our results on an option-based strategy that benefits from declining uncertainty around FOMC announcements. In addition, several papers have shown that the VIX tends to fall around FOMC announcements (Fernandez-Perez *et al.*, 2017; Amengual and Xiu, 2018; Gu *et al.*, 2018). Finally, Benamar *et al.* (2021) investigated the role of uncertainty for the response of yields to macroeconomic news.

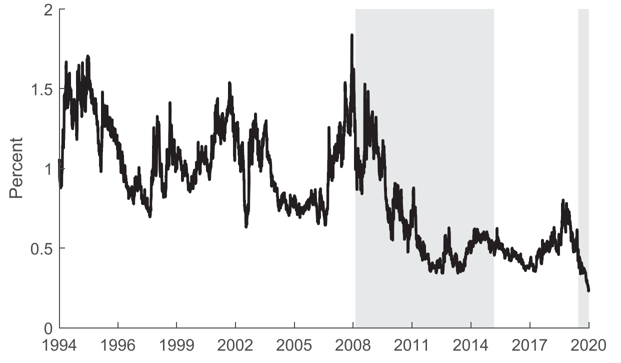

Fig. 1. *Option-Based Estimate of Short-Rate Uncertainty.*
Notes: Risk-neutral standard deviation of the three-month LIBOR rate at a one-year horizon, estimated from Eurodollar futures and options. Grey-shaded areas show ZLB periods. Sample period: 1/3/1994 to 09/30/2020.

1. Measuring Short-Rate Uncertainty with Option Prices

While long-term interest rates are driven by *expectations* of future short rates, market-based estimation of the *uncertainty* around these expectations requires option prices, which reflect information about the entire distribution of future short rates. We use daily prices of Eurodollar futures and options from CME Group for the period from January 1994 to September 2020. The advantages of these exchange-traded interest rate derivatives include their high liquidity, long maturity horizons and extensive historical data availability. Their underlying rate is the three-month US Dollar London Interbank Offered Rate, or LIBOR, a benchmark short-term interest rate. For any trading day t and option expiration date T, we use the prices of out-of-the-money options to calculate the implied conditional variance of future LIBOR, L_T, that is, a market-based estimate of $\text{Var}_t(L_T)$. The methodology is based on modern variance swap theory (like the VIX), and Online Appendix A.1 contains the details. Our market-based short-rate uncertainty is the conditional standard deviation, $SRU_{t,T} = [\text{Var}_t(L_T)]^{1/2}$, measured in percentage points. For most of what follows, we use a constant-maturity measure that is linearly interpolated to a one-year horizon.

Figure 1 plots the time series of *SRU* from 1994 to 2020. Uncertainty exhibits considerable variation, ranging from about 0.2% to 2%, and a pronounced downward trend that is only briefly interrupted by a period of elevated uncertainty during the financial crisis in 2008.[8] One possible explanation for the secular decline in uncertainty is the increasing transparency of the Fed about its monetary policy decisions, including ever more extensive use of forward guidance (Swanson, 2006). During the two zero-lower-bound (ZLB) periods the Fed's forward guidance appears to play an important role in lowering uncertainty. In the first ZLB episode *SRU* at first remained elevated due to uncertainty about possible liftoff but then dropped to very low levels with the introduction of extensive forward guidance in 2011. During the second ZLB episode during the

[8] There is a moderate positive correlation between the level of interest rates and uncertainty, consistent with existing findings of a positive relationship between the level and volatility of short rates (Chan *et al.*, 1992): comparing the one-year interpolated Eurodollar futures rate (not shown) to one-year *SRU*, the correlation is 0.6 in levels and 0.4 in daily changes.

COVID pandemic *SRU* reaches an all-time low, potentially again driven by extensive forward guidance from the Fed.

But interpreting the changes in *SRU* shown in Figure 1 is difficult. Uncertainty about future short rates can arise both from uncertainty about monetary policy, i.e., about the Fed's policy actions, as well as from uncertainty about the economic outlook. Given the two-way endogenous feedback between economic conditions and monetary policy, a structural dynamic model would be required for a meaningful decomposition into pure monetary policy uncertainty on the one hand and macro uncertainty on the other hand.[9] We take a different route to overcome this identification challenge by instead focusing on daily changes in *SRU* around the Fed's monetary policy announcements. In doing so, we follow a large existing event-study literature that takes advantage of the fact that over short event windows, these announcements are the key drivers of asset prices. Since these changes in *SRU* are caused by the FOMC announcements, we refer to them as monetary policy uncertainty (*MPU*). The traditional view of central bank communication is that monetary policy announcements contain new information about the conduct of monetary policy (i.e., the Fed's reaction function or policy shocks). In addition, as emphasised by a more recent literature on central bank 'information effects', such announcements may also directly affect beliefs and uncertainty about the economic outlook, although recent work by Bauer and Swanson (2021) suggests that there is little evidence for such information effects. Here, however, we do not need to take a stand on this issue: our goal is simply to capture all effects due to changes in uncertainty around FOMC announcements, and to investigate their role in the transmission of the Fed's policy actions to financial markets.

Before turning to the event-study analysis, we discuss a few issues related to the measurement of uncertainty. Given our focus on monetary policy, a disadvantage of Eurodollar derivatives is that their underlying rate is LIBOR. Because the spread between LIBOR and the Fed's policy rate varies over time, *SRU* also captures uncertainty about changes in this spread. Online Appendix A.2 shows that the spread exhibits pronounced variation and sudden spikes during the financial crisis from July 2007 to June 2009. Outside of this period, however, the spread is remarkably stable. Therefore, our pragmatic solution is to exclude this period from our sample, and to rely on the assumption that over our sample period *SRU* mainly reflects uncertainty about the future value of the policy rate.[10]

Our *SRU* series, which could be called 'model-free basis point volatility' for LIBOR, has several advantages over other commonly used market-based measures of interest-rate uncertainty: it is model-free (instead of relying on distributional assumptions or even just the absence of jumps), it incorporates information from a range of strike prices (instead of only at-the-money [ATM] contracts), it uses prices of exchange-traded option contracts (instead of potentially stale quotes or over-the-counter prices) and it provides a market-based measure of the conditional volatility of the future short-term interest rate (instead of uncertainty about medium- or long-term rates or about returns). Table 1 compares *SRU* to other interest-rate uncertainty measures that do not have all of these advantages.[11] Basis point volatility is the product of Black implied volatility (IV) with the futures price, and we interpolate to a constant one-year horizon as well. This measure

[9] Online Appendix B shows that several commonly used macro uncertainty measures have only a very modest correlation with *SRU*. There, we also discuss the issues and different possible approaches for decomposing short-rate uncertainty into macro and policy uncertainty in the context of a structural model, the canonical three-equation New Keynesian model.

[10] This uncertainty about the federal funds rate is, in turn, driven by both monetary policy uncertainty and macroeconomic uncertainty, as explained above.

[11] Online Appendix A.3 provides more details and a visual comparison.

Table 1. *Comparison of Market-Based Measures of Interest-Rate Uncertainty.*

Measure	$E(U_t)$	$\sigma(U_t)$	$\sigma(\Delta U_t)$	$\rho(U_t, SRU_t)$	$\rho(\Delta U_t, \Delta SRU_t)$	Period	Obs.
SRU	0.902	0.341	0.023	1.000	1.000	01/1990–09/2020	7,756
BP vol	0.858	0.352	0.027	0.995	0.861	01/1990–09/2020	7,756
Bundick	1.167	0.259	0.036	0.969	0.688	01/1994–12/2008	3,782
Swanson	1.420	0.520	0.139	0.908	0.339	10/1995–12/2012	4,337
Swaption IV	0.706	0.308	0.023	0.964	0.688	05/2005–09/2020	3,764
SRVIX	0.803	0.102	0.008	0.045	0.395	06/2012–09/2020	2,068
MOVE	0.921	0.275	0.040	0.766	0.438	01/1990–09/2020	7,751
TIV/TYVIX	6.715	1.883	0.519	0.669	0.211	01/1990–05/2020	7,598

Notes: Summary statistics for daily market-based measures of interest-rate uncertainty. *BP vol*: basis point volatility (Black IV multiplied by futures price) for ATM Eurodollar options, interpolated (as *SRU*) to the one-year horizon. *Bundick*: model-free IV measure for Eurodollar options from Bundick *et al.* (2017) at a four-quarter horizon. *Swanson*: short-rate uncertainty measure of Swanson and Williams (2014). *Swaption IV*: normal volatility for 1y-1y ATM swaptions. *SRVIX*: CBOE interest rate volatility index based on 1y-10y swaptions. *MOVE*: weighted average of BP volatility for 1m Treasury options. *TIV/TYVIX*: model-free IV for 1y options on 10y T-Note futures from Choi *et al.* (2017). For each series U_t, the table reports the mean, volatility of levels and daily changes, correlation with *SRU* in levels and changes, available sample period and the number of daily observations.

has a mean modestly below that of *SRU*, because it uses only ATM options and misses some additional uncertainty that is present in the tails of the distribution and reflected in out-of-the-money options. The volatility is similar to that of *SRU*, both for levels and changes, and the levels of the two series are very highly correlated. However, for daily changes, which are the main focus of our subsequent analysis, the correlation is only 0.86, which raises a warning flag against exclusively relying on ATM options and the Black model for investigating changes in short-rate uncertainty. Two other model-free volatility measures using Eurodollar options have been proposed in other work. Bundick *et al.* (2017) used the well-known VIX formula, resulting in an approximate IV for changes in LIBOR. Table 1 reports results for IV at the four-quarter horizon, which has similar properties to *SRU* but with a correlation of daily changes of below 0.7. Swanson (2006) calculated an uncertainty measure, later used in Swanson and Williams (2014), as the interquintile range of an option-based probability distribution. This series is a fair amount more volatile than ours, and changes in the two are not very highly correlated.[12]

Financial professionals typically measure interest-rate uncertainty using swaptions or Treasury derivatives, and we consider four popular measures in Table 1. Among them, Swaption IV, which is the normal volatility (i.e., IV assuming a normal distribution) of ATM 1y-1y swaptions, is the most closely related to our measure, though the correlation of daily changes is still below 0.7. The SRVIX, a relatively new model-free interest rate volatility index from CBOE that is based on 1y-10y swaptions, has a correlation with our measure (and with other measures) that is surprisingly low.[13] The long-standing MOVE index, a weighted average of basis point volatility for one-month Treasury options across bond maturities, as well as the 'Treasury Implied Volatility' (TIV) index of Choi *et al.* (2017) that is essentially identical to the TYVIX from Bloomberg, both have only moderate correlation with our preferred measure.[14] All of these series measure uncertainty about medium- or long-term interest rates, which reflect not only expected future short rates but also a

[12] We have also carried out a comparison for daily changes on FOMC days only, in order to compare measured changes in monetary policy uncertainty. The correlations are generally similar as those for the full daily sample reported in Table 1. The only exception is the measure of Bundick *et al.* (2017), which for FOMC days has a higher correlation, around 0.9, with our measure.

[13] Swaption IVs and the SRVIX are based on over-the-counter prices.

[14] We splice together the historical data for the TIV index with the more recent data for TYVIX (which was discontinued in May 2020), using the average of the two series from 2002 to 2015 when both are available.

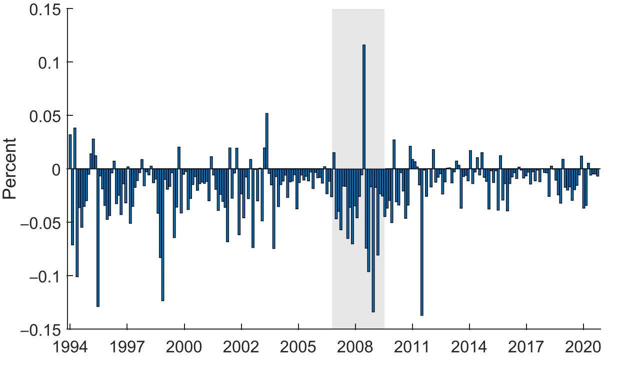

Fig. 2. *Changes in Monetary Policy Uncertainty Around FOMC Announcements.*
Notes: Changes in monetary policy uncertainty on days with FOMC announcements, or *MPU*. Sample includes all 229 FOMC announcements from January 1994 to September 2020. Shaded region shows the period from July 2007 to June 2009 containing the Global Financial Crisis.

time-varying term premium. Therefore, these alternative measures are not suitable for analysing uncertainty about short-term interest rates and monetary policy, which is the purpose of our study.

Market-based uncertainty measures reflect not only the true uncertainty but also a potentially time-varying variance risk premium (Choi *et al.*, 2017). Analogously, market interest rates reflect not only expected future overnight rates but also a term premium. In this paper, we follow the tradition in the macro-finance literature of using market-based measures in monetary policy event studies. Our model-free approach ensures that we accurately capture, on a day-to-day basis, how investors perceive and value the uncertainty about future short rates.[15]

2. Changes in Uncertainty Around FOMC Announcements

The first step of our event-study analysis is to characterise and understand changes in *SRU* around FOMC announcements. As discussed above, these daily changes are mainly driven by the monetary policy announcements, so we refer to 'monetary policy uncertainty' and denote these changes by *MPU*.

FOMC announcements and policy actions typically lead to a substantial *resolution of uncertainty* about the future path of interest rates. Figure 2 plots *MPU* for all 229 FOMC announcements between January 1994 and September 2020, and shows that uncertainty declines around most of them (188 or 82%). Table 2 shows summary statistics for the 197 announcements that followed regularly scheduled FOMC meetings and occurred outside the period from July 2007 to June 2009 containing the Global Financial Crisis.[16] The first column reports an average decline on FOMC days of 1.6 basis points (bps), which is both highly statistically significant and large in magnitude, compared to the standard deviation of 2.5 bps on FOMC days and 1.9 bps on other days. Negative skewness arises from the frequent large declines in uncertainty evident in

[15] Further separating statistical variance from variance risk premia requires a dynamic model for volatility (as in Bekaert *et al.*, 2013) that entails substantial estimation and specification uncertainty.

[16] All our results remain essentially unchanged when we include the unscheduled FOMC announcements.

Table 2. *Summary Statistics for Changes in Uncertainty.*

	Jan. 1994 to Sept. 2020		Jan. 2012 to Dec. 2018		
	FOMC	Non-FOMC	All FOMC	With SEP	W/o SEP
Observations	197	6,032	56	29	27
Mean	−0.016	0.000	−0.008	−0.013	−0.002
t-statistic	−8.94	1.37	−4.60	−5.12	−1.35
SD	0.025	0.019	0.013	0.014	0.009
Skewness	−1.64	1.31	−0.56	−0.33	0.68
Cumulative change	−3.16	2.08	−0.44	−0.38	−0.06

Notes: Summary statistics for changes in *SRU*, the market-based standard deviation for the short-term interest rate one year into the future, measured in percentage points. The t-statistics are based on White heteroscedasticity-robust SEs. The first two columns report results for our baseline sample period from January 1994 to September 2020, excluding the period from July 2007 to June 2009 containing the Global Financial Crisis. The last three columns focus on the period from January 2012 to December 2018, when every alternate FOMC meeting was followed by a press conference and release of the Summary of Economic Projections (SEP).

Figure 2. The resolution of uncertainty around FOMC meetings contrasts with the average change on non-FOMC days, reported in the second column, which is essentially zero.[17]

The Federal Reserve has made substantial changes to the way the outlook for the economy and interest rates is communicated to the public. Most significant are the press conferences held by the Chair and the release of the economic forecasts of the FOMC participants, the 'Summary of Economic Projections' (SEP).[18] Through these communication channels the Committee provides more information about economic fundamentals and the rationale underlying the policy actions. From January 2012 to December 2018, the FOMC released the SEP and held a press conference after every other FOMC meeting. The last three columns of Table 2 show summary statistics for this period, comparing those meetings with and without a SEP release. Policy uncertainty declined mainly around SEP meetings, while the average change around other meetings is small and not significantly different from zero. Thus, it appears that the release of this extra information about the policy and economic outlook through the SEP and press conference contributes in a meaningful way to the resolution of policy uncertainty.[19]

A simple model of the short-term interest rate helps with the interpretation of our empirical results. Since FOMC announcements generally follow a known schedule and often lead to substantial changes in asset prices (Gürkaynak *et al.*, 2005a; Bauer, 2015), the model includes jumps in the short rate that occur at deterministic times, as in Piazzesi (2001). The details of the model are given in Online Appendix C, which also reports additional empirical results on the importance of jumps and jump risk premia. The short rate L_t follows a jump-diffusion process

[17] Our results are based on daily uncertainty estimates and leave open the question of when exactly uncertainty gets resolved around the release of a FOMC announcement. Pre-announcement effects in stock prices (Lucca and Moench, 2015) and the VIX (Hu *et al.*, 2019) suggest that some uncertainty might decline *before* the actual FOMC announcement. While we cannot conclusively answer this question with daily data, our evidence below that link *MPU* to changes in the FOMC statement language, as well as further evidence in online Appendix D.1 on pre-announcement effects, on the whole is most consistent with the view that changes in uncertainty occur *in response to* the actual announcement.

[18] In October 2007, the FOMC began releasing the SEP together with the minutes three weeks after the FOMC meeting and since April 2011 the SEP is released on the same day as the FOMC statement. In April 2011 Chairman Ben Bernanke also started the tradition of holding regular press conferences at every other FOMC meeting; since January 2019, every meeting is followed by a press conference. From January 2012 onwards, the FOMC also started releasing committee members' projections for the appropriate future path of the policy rate as part of the SEP, the so-called 'dot plot'.

[19] Consistent with this interpretation, Boguth *et al.* (2019) found that more attention is being paid to these particular FOMC meetings. Bundick and Herriford (2017) also investigated the impact of SEP releases on monetary policy uncertainty, but focused on the level instead of changes: they showed that short-rate uncertainty has been lower since the FOMC started releasing the SEP.

with diffusion variance σ^2. Jump j occurs at time $t = \tau_j$ and has stochastic jump size Z_j, which is Gaussian with zero mean and jump variance σ_j^2. On the day of the FOMC announcement corresponding to this jump, the change in the conditional variance for the future short rate is

$$\mathrm{Var}_t(L_T) - \mathrm{Var}_{t-\delta}(L_T) = -\delta\sigma^2 - \sigma_j^2 + \sum_{i:t<\tau_i\leq T} (E_t - E_{t-\delta})Z_i^2, \tag{1}$$

where δ is the length of a trading day in years. Aside from the passing of time that results in lower diffusion variance for a fixed expiration ($-\delta\sigma^2$), uncertainty changes for two reasons. First, it systematically declines around FOMC meetings because after the meeting there is one less market-moving event causing uncertainty. This 'dropping-out' effect is reflected by the term $-\sigma_j^2$ in (1), and it explains the resolution of uncertainty around FOMC meetings. It also explains why SEP meetings had larger declines in uncertainty: presumably the interest-rate jumps on these meetings had larger variance, since between January 2012 to December 2018 the FOMC only changed the policy rate at such meetings. A second reason for variation in uncertainty are changes in beliefs about future jump variances, captured by the last term in (1). If FOMC announcements provide information about the likely size of future short-rate jumps, this explains why *MPU* exhibits substantial variation and is sometimes even positive. Consistent with this interpretation, we show below that the biggest changes in uncertainty occurred when the FOMC changed its forward guidance about future policy rates. In sum, the passing of the current FOMC jump explains the negative mean of *MPU*, while changes in the beliefs about the likely size of future FOMC jumps explains the substantial variation in *MPU*.[20]

Many other types of news could affect short-rate uncertainty. Macroeconomic data releases are known to create substantial volatility in stock and bond markets (Andersen *et al.*, 2007). However, *SRU* declines only modestly on days with key macro announcements, such as the monthly employment report, and no macro release leads to a similarly large resolution of uncertainty as FOMC announcements, as documented in Online Appendix D.3. Other important news for financial markets include speeches by FOMC participants, which one might expect to potentially increase short-rate uncertainty due to the wide range of views expressed about the outlook for monetary policy, but Online Appendix D.4 shows that they have no systematic effect on *SRU*. Indeed, FOMC announcements appear unique in terms of their impact on short-rate uncertainty.

While short-rate uncertainty declines markedly on days with FOMC announcements, it tends to increase on non-FOMC days, as evident from the cumulative change reported in Table 2. Since the creation of uncertainty does not appear to be linked to macro announcements or other policy events, the question arises, when is uncertainty actually created? Figure 3 shows that after the initial drop around FOMC announcements, short-rate uncertainty tends to steadily increase over the first two weeks of the intermeeting period. This 'FOMC uncertainty cycle' reveals that the average decline in short-rate uncertainty is transitory and soon reversed.[21] Part of the explanation

[20] As shown in online Appendix C, the average decline in the conditional variance around FOMC meetings implies a typical jump volatility around 8–19 bps, which is substantially larger than the historical volatility of interest rate changes on FOMC days, about 1.5 bps. This suggests that jump risk premia may play an important role in explaining the resolution of uncertainty around FOMC announcements. Online Appendix C presents additional evidence that investors may indeed require compensation for the risk of FOMC jumps: a simple option trading strategy designed to benefit from falling uncertainty—short straddle positions around FOMC announcements—yields significantly positive returns. Despite some caveats to these specific results, such as the presence of transaction costs, the evidence on the whole appears consistent with the presence of significant FOMC jump risk premia.

[21] This pattern of short-rate uncertainty over the FOMC intermeeting period is much more pronounced than the pattern for the VIX. Online Appendix D.5 shows that the decline in *SRU* on FOMC days is about twice as large as the decline in the VIX, and there is no clear ramp-up pattern in the VIX aside from a modest increase towards the day before the FOMC

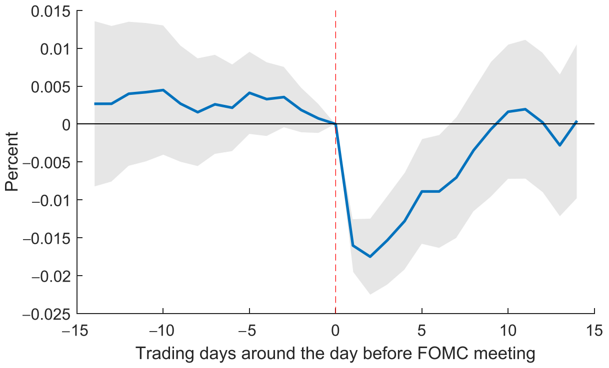

Fig. 3. *The FOMC Uncertainty Cycle.*
Notes: Changes in uncertainty over the FOMC meeting cycle: average change in one-year *SRU* on trading days around scheduled FOMC announcements, relative to the day before the announcement (marked with a dashed red line), that is, sample mean of $SRU_{t+j-1} - SRU_{t-1}$ across all FOMC days t, for each value of j ranging from -14 to $+14$ (since the average FOMC intermeeting period is about thirty trading days). Shaded areas show 95% confidence intervals based on White SEs. Sample: 197 scheduled FOMC announcements from January 1994 to September 2020, excluding the period from July 2007 to June 2009 containing the Global Financial Crisis.

for the increase over the FOMC intermeeting period is mechanical: right after a FOMC meeting, our interpolated one-year uncertainty measure contains fewer scheduled announcements within its horizon. According to our model, the measured uncertainty should then gradually move up as the average number of FOMC announcements within the next year increases. Interestingly, Figure 3 suggests that uncertainty ramps up only over the first two weeks after the announcement. Additional evidence in Online Appendix D.5 confirms that these two weeks are special and exhibit a significantly larger change in uncertainty than the rest of the intermeeting period. This quick ramp up in priced uncertainty, which is not explained by our simple jump model, is an intriguing characteristic of the FOMC uncertainty cycle.

How do actions taken by the FOMC affect monetary policy uncertainty? The substantial variation in *MPU* evident in Figure 2 naturally raises this question. To answer it, we first investigate the relationship between *MPU* and conventional (first-moment) moment policy surprises arising from FOMC announcements. Then we zoom in on the largest changes in *MPU* and uncover the drivers of these changes in the language of the actual FOMC statements.

Monetary policy surprises are typically measured as the changes in the expected policy rate path, using money market futures rates. We follow Nakamura and Steinsson (2018) and construct our monetary policy surprise, *MPS*, as the first principal component of rate changes based on federal funds and Eurodollar futures contracts expiring up to a year following the FOMC meeting.[22]

meeting. While further research is needed to pinpoint the exact reasons for these differences, a crucial distinction is that *SRU* directly measures the uncertainty most directly affected by FOMC decisions, whereas stock market uncertainty is affected by many other factors. In addition, the shorter horizon and somewhat different methodology of the VIX (which uses option contracts of almost exactly 30 days maturity) may contribute to the differences.

[22] We use daily rate changes to be consistent with the daily changes in uncertainty. *MPS* is scaled so that the effect on the four-quarters-ahead futures rate is equal to one.

A regression of *MPU* on *MPS* reveals a moderate positive correlation between changes in perceived first and second moments of future short rates, with an R^2 of 0.27 and a positive slope coefficient that is highly statistically significant. This means that a more hawkish policy surprise—an increase in the expected rate path—is associated with a smaller than average decline or even an increase in uncertainty, and a dovish policy surprise is associated with a larger than average decline.[23] There are two important implications. First, because of this correlation, estimates of the financial market impact of FOMC announcements should include not only the conventional monetary policy surprise measure but also changes in policy uncertainty. Otherwise, such regressions may suffer from an omitted variable bias and incorrectly attribute some of the effects of *MPU* on asset prices to *MPS*. Second, a substantial portion of the variation in *MPU* is orthogonal to the first-moment surprise, which raises the possibility of a separate uncertainty channel for the monetary transmission. In Section 3 we present results that separately account for both effects.

A narrative analysis of FOMC statements shows that the most pronounced impact of policy actions on uncertainty typically results from changes in the Fed's forward guidance. Table 3 lists the most influential FOMC announcements: those ten with the biggest declines and those five with the biggest increases in uncertainty (also clearly visible in Figure 2). For each announcement, the table notes a key phrase or aspect of the FOMC statement and its role in the current monetary policy cycle. The first phase of explicit forward guidance began in 2003 when the FOMC under Alan Greenspan introduced the '*considerable period*' language at its May meeting to more clearly signal low future policy rates, which substantially reduced uncertainty. However, in January 2004 this language was replaced by a phrase '*can be patient*' that led to the second-largest increase in uncertainty in our sample. The second phase of explicit forward guidance began during the financial crisis and was marked by clearer messaging about the likely path for the future funds rate. It started with the '*for some time*' language introduced in December 2008, when the FOMC lowered the policy rate to essentially zero, coinciding with the second largest decline in uncertainty. The guidance was strengthened in March 2009 to '*for an extended period*' that also reduced uncertainty substantially. A third phase was the introduction of calendar-based guidance in August 2011 with the phrase '*at least through mid-2013*'. This forward guidance dramatically reduced the uncertainty about liftoff and the future rate path, with the largest decrease in our sample.

Table 3 also shows that the effects on uncertainty are often quite distinct from those on the expected policy path. The positive correlation between *MPS* and *MPU* is evident in these announcements, but the correlation is far from perfect: the largest declines in uncertainty did not always coincide with large dovish surprises about the policy path, and vice versa. For example, among the four announcements with the largest declines in uncertainty, two of them (in July 1995 and December 2008) also led to substantial dovish surprises, whereas the other two (in August 2011 and November 1998) caused only modest first-moment policy surprises. The change in forward guidance on August 9, 2011, is particularly noteworthy in this regard. Overall, our narrative evidence suggests that Fed communication has important effects on perceived monetary policy uncertainty, and that these changes in uncertainty are often a separate dimension of the

[23] Details, including a scatter plot, are given in online Appendix D.2. There we also show results for alternative measures of the policy surprise, such as the target and path factors of Gürkaynak *et al.* (2005a). The positive correlation between *MPU* and the policy surprises does not explain the negative mean of *MPU*, i.e., the resolution of uncertainty around FOMC meetings.

Table 3. *FOMC Announcements and the Largest Changes in Monetary Policy Uncertainty.*

Top-ten declines in monetary policy uncertainty			
Meeting date	*MPU*	*MPS*	Description
Aug 09, 2011	−0.137	−0.032	Introduction of calendar-based forward guidance: ‘exceptionally low levels for the federal funds rate *at least through mid-2013*.’
Dec 16, 2008	−0.134	−0.252	ZLB is reached and introduction of clear forward guidance phrase: ‘exceptionally low levels of the federal funds rate *for some time*.’
July 06, 1995	−0.129	−0.213	First explicit mention of numerical target for federal funds rate. Also, interest rate cut: ‘... inflationary pressures have receded enough to accommodate a modest adjustment in monetary conditions.’
Nov 17, 1998	−0.123	−0.032	Third cut in a row and signal that there may not be further cuts: ‘financial conditions can reasonably be expected to be consistent with fostering sustained economic expansion’
May 17, 1994	−0.101	−0.140	Fed funds target rate increased by 50 bps to ‘... substantially remove the degree of monetary accommodation which prevailed throughout 1993.’
Nov 25, 2008	−0.096	−0.156	TALF announcement: ’... increase credit availability and support economic activity by facilitating renewed issuance of consumer and small business ABS at more normal interest rate spreads.’
Oct 15, 1998	−0.083	0.085	FOMC stated that ‘further easing of the stance of monetary policy was judged to be warranted to sustain economic growth’
Mar 18, 2009	−0.081	−0.189	Change in language about low rates to ‘for an extended period’ from previous statement which said ‘for some time’
June 30, 2004	−0.074	−0.091	First increase in four years and guidance about future rate increases.
Oct 29, 2008	−0.074	−0.108	Fed funds target rate cut by 50 bps. Confirmation that the FOMC ‘... will act as needed to promote sustainable economic growth and price stability.’
Top-five increases in monetary policy uncertainty			
Meeting date	*MPU*	*MPS*	Description
Oct 08, 2008	0.116	−0.020	Announcement after unscheduled meeting of concerted actions by central banks around the world
Jan 28, 2004	0.052	0.115	Change in language to ‘... can be patient in removing its policy accommodation’ and removal of ‘considerable period’ language
Apr 18, 1994	0.038	0.207	Unscheduled conference call: ‘increase slightly the degree of pressure on reserve positions. This action is expected to be associated with a small increase in short-term money market interest rates.’
Feb 04, 1994	0.032	0.139	First rate hike in years in line with the FOMC decision ‘... to move toward a less accommodative stance in monetary policy ...’
Mar 28, 1995	0.028	0.121	The FOMC indicated ‘asymmetric directive also would provide a clear signal of the Committee’s intention to resist higher inflation.’

Notes: Ten largest declines and five largest increases in monetary policy uncertainty, *MPU*, along with the monetary policy surprise, *MPS*, and a brief narrative based on the FOMC statement.

Fed’s policy actions. Through the lens of our jump model, the Fed’s forward guidance changed investors’ perceptions about future rate jumps and thus affected market-based uncertainty about future short rates. The next section will show the effects of such changes on asset prices.

3. Monetary Policy Transmission to Asset Prices

Having established how short-rate uncertainty changes on FOMC announcement days and over the FOMC meeting cycle, we now investigate its role in the transmission of monetary policy to asset prices. We estimate the financial market effects of FOMC announcements using three different event-study regressions. A baseline regression estimates the response of asset prices to *MPS*, the conventional, market-based measure of the monetary policy surprise described in Section 2. A second regression adds the change in monetary policy uncertainty around the announcement, $MPU = \Delta SRU$, to estimate its effects on asset prices while controlling for its correlation with *MPS*. Finally, we further add an interaction effect between *MPS* and the level of short-rate uncertainty on the day before the FOMC announcement, SRU_{-1}, to investigate whether the prevailing level of uncertainty affects the financial market response to policy surprises.[24]

The top panel of Table 4 reports estimates for changes in nominal and real Treasury yields. We use nominal yields from Gürkaynak *et al.* (2007) and Treasury Inflation-Protected Securities (TIPS) yields from Gürkaynak *et al.* (2010) that start in February 1999. For nominal yields, the first specification confirms the well-established result that policy surprises have sizeable and significant effects (Gürkaynak *et al.*, 2005a). The second regression shows a statistically significant and positive response of yields to *MPU*, in addition to the well-known effects of the policy surprise. A one standard deviation increase in uncertainty raises the five- and ten-year nominal yields by around 2 bps. Real (TIPS) yields also exhibit strong responses to policy surprises, in line with the findings by Hanson and Stein (2015) and Nakamura and Steinsson (2018). Uncertainty has statistically significant effects on real yields that are similar in magnitude to its effects on nominal yields.[25]

Changes in monetary policy uncertainty also matter for other asset prices, as shown in the bottom panel of Table 4. Stock prices tend to fall not only in response to hawkish policy surprises, but also when short-rate uncertainty increases.[26] A one standard deviation increase in uncertainty reduces stock prices by 0.3%. Similarly, the VIX and thus stock market volatility tends to increase not only with a hawkish policy surprise but also with rising policy uncertainty. A one standard deviation increase in uncertainty increases the VIX by 0.7 percentage points. Changes in monetary policy uncertainty appear to be an important driver of the stock market around FOMC announcements. Finally, we consider the transmission of uncertainty to the foreign exchange market, using a US Dollar index based on a foreign exchange portfolio that goes short the G9 currencies and long the US Dollar.[27] A contractionary policy surprise leads to an appreciation of the Dollar, consistent with the notion that tighter Fed policy make Dollar fixed

[24] Our sample of FOMC announcements was described in Section 2. To economise on space in our tables, we do not report the estimated regression intercept, or the coefficient on the lagged level of uncertainty that is included in the third regression specification to accurately estimate the interaction effect.

[25] These estimates suggest that effects of changes in policy uncertainty around the notable FOMC announcements highlighted in Table 3 are sizeable. For example, on August 11, 2011 uncertainty dropped by 13.7 bps, and our estimates indicate that roughly half the actual decline of 20 bps in the nominal and 18 bps in the real ten-year Treasury yield on that day is attributable to *MPU*.

[26] In our baseline regression the stock market response to *MPS* is a little smaller relative to Bernanke and Kuttner (2005) and Gürkaynak *et al.* (2005a), mainly because of our use of a daily window to construct *MPS*. Using an intra-day policy surprise yields larger estimates of the effects on stock prices, as noted in Lakdawala and Schaffer (2019).

[27] The return to the Dollar index is constructed by forming an equal weighted portfolio of the Australian Dollar, the Canadian Dollar, the British pound, the Euro, the Japanese yen, the New Zealand Dollar, the Norwegian krone, the Swedish krona and the Swiss franc, as in Lustig *et al.* (2011). Owing to data availability, the sample for the exchange rate regression ends in June 2020.

Table 4. *Transmission of Monetary Policy Uncertainty to Financial Markets.*

	Five-year nominal yield			Ten-year nominal yield			Ten-year TIPS yield		
MPS	0.65	0.53	1.26	0.46	0.32	0.74	0.44	0.33	1.25
	[8.64]	[6.33]	[6.51]	[7.42]	[4.78]	[4.42]	[6.06]	[4.35]	[3.57]
MPU		0.60	0.81		0.68	0.86		0.72	0.88
		[2.76]	[3.49]		[2.82]	[3.33]		[3.13]	[3.62]
$MPS \times SRU_{-1}$			−0.66			−0.38			−0.97
			[−3.54]			[−2.33]			[−2.68]
R^2	0.46	0.51	0.57	0.27	0.34	0.38	0.20	0.26	0.36
	S&P 500			VIX			Dollar index		
MPS	−3.31	−1.60	−11.22	4.07	−0.28	16.95	2.51	1.79	12.30
	[−3.32]	[−1.26]	[−3.13]	[2.83]	[−0.12]	[2.99]	[3.83]	[2.56]	[4.39]
MPU		−8.66	−10.88		22.06	26.60		3.66	6.01
		[−1.75]	[−2.16]		[1.73]	[1.95]		[1.94]	[4.01]
$MPU \times SRU_{-1}$			8.73			−15.63			−9.53
			[2.82]			[−2.75]			[−4.42]
R^2	0.05	0.09	0.13	0.04	0.14	0.21	0.11	0.14	0.32

Notes: Event-study regressions for FOMC announcemente of changes in asset prices on a monetary policy surprise (*MPS*), the change in policy uncertainty (*MPU*) and an interaction of *MPS* with the ex ante level of short-rate uncertainty (SRU_{-1}). The third specification also includes SRU_{-1} but the coefficient is omitted, as are all regression intercepts, to economise on space. Dependent variables are daily changes in yields, daily returns in the S&P500 index, changes in the VIX, and returns on a foreign currency portfolio short G9 currencies and long the Dollar. White heteroscedasticity-robust t-statistics are in brackets. Sample: 197 scheduled FOMC announcements from January 1994 to September 2020, excluding the period from July 2007 to June 2009 containing the Global Financial Crisis, except that the sample for TIPS yields starts in September 1999, and the sample for the Dollar index ends in June 2020.

income investments more attractive and increase demand for the US Dollar. Again, the table shows a statistically significant and economically meaningful additional impact of *MPU*. A one standard deviation rise in uncertainty leads to an appreciation of the US Dollar index by 0.16%.

Regressions that include both *MPS* and *MPU* show clear evidence for an uncertainty channel of the transmission of FOMC actions to financial markets. Interestingly, they estimate a smaller effect of *MPS* than a univariate regression does. This suggests that part of the large previously estimated effects of policy surprises on yields and asset prices may be partly due to the impact of policy uncertainty, which is omitted in the commonly used univariate regressions. Since conventional policy surprises are positively correlated with changes in uncertainty, omitting *MPU* from event-study regressions attributes its asset price effects to *MPS* and may lead to an upward bias in the estimated impact of the policy surprise. Once we control for changes in uncertainty, these estimated responses decline.

Estimates for our third specification reveal that, for all yields and asset prices, the magnitude of the response to policy surprises depends on the level of short-rate uncertainty on the day before the FOMC announcement (SRU_{-1}): the response to *MPS* is generally more muted when uncertainty is high. For yields, the interaction coefficients are negative, meaning that the positive impact of *MPS* on yields is stronger when uncertainty is low. To gauge the magnitude of the effect, we use the 25th and 75th percentiles of *SRU* to classify 'low' and 'high' uncertainty periods. In response to a 100 basis point contractionary monetary policy surprise, the five-year (ten-year) nominal yield increases by 91 (54) bps when uncertainty is low but only by 54 (33) bps when uncertainty is high. The dependence of the real yield response on uncertainty is even more pronounced. The ten-year real yield increases by 74 bps when uncertainty is low but only by 19 bps when uncertainty is high. A similar calculation for the S&P 500 shows that in response to a 100 bps hawkish surprise, stock prices fall 6.6% when uncertainty is low but only by 1.7% when uncertainty is high.

These findings are robust across a variety of different empirical specifications. Neither the inclusion of unscheduled announcements and those during the financial crisis period, nor different choices of the monetary policy surprise—using, for example, higher-frequency (30-minute window) or lower-frequency (two-day window) changes—has any material impact on our results (results omitted). Online Appendix E reports two additional sets of robustness checks: estimates for nominal and real forward rates, using the empirical approach of Hanson and Stein (2015), show similar results to those reported above both for the effect of changes in uncertainty and the interaction effects. And regressions that replace *MPS* with the target and path facts of Gürkaynak *et al.* (2005a), who showed that two separate factors are useful for accurately characterising monetary policy surprises, also lead to similar results. This last result implies that even when controlling for the policy surprise, i.e., for shifts in first moments, in this more flexible two-dimensional way, there is a clear separate role for second moments in the transmission of policy actions to financial markets.

Our analysis has shown that the uncertainty channel has been an important part of monetary policy actions taken by the Federal Reserve over about the last quarter century. Most of these were conventional policy actions. Online Appendix F presents additional results for an event study of specific announcements of unconventional monetary policies, such as balance sheet policies and forward guidance. Such announcements had substantial effects on perceived monetary policy uncertainty, which increased the effectiveness of forward guidance and of the signalling channel of asset purchases (Bauer and Rudebusch, 2014). Overall, the uncertainty channel also appears to significantly contribute to the financial market effects of unconventional monetary policy.

We have documented two channels through which uncertainty matters for monetary transmission to financial markets, related to (*i*) changes in uncertainty due to FOMC announcement and (*ii*) the prevailing level of uncertainty before the FOMC announcement. While a full theoretical account of the empirical findings is beyond the scope of our paper, we suggest a plausible explanation for each one.

A simple risk-based explanation can provide a rationale for the negative effects of higher uncertainty on bond prices, stock prices and the value of foreign currencies vis-à-vis the Dollar. Standard asset pricing theory implies that expected excess returns depend on the negative covariance of returns with the stochastic discount factor (SDF). As pointed out by Hanson and Stein (2015), the factors driving this covariance are the uncertainty about future returns, the uncertainty about the SDF and the correlation. Our results are consistent with effects of higher uncertainty on risk premia: if higher short-rate uncertainty coincides with higher uncertainty about the returns of the above-mentioned asset classes, then this raises expected excess returns/risk premia and lowers asset prices.[28] Additional evidence in support of this risk-based explanation comes from estimated risk premia: Online Appendix E shows that estimates of the term premium exhibit a strong positive response to *MPU*.[29] Given the estimation uncertainty in such empirical risk premia, this evidence is only suggestive, but it supports the view that the effects of monetary policy uncertainty on asset prices are partly due to changes in risk premia.

This risk-based explanation has implications for how we should interpret the large effects of monetary policy surprises on asset prices that previous studies have estimated (Bernanke and Kuttner, 2005; Gürkaynak *et al.*, 2005a,b; Hanson and Stein, 2015; Nakamura and Steinsson, 2018). A portion of these large estimated effects appears to be due to a positive correlation with changes in uncertainty and risk premia. Hanson and Stein (2015) questioned whether policy surprises really increase term premia by changing uncertainty, stating that 'little evidence exists for it in the data' (p. 442). But we have provided exactly this evidence, by documenting the positive correlation between *MPS* and *MPU*, as well as the effects on risk premia. The effects of monetary policy uncertainty can provide an explanation for the puzzle why policy surprises cause such large swings in asset prices.

The second channel we document is that high uncertainty mutes the effects of a monetary policy surprise on asset prices, while low uncertainty leads to a significantly stronger impact. This result can be rationalised using the logic of signal extraction (for a formal argument, see Online Appendix G). Market participants form their forecasts of future asset prices and fundamentals based on a variety of signals, including signals from the Fed about the expected path of future policy rates. Under general conditions, the weight put on the signal from the Fed increases in the precision of that signal. Thus, when uncertainty is low (precision of the signal is

[28] Specifically, for gross return R_{t+1}, risk-free rate R_t^f and SDF M_{t+1}, absence of arbitrage implies that

$$E_t R_{t+1} - R_t^f = -\mathrm{Cov}_t(M_{t+1}, R_{t+1})/E_t M_{t+1}.$$

The risk premium increases and the current asset price declines if the covariance between M_{t+1} and R_{t+1} becomes more negative, which could arise due to (a) higher $\sigma_t(R_{t+1})$, (b) higher $\sigma_t(M_{t+1})$, (c) a more negative correlation, or a combination of these factors. If higher *SRU* coincides with higher conditional return volatility $\sigma_t(R_{t+1})$ then asset prices will fall. Another risk-based channel could work through higher $\sigma_t(M_{t+1})$, which would simultaneously raise both the variance risk premia inherent in our *SRU* measure as well as the risk premia in all other financial assets.

[29] These findings are consistent with those of Bundick *et al.* (2017), although we use a different empirical framework. In particular, we control for changes in the expected policy path, measured by *MPS*, which is important because of the correlation with *MPU*.

high), market participants will revise their forecasts more in response to the information in the public signal (i.e., policy surprise). Vice versa, in the presence of high uncertainty, signals from the Fed are less precise and thus elicit a more muted reaction of asset prices.[30]

4. Conclusion

While the macro-finance literature has mainly studied the effects of changes in the first moment of the distribution of the future policy rate, this paper provides new evidence that the second moment of this distribution also plays an important role for the transmission of monetary policy to financial markets. FOMC announcements have substantial effects on uncertainty: on average, we observe a systematic resolution of uncertainty that is most drastic for announcements of forward guidance. In addition, monetary policy uncertainty matters for the transmission of policy actions to financial markets in two ways. First, changes in uncertainty about the policy rate have strong additional effects on a variety of asset prices, even after controlling for changes in the expected policy rate path. Second, the level of uncertainty leading up to a FOMC announcement is critical in determining how policy surprises are transmitted to financial markets. Specifically, policy surprises have larger effects on asset prices when monetary policy uncertainty is lower. Taken together, this evidence indicates the presence of an uncertainty channel for the transmission of monetary policy to financial markets.

Our paper points to several fruitful directions for future research. What are the respective roles of macroeconomic and policy uncertainty for the overall level of uncertainty about future interest rates? A meaningful decomposition using structural models with time-varying uncertainty would likely yield important new insights. What type of central bank communications and policy actions are most effective in lowering policy uncertainty? The use of novel tools of textual analysis and natural language processing appears particularly promising to address this question. And what are the macroeconomic effects of changes in monetary policy uncertainty? Some recent studies have taken important first steps in this direction, including Bundick *et al.* (2017) and Husted *et al.* (2020). However, much work remains to be done to make full use of high-frequency, market-based uncertainty measures to identify the causal effects of changes in monetary policy uncertainty on macroeconomic variables.

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Additional Supporting Information may be found in the online version of this article:

Online Appendix
Replication Package

[30] De Pooter *et al.* (2021) also showed that monetary policy surprises have stronger effects on Treasury yields when uncertainty is low. They proposed a very different explanation that relies on institutional features of the Treasury market: primary dealers appear to behave differently during times when uncertainty is low, and this behaviour might amplify the impact of policy surprises on Treasury yields. Our signal-extraction argument, by contrast, can explain the broader findings beyond Treasury markets that we document in Table 4.

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