Monetary Policy Uncertainty*

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Abstract

We construct new measures of uncertainty about Federal Reserve policy actions and their consequences, monetary policy uncertainty (MPU) indexes. We evaluate the information content of our index, and show that positive shocks to MPU raise credit spreads and reduce output. These effects are as large as those of conventionally identified monetary policy shocks. In addition, we construct an index that captures uncertainty about monetary policy over the short term, and also find significant aggregate implications. Finally, we investigate the transmission channels of MPU, exploiting a large panel data set. Heightened MPU leads to protracted declines in investment through both real options and financial frictions channels.

Keywords: Monetary transmission, Investment channel, Firm-level evidence

JEL Classifications: E40, E50.
"The Federal Reserve’s experiences over the past two decades make it clear that uncertainty is not just a pervasive feature of the monetary policy landscape, it is the defining characteristic of that landscape."

— Alan Greenspan

1 Introduction

As the Federal Reserve poised itself in 2015 to lift off from the zero interest rate policy in place since 2008, the intentions of monetary policymakers and effects of their actions again faced increased scrutiny. Reflecting this monetary policy mise-en-scene, the Financial Times proclaimed on the day after the October 2015 Federal Open Market Committee (FOMC) meeting, “Fed Speaks Plainer English on Rates: A clearer marker has been laid down for a December increase, though divisions remain.” In December 2015, the Federal Reserve lifted the policy rate off its effective lower bound in a 25 basis point hike that has been repeated several times. Although the general consensus is that the December 2015 Fed liftoff removed the prevailing uncertainty about when rates would finally be raised, it remains less clear more generally how to quantify uncertainty about monetary policy and its transmission (Brainard (2017)). Measuring monetary policy uncertainty and estimating its transmission effects are the focus of this paper.

Recently, there has been a surge of interest in economic policy uncertainty. Baker, Bloom, and Davis (2016) develop an index of overall economic policy uncertainty (EPU), including fiscal, monetary, trade, healthcare, national security, and regulatory policies, based on the occurrence of certain keywords in newspaper coverage. The existing literature on monetary policy uncertainty per se predominantly utilizes market-based proxies such as implied volatility computed from interest rate option prices and realized volatility computed from intraday prices of interest rate futures (Neely (2005), Carlson, Craig and Melick (2005), Emmons, Lakdawala and Neely (2006) Swanson (2006), Bauer (2012), and Chang and Feunou (2013)). As made evident below, our measure is complementary to these derivative-based measures but differs in three important dimensions, because the market-based measures: (1) reflect the perception of only the households participating in the options market, (2) may have a component driven by time-varying risk aversion and/or state-dependent marginal utility rather than uncertainty and (3) are essentially all about (policy) interest rate un-
certainty. Our analysis suggests that there exists a significant degree of uncertainty about monetary policy beyond interest rate fluctuations.

Our paper is also related to a rapidly growing literature using textual analysis to measure economic variables. The news-based search has been recently adopted to construct new measures for a broad economic policy index (Baker, Bloom, and Davis (2016)), partisan conflict (Azzimonti (2017)), geopolitical risk (Caldara and Iacoviello (2017)), and corporate news (e.g., Demers and Vega (2010) and Hoberg and Phillips (2010)). A number of papers use variables generated from publicly released FOMC documents to study FOMC communication, including Boukus and Rosenberg (2006), Ehrmann and Fratzscher (2007), Meade and Stasavage (2008), Schonhardt-Bailey (2013), Acosta and Meade (2015), and Acosta (2015). Our paper suggests that text searches can deliver useful proxies of uncertainty tracing back decades.\(^1\)

Specifically, we do three things in this paper. First, we construct a news-based index of monetary policy uncertainty to capture the degree of uncertainty that the public perceives about central bank policy actions and their consequences. We use an approach similar to Baker, Bloom, and Davis (2016), and highlight some important advantages of ours. We also detail our large-scale “human audit” that assesses accuracy. We focus on the Fed starting in 1985.\(^2\) As shown below, large spikes occurred around the March 2003 invasion of Iraq, prior to the September 2015 FOMC meeting when “liftoff uncertainty” peaked, Brexit, and the November 2016 elections. Our MPU index closely tracks a computer-free index created using human intelligence, and exhibits close comovements with a direct measure of monetary policy uncertainty constructed from a survey of primary dealers. In addition, we construct an index that captures uncertainty about monetary policy in the short run, using both computer-automated and human-audited approaches. The short-run MPU index spikes much more sharply prior to FOMC meeting days than baseline MPU does.

Second, we estimate the effect of shocks to monetary policy uncertainty using impulse response analysis. We find that positive shocks to MPU consistently raise credit spreads and lower output. Shocks to short-run MPU can also generate reasonably strong transmission

\(^1\)See references of related papers on uncertainty concerning government policy at http://www.policyuncertainty.com/research.htm, as well as Fischer (2017).

\(^2\)In Husted, Rogers, and Sun (2016b), we construct these indexes for the ECB and central banks of Canada, England, and Japan.
effects.

Finally, we examine how fluctuations in MPU are transmitted to the real economy by exploiting the U.S. firm-level data. Using a large panel data set, we first show a strong, negative relationship between MPU and firm investment. Our results also suggest that an increase in MPU can induce protracted declines in investment that persist over at least four quarters into the future. We then document the empirical relevance of two different channels that have been emphasized in the literature, the “real options” theory that builds on irreversible investment (e.g., Bernanke, 1983; Bertola and Caballero, 1994; Abel and Eberly, 1994, 1996; Caballero and Pindyck, 1996; Bloom, 2009) and the financial frictions approach stipulating that increased financing cost delays investment (e.g., Gilchrist, Sim, and Zakrjjesk, 2011; Christiano, Motto, and Rostagno, 2014; Arellano, Bai, and Kehoe, 2018). We find evidence that investment irreversibility and financial constraints magnify the negative effect of MPU, indicating that both channels are at work in MPU transmission.

2 Measuring Monetary Policy Uncertainty

2.1 Construction

Our approach to constructing the baseline MPU index is to track the frequency of newspaper articles related to monetary policy uncertainty. Using the ProQuest Newsstand and historical archives, we construct the index by searching for keywords related to monetary policy uncertainty in major newspapers. We search for articles containing the triple of (i) “uncertainty” or “uncertain,” (ii) “monetary policy(ies)” or “interest rate(s)” or “Federal fund(s) rate” or “Fed fund(s) rate,” and (iii) “Federal Reserve” or “the Fed” or “Federal Open Market Committee” or “FOMC”. We do this for every day’s issue of the Washington Post, Wall Street Journal, and New York Times.

Importantly, we control for the changing volume of total news articles over time and the possibility that some newspapers naturally cover monetary policy more than others by first dividing the raw count of identified articles by the total number of news articles mentioning “Federal Reserve”, or more precisely, any of the words in category (iii), for each newspaper in a given period. This scaling choice also helps address issues related to time-varying popularity and increased coverage of the Fed due to improved transparency in its communication strategy. The share of articles is subsequently normalized to have a unit
standard deviation for each newspaper over the sample period. Each of our monetary policy uncertainty indexes is aggregated by summing the resulting series and scaling them to have a mean of 100 over the sample. We construct the index at both a monthly frequency and FOMC meeting-interval frequency.

We display our baseline MPU index in Figure 1. The sample is January 1985 to May 2018. The index spikes notably at the time of the March 2003 invasion of Iraq,\(^3\) the lead-up to the global financial crisis, the Taper Tantrum, prior to the October 2015 FOMC meeting (when “liftoff uncertainty” seemed to have peaked), and around the Brexit vote that followed liftoff.\(^4\) Our index thus fluctuates substantially during the period the Federal Funds rate was at the zero lower bound. We examine the sensitivity of our baseline index by considering several adjustments to its construction, most notably, proximity refinements, in online Appendix A.

### 2.2 Human auditing

To address concerns about automated news-based computer search, we conduct an audit based on human readings. We begin with randomly-selected 6000 articles and construct a human index based on the count of articles that we code as discussing high or rising monetary policy uncertainty. To concentrate on articles that are likely relevant, we draw from the set of articles that meet our criterion (iii), that is, containing “Federal Reserve” or “the Fed” or “Federal Open Market Committee” or “FOMC”. We compare the evolution of the human index with the computer-automated index, including calculating the Type II error rate. We also characterize the nature of monetary policy uncertainty, quantifying the number of articles on uncertainty concerning Fed actions versus uncertainty about the consequences of those actions. We then read an additional 1500 randomly-selected articles contained in our computer-automated MPU index in order to estimate the Type I error rate associated

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\(^3\)Consistent with the large spike in March 2003, Bernanke (2015) recalls, “U.S. forces had invaded Iraq a few days before the (March 2003) meeting. Businesses and households were reluctant to invest or borrow until they saw how the invasion would play out. My colleagues and I were also uncertain about the economic consequences of the war, especially its effect on energy prices. At Greenspan’s urging, we decided to wait before considering further action. In our post-meeting statement, we said uncertainty was so high that we couldn’t usefully characterize the near-term course of the economy or monetary policy. That unprecedented assertion probably added to the public’s angst about the economy.”

\(^4\)Human reading of articles published during the spike in U.S. MPU around Brexit assured us that these articles were not discussing simply how much uncertainty *per se* resulted from the vote, but rather uncertainty about whether the Fed would follow through on the post-liftoff planned further rate hikes in 2016.
with our baseline MPU index. Our MPU index shows a remarkably high correlation with the index constructed by human intelligence, and its Type I and Type II error rates are reasonably small and do not exhibit large time-series variation.

2.2.1 A human index

Each month the newspapers used to construct our MPU index contain about 30,000 articles on average. Of these, 0.17% meet our computer-automated criteria to be included in the MPU index. We label this set (M). In constructing our human index, we restrict our reading to articles containing at least one of the words listed in category (iii). This set, labelled (E), accounts for about 2% of the universe of newspaper articles. We choose this set (E) to draw articles from because (i) a pilot audit (human reading of 300 articles) suggests that the mention of Fed is at the heart of relevant discussions, significantly more so than the mention of monetary policy, for example; and (ii) the human index can also be normalized in a way consistent with the computer-generated index, i.e., scaled by the number of articles in set E, which could help minimize the effect of sampling uncertainty.

We randomly select about 5% of the newspaper articles in set E and read the full text of all 6000 articles.\(^5\) Following a detailed auditing guideline, we identify phrases that likely indicate true positives as well as likely false positives. We repeat this process and refine the search words until additional adjustments bring only minor improvements in the error rates (detailed below). For example, although in some instances articles use words such as “anxiety” and “fear” to discuss uncertainty related to monetary policy, including these additional words in the search also generates additional false positives, which on balance does not improve our index.\(^6\)

An article is coded as 1 if it contains references to high or rising uncertainty in monetary policy actions and/or their consequences. Articles are coded as -1 if they contain references to low or declines in such uncertainty, and 0 if the article contains no references to relevant

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\(^5\)For details of our sampling technique, please see our audit guide at: https://sites.google.com/site/bosn99/monetary-policy-uncertainty-index. The reading is done either by one of the authors or a Fed research assistant.

\(^6\)In our pilot human audit, we noticed for instance that articles in the 1980s and early 1990s use “discount rate” to refer to the monetary policy instrument, while such reference disappeared in recent years. With this in mind, we produced an “MPU 2.0” adding the following words in category (i) of our search: concern(s), or concerned or fear(s) or nervous or worry (worries) or speculate(s) or scare(s) or scared. We also added a proximity constraint that word(s) in category (i) must be within 10 words of those in category (ii) or (iii). MPU 2.0 shows a significantly lower correlation with the human index than does our baseline index.
uncertainty. About 26 percent of the articles in set $E$ are coded as 1 from our reading. Panel A of Figure 2 displays the human index against the computer-generated MPU index. The correlation is high, at 0.84.

### 2.2.2 Type I vs Type II error

To further evaluate the statistical properties of our MPU index, we analyze the rate of Type I (false positives) and Type II (false negatives) errors. In the second stage of our audit, we randomly select 1500 articles from those contained in our MPU index. This accounts for over 10% of set $M$. From our human reading of these articles belonging to our MPU index, about 85 percent are classified as mentioning high or rising uncertainty related to monetary policy, judged by human intelligence. The month-to-month variation of this fraction of false positives is minimal, alleviating concerns about time-varying biases. One might be particularly concerned about articles on low or declining monetary policy uncertainty getting included in the MPU index. In our sample, only 3.7% of the articles in set $M$ (those included in the computer-generated MPU index) discuss falling uncertainty. Figure A.1 in online Appendix A shows the time-series variation in the Type I error rate. The error rate is quite flat, and clearly uncorrelated with our MPU index itself or with other macroeconomic variables.\(^7\)

Given the time-varying writing styles in newspapers, we are mindful that the ratio of false negatives could also vary systematically over time. We thus calculate the Type II error every month as follows. We first identify the articles in our sample of set $E$ that would be included in the computer-automated index (set $M$, which is a strict subset of $E$), i.e., containing the triple of key words we search for. In the remaining sample (set $E - M$), we count the number of articles that contain references to high or rising monetary policy uncertainty, which gives us the Type II error rate. Our Type II error rate is on average 0.24 per year, with a standard deviation of 0.05. This indicates that false negatives are also not a major concern for our index. Figure A.2 in online Appendix A plots the Type II error rate.

\(^7\)We also audit whether the uncertainty pertains to Fed actions or their consequences. We find that our index mainly captures uncertainty about the Fed’s actions: among the true positives, only 10.6% are about consequences (including the ones on both actions and consequences). The remainder are about uncertainty concerning Fed actions themselves. During the earlier part of the ZLB, newspaper articles were mostly discussing uncertainty about economic implications of the ZLB, while uncertainty about Fed actions took center stage in the 2013 Taper Tantrum and in the second half of 2015.
rate, which is also very flat and uncorrelated with our MPU index and other macroeconomic
indicators. We provide more detailed discussions on the properties of our MPU index in
online Appendix C and its proximate determinants in online Appendix D.

2.3 Short-run MPU

As part of our human audit, we also classify all the true positive articles (i.e., those coded
as 1) as to whether the uncertainty pertained most to (i) the very near term, that is, the
upcoming FOMC meeting or within one month, (ii) the near term, that is, beyond the
upcoming meeting but within one year, or (iii) the medium to long run, that is, beyond a
year. Every article that has been coded as 1 has one of the three classifications.

In Panel B of Figure 2 we show two bar charts: in dark grey the number of very near
term articles as a fraction of the total true positive articles (# articles coded as (i)
# articles coded as 1), and in
light grey the share # articles coded as (i) or (ii)
# articles coded as 1. Both measures are displayed aggregated
to an annual frequency. The bar charts make clear that for most of our sample period the
majority of the uncertainty discussed in newspapers concerns time horizons of one year or
less. Very near-term uncertainty was high during the interest rate hikes of the mid-1990’s
through Y2K, nearly tripled from 2005 to the onset of the financial crisis, and then rose
consistently from 2009 until liftoff materialized.

Guided by our time-horizon human audit, we select additional search terms to add to
our existing algorithm to construct a computer-automated short-run MPU index. Keeping
the triple of search terms used for the overall MPU index, we also require at least one of the
following two conditions to be met: (a) the mention of Fed (any category (ii) word) must be
within 5 words of one of the following phrases: “soon” or “today” or “tomorrow” or “this
week” or “this month” or “next week” or “next month”; and (b) “this / next / upcoming
/ coming (FOMC) meeting” appears in the article. That is, for an article to be included in
our computer-generated short-run MPU index, it has to contain the triple of key words used
in constructing the baseline MPU index and satisfy at least one of the two conditions above.

The short-run MPU index is normalized to be a stand-alone index in a way consistent
with our overall MPU index.\(^8\) We construct the index at both a monthly frequency and at

\(^8\)That is, we scale the raw count of identified articles by the total number of news articles mentioning
“Federal Reserve”, or more precisely, any of the words in category (iii) in our baseline search, for each
FOMC meeting intervals. The short-run MPU index is plotted as the solid line in Panel B of Figure 2 at a meeting frequency. It spikes up during the Iraq Invasion and Taper Tantrum episode, for example. For comparison, this figure overlays the computer-automated short-run MPU index on top of the bar charts described above. The computer index tracks the share of very near-term and near-term articles from the human audit closely.

To get a sense of what the short-run MPU index conveys differently from the baseline index, we examine how each evolves on the days before and after FOMC meeting days. It is natural to expect that monetary policy uncertainty would decline after the FOMC meets, assuming that policy (in)actions and the associated explanations help mitigate near-term uncertainty about monetary policy. The event-study results are depicted in Figure 3. There is a rise in both MPU indexes in the days before the typical FOMC meeting. Short-run uncertainty rises much more steeply though, leading to a peak effect on FOMC meeting day—the last day of newspaper coverage before the FOMC meeting—that is well above that reached by the baseline index. Similarly, the decline in short-run MPU is much sharper than for overall MPU. This comparison bolsters the notion that our short-run index is indeed capturing uncertainty about monetary policy at short horizons.

2.4 The Information Content of MPU

To evaluate the information content of our MPU index, we compare our baseline MPU index to a number of alternative measures that have been used as proxies for monetary policy uncertainty. The first is from the Federal Reserve Bank of New York’s Survey of Primary Dealers, which is conducted one week before each FOMC meeting. The Survey has the appealing feature of asking respondents to directly report both their forecasted policy rates and their forecast uncertainty. We use the dealers’ responses to the following question, over the time period for which this question was relevant and hence asked (i.e., through late 2012): “Of the possible outcomes below (that is, $-50$ bps, $-25$ bps, $+0$ bps, $+25$ bps, $+50$ bps), please indicate the percent chance you attach to the indicated policy move at each of newspaper in a given period. The share of articles is subsequently normalized to have a unit standard deviation for each newspaper over the sample period. Our short-run monetary policy uncertainty index is aggregated by summing the resulting series and scaling them to have a mean of 100 over the sample.

It is also natural to believe that newspaper coverage of monetary policy also rises in the days proceeding FOMC meetings and declines afterward. Hence the importance of our dividing the raw count of identified articles by the number mentioning “Federal Reserve”.

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the next three FOMC meetings”. To gauge the respondents’ perceived uncertainty regarding monetary policy, we calculate the average within-respondent standard deviation of forecasted policy rates.

Our baseline MPU index tracks the survey-based measure closely prior to 2008, with a correlation of 0.75 for the one-meeting ahead forecast and progressively slightly less for each of the next two meeting-ahead forecasts (Panel A of Figure 4). In the months preceding actual liftoff, a major component of monetary policy uncertainty centered on the timing of liftoff. We construct from the Primary Dealers Survey a measure of liftoff uncertainty in a manner similar to the interest rate uncertainty above for the year 2015 when the Survey consistently asked about the likelihood of liftoff over a pre-defined horizon. Our MPU index moves quite closely with liftoff uncertainty (Panel B of Figure 4), consistent with the notion that in that year monetary policy uncertainty more generally was primarily about expectations concerning the timing of liftoff. These two findings again indicate that our news-based search results capture uncertainty over both near-term and longer-term horizons, with a relatively stronger focus on the near-term.

Second, we compare our MPU index to the market-based indicator of monetary policy uncertainty. In Panel A of Figure 5, we display our measure against the implied volatility of options on one-year swap rates (swaptions), taken from Carlston and Ochoa (2016). Note that as the short-term policy rate approached zero, the market-based indicator fell quickly and remained extremely low during the ZLB period. This suggests that the market-based measures do not fully capture monetary policy uncertainty in a broad sense. Episodes such as the Taper Tantrum in 2013 and financial market turmoil prior to the September 2015 FOMC meeting suggest that uncertainty regarding the timing and pace of policy rate normalization was far from zero. To highlight the differences between the market-based measure, which is essentially exclusively about the policy rate itself, and our MPU index, we plot in Panel B of Figure 5 the percentage of the articles included in our overall MPU index that mention at least one of the following phrases: “forward guidance,” “quantitative easing,” “QE,” “asset purchases,” “LSAP,” or “unconventional monetary policy.” This percentage was essentially zero prior to 2008, but reached one-quarter during the first half of the ZLB period. This indicates that a nontrivial degree of uncertainty exists beyond the short-term fed funds rate and is captured by our MPU index.
Compared to these measures based on survey data and market volatility, our measure therefore has the advantage of (1) being available in countries and during time periods when market or survey data are not available and (2) better capturing uncertainty in periods with unconventional monetary policy when the policy rate is at or near the lower bound. In addition, our measure can in principle represent uncertainty perceived by a different and potentially broader segment of the population, compared to the alternative measures. In principle, the survey measure reflects the opinion of the 20 primary dealers participating in the survey, and the market measure reflects the opinion of individuals participating in the option market. The news-based approach implicitly assumes that newspapers reflect readership and at the same time can also have an effect of influencing and shaping public opinions. While we do not intend to claim that our measure is more encompassing in all scenarios, it arguably proxies for the perception of a different population compared with the existing measures and hence contains additional information.

Relative to Baker, Bloom, and Davis’ (BBD) EPU index that captures uncertainty related to fiscal, healthcare, national security, and international trade policies, our measure is specifically focused on U.S. monetary policy. Because of our singular focus, we are also able to refine our index in various ways and normalize our index carefully to control the time-varying popularity of the Fed. Our large-scale human audit exercises, detailed below, provide reassurance that our index is an informative and reliable measure of newspaper coverage specifically pertinent to monetary policy, as opposed to a broad set of government policies. For completeness, we provide details on reconciliation exercises in online Appendix C.3 between our index and BBD EPU as well as its categorical subindex.

3 Aggregate implications of MPU shocks

We now turn to the central question: how do economic and financial variables respond to exogenous shocks to monetary policy uncertainty? We address this using impulse response analysis, with the sample period 1985:01–2015:12. The end point is chosen to coincide with the precise ending of the ZLB period. Our estimates consistently indicate that monetary policy uncertainty shocks tighten credit costs and reduce output.\footnote{Creal and Wu (2016) also examine the transmission of (overall) monetary policy uncertainty shocks, using very different uncertainty measures and estimation framework. They do not distinguish between overall and}
3.1 Cholesky decomposition

We start with our baseline identification strategy, a standard Cholesky decomposition (Sims (1980)) with the following recursive VAR structure:

\[ \mathbf{Y}_t = \begin{bmatrix} ip_t, cpi_t, epu_t, ebp_t, i_t, mpu_t \end{bmatrix}, \]

where \( ip \) denotes the log industrial production, \( cpi \) denotes the log consumer price index, \( epu \) is the EPU index constructed by Baker, Bloom, and Davis (2016), \( ebp \) is the Gilchrist and Zakrajsek (2012) (GZ) excess bond premium, \( i \) is the one-year government bond rate, and \( mpu \) is our MPU index.

We include the EPU index in all of our systems to examine whether there is any residual effect of uncertainty that is specific to monetary policy. The GZ excess bond premium is the component of the remaining spread between an index of rates of return on corporate securities and the rate on a government bond of a similar maturity after the default risk component is removed, serving as a proxy for credit spreads and providing a convenient summary of the other financial indicators left out in the VAR. We follow Gertler and Karadi (2015) (hereafter GK) in taking the one-year government bond rate to account for changes in forward guidance about the path of future rates. To be conservative, we order MPU last in our baseline specification, allowing innovations in interest rates, excess bond premium, and general policy uncertainty to affect MPU contemporaneously.

Panel A of Figure 6 shows the impulse responses following a surprise increase in MPU of one standard deviation, about 20 points. The excess bond premium rises on impact, suggestive of increased borrowing costs in response to higher monetary policy uncertainty. There is a drop in the one-year government bond rate, perhaps induced by the central bank responding to the increased uncertainty and higher credit spreads by lowering the policy rate. Finally, despite the loosening of interest rates, industrial output and inflation fall on impact and reach a trough in month 39.

The timing restriction we impose in our baseline Cholesky identification is to suppose that within a period, MPU responds to all the other variables in the VAR but not vice versa. That is, the impact of MPU on the other variables occurs with a lag of at least one month. We examine the robustness of our results to alternative timing assumptions. We continue short-run uncertainty.
to rank slow-moving macroeconomic variables first, namely, log industrial production and log CPI, and rank MPU everywhere else within that structure. The results are robust to the following cases: (i) EBP responds to MPU contemporaneously and/or (ii) the one-year government bond rate responds to MPU shocks. Also for robustness, we replace EPU in the system with the policy uncertainty measure constructed by Azqueta-Gavaldon (2017) who uses advanced textual analysis technique developed in other work on monetary policy (see, for example, Hansen, McMahon, and Prat (2018)). As shown in Figure E.2 in online Appendix E, the results are remarkably similar.

In addition, we examine shocks to short-run MPU. We estimate our baseline Cholesky VAR, replacing overall MPU with short-run MPU. The results displayed in Figure 7 show that a positive shock to short-run MPU significantly raises credit costs, as measured by EBP, and generates a contractionary effect on output, with a trough of about 2 years. The responses to shocks to short-run MPU are mildly smaller in magnitudes, compared to the overall MPU.

Based on the real option theory, policy uncertainty should affect the economy by creating an incentive for businesses to delay hiring and investing. Also importantly, for uncertainty associated with monetary policy stance, the upward pressure on financing costs is meaningful. Although the risk-free rate falls in response to increased uncertainty, this easing of financial conditions is more than offset by the sharp and persistent increase in credit spreads. Consistent with this view, by inducing a significant widening of credit spreads, unanticipated increases in MPU lead to a decline in output presumably primarily driven by protracted drop in investment. We further investigate the transmission channels of MPU using a large firm-level panel dataset in Section 4.

### 3.2 External instruments

To check the robustness of the IRF results, we follow GK in undertaking a high frequency approach that employs no timing restrictions. The motivation is to take a VAR model that is considered rigorous from a technical standpoint and is representative of findings in the literature, and assess the robustness of Cholesky results.\(^{11}\) We thus introduce MPU and EPU to the baseline VAR model of GK with the log industrial production, log consumer

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\(^{11}\)GK note of their findings, “Shocks produce responses in output and inflation that are typical in monetary VAR analysis”. See also Stock and Watson (2012) and Rogers, Scotti, and Wright (2016) (RSW).
price index, one-year government bond rate, and the Gilchrist and Zakrajsek (2012) (GZ) excess bond premium, maintaining the same six variables as in our Cholesky identification.

To estimate shocks to monetary policy, the instrument used by GK is the surprise in the monthly fed funds futures contract FF4 within a 30 minute window of the FOMC announcement. The key identifying assumption is that news about the rest of the economy within that window on FOMC day is orthogonal to the policy surprise.\textsuperscript{12} As argued by RSW and others, during the ZLB period monetary policy was aimed at rates of longer maturity, through forward guidance and quantitative easing. Even away from the ZLB, forward guidance surprises have been important, as the FOMC has long tried to manage expectations of future changes to the target fed funds rate. Thus, to update GK’s results and construct our policy surprises, we use the three separate measures of U.S. monetary policy surprises constructed by RSW: target rate, forward guidance, and asset purchase, available since February 1996 when the bond futures began trading. These are respectively,

- **Target.** The surprise component of the decision about the target fed funds rate based on the change in yield on the current- or next-month federal funds futures contracts from 15 minutes before the FOMC announcement to 1 hour and 45 minutes afterwards. The target surprise was effectively zero during the ZLB.

- **Forward Guidance.** The residual from a regression of the change in the yield for the fourth Eurodollar futures contract from 15 minutes before the announcement to 1 hour 45 minutes afterwards onto the target surprise.

- **Asset Purchase.** The residual from a regression of the change in the ten-year Treasury futures yield from 15 minutes before the FOMC announcement to 1 hour and 45 minutes afterwards onto the target and forward guidance surprises. This measures the jumps in long-term interest rates that are associated with FOMC announcements related to large-scale asset purchases. This is computed only over 2008:09–2015:12.

To estimate the transmission of MPU shocks using the external instruments approach, we use as our instrument the “monetary policy uncertainty surprise”. This is constructed as the uncertainty (volatility) on FOMC meeting days, *orthogonalized with respect to the* 
\textsuperscript{12}GK establish this as their preferred external instrument for the one-year government bond rate, their monetary policy indicator.
monetary policy surprise described above. Denote the daily implied volatility of the 1-year swap rate at a 1-month horizon $\sigma_t$. This is a measure of uncertainty about future monetary policy. We regress this on the monetary policy surprise on FOMC meeting days,
\[
\sigma_t = \gamma_1 \text{target surprise}_t + \gamma_2 \text{forward guidance surprise}_t + \gamma_3 \text{asset purchase surprise}_t + \eta_t.
\]
The residual from this regression, $\eta_t$, is the monetary policy uncertainty surprise.\textsuperscript{13} This instrument series has the interpretation as the amount of volatility due to monetary policy announcements on FOMC meeting days that is unexplained by the change in monetary policy itself. The orthogonalization is important because at the ZLB, a downward shift in the expected path of policy will mechanically lower interest rate uncertainty. Our approach thus provides instruments using high-frequency data, with the key identifying assumption that shocks to the economy and monetary policy (within narrow windows around FOMC announcements) are uncorrelated with the residual. The F-statistic from the regression of the first-stage VAR residuals on this instrument is 12.2, above the recommended threshold suggested by Stock et al. (2002), mitigating concerns of a weak instruments problem.

Panel B of Figure 6 displays the impulse responses estimated using external instruments. Once again, we observe that positive shocks to MPU are contractionary: EBP remains elevated for over a year before reverting to trend; there is a fairly rapid decline in IP which reaches a trough in about 20 months; the CPI response is insignificant, as in the GK replication analysis, while the interest rate response eventually becomes negative in order to offset the contractionary effects on IP and EBP.

3.3 Local projections

Finally, we use local projections to estimate the effects of shocks to monetary policy uncertainty. Since the VAR estimation relies on a moving average representation of the variables, any specification errors will be compounded at each horizon if the VAR is misspecified. Following Jorda (2005), we estimate the impulse responses of variables $Y_t$ at horizon $h$ using the following single regression:
\[
Y_{i,t+h} = \theta_{i,h} \epsilon_{1,t} + \text{control variables} + \eta_{t+h}
\]
\textsuperscript{13}This is in the spirit of Akkaya, Gurkaynak, Kisacikoglu, and Wright (2015). We tried several measures of high-frequency monetary policy surprises on the right hand side, including surprises on instruments at horizons from 1-quarter ahead to 8. All produced similar results.
\( \theta_{i,h} \) is the estimate of the impulse response of \( Y_i \) at horizon \( h \) to a MPU shock \( \epsilon_{1t} \). We include as control variables everything in the VAR above, including lagged values of the variables.

Panel C of Figure 6 presents the results. We display the local projections IRFs in the far right column, the Cholesky case in the far left column, and the external instrument case in the middle. The impulse response functions under local projections indicate sizable negative effects of MPU. These are robust to several modifications of the specification, variable set, causal ordering, and sample period (not shown).

4 Transmission channels of MPU: firm-level evidence

In this section, we further study how fluctuations in MPU are transmitted to the real economy by exploiting a large panel data of publicly traded firms. There are predominantly two channels of how changes in uncertainty can influence the real economy that have been studied in the literature: the ”real options” approach builds on irreversible investment, emphasizing the importance of delaying investment until uncertainty is resolved (e.g., Bernanke, 1983; Rodrik, 1991; Bertola and Caballero, 1994; Abel and Eberly, 1994, 1996; Caballero and Pindyck, 1996; Bloom, 2009); the financial friction theory stipulates that a rise in credit spreads to compensate bondholders for heightened uncertainty induces protracted declines in investment (e.g., Gilchrist, Sim, and Zakrajesk, 2011; Arellano, Bai, and Kehoe, 2012; Christiano, Motto, and Rostagno, 2014). In an attempt to identify possible mechanisms through which MPU propagates through the real economy, we investigate the relationship between MPU and firm investment, and we further examine whether the effect of MPU on firm investment exhibits heterogeneity in the cross section depending on firm-specific investment irreversibility and financial frictions.

4.1 MPU and firm investment

We use quarterly firm-level data from COMPUSTAT, and the sample period extends from 1985 Q1 through 2018 Q1, which is chosen to match the availability of our MPU index. Following Gulen and Ion (2015), we use the following baseline specification to estimate the average relationship between MPU and firm investment.

\[
\frac{CAPX_{i,t}}{TA_{i,t-1}} = \alpha_i + \beta_1 MPU_{i,t-\ell} + \beta_2 Q_{i,t-1} + \beta_3 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_4 SG_{i,t} + \beta_5 M_{i,t-1} + \epsilon_{i,t}, \tag{2}
\]
where the main dependent variable, investment rate, is measured as capital expenditures (CAPX) scaled by lagged total assets (TA), $i$ indexes firm, $t$ indexes calendar quarter, and $\ell \in \{1, 2, 3, 4\}$ represents the quarter lead between the investment rate and MPU ($MPU_{t-\ell}$).

The firm-level controls include the explanatory variables commonly employed for testing the Q theory of investment: cash flows ($\frac{CF_{i,t}}{TA_{i,t-1}}$), sales growth ($SG_{i,t}$, the year-on-year growth in quarterly firm sales), and Tobin’s Q ($Q_{i,t-1}$, computed as the market to book value of assets). To control for macroeconomic conditions ($M_{i,t-1}$), we use quarterly GDP growth, and we also include Baker, Bloom, and Davis’ EPU index to control for other policy uncertainty. In robustness checks, we also control for other measures of expectations about macroeconomic conditions, discussed in more detail in the next subsection. $\alpha_i$ represents the firm (or industry) fixed effect.

Following the convention (e.g., Gulen and Ion, 2015; Farre-Mensa and Ljungqvist, 2016), we exclude financials (SIC between 6000 and 6999), utilities (SIC between 4900 and 4999), and all observations which have total assets, sales or book equity smaller or equal to zero. we winsorize all variables at the 1st and 99th percentiles in order to minimize the impact of data errors and outliers. All variables have been normalized by their sample standard deviation to facilitate the comparison of economic magnitudes across covariates: each estimated coefficient represents the change in investment rates as a proportion to their standard deviation to a one-standard-deviation increase in the respective independent variable.

We run four specifications of Equation (2), one for each $\ell \in \{1, 2, 3, 4\}$, to entertain the possibility that the effect of MPU on firm investment may persist and manifest over multiple quarters. The results robustly show that MPU has a strong negative relationship with corporate investment at both firm and industry level that persist at least up to four quarter in the future. As shown in Column 1 (4) of Panel A in Table 2, the economic magnitude is also sizable, implying that a one standard deviation increase in MPU is associated with a 0.057 (0.050) standard deviation decrease in investment rates in the next quarter (four quarters later), equivalent to 8.7% (7.74%) of the average investment rate in the sample.

4.2 Controlling for expectations

One potential concern is that if MPU tends to move when expected future economic conditions and hence investment profitability change, the estimates may be biased due to omitted
variables. Following the literature (e.g., Gulen and Ion, 2015; Baker, Bloom, and Davis, 2016; Azzimonti, 2017), we augment our baseline specification with several variables that capture expectations about future economic conditions. First, we use expected 6-month-ahead GDP growth that is obtained from the Federal Reserve Bank of Philadelphia’s Survey of Professional Forecasters. Second, we include the measure of expected business conditions during the next year, constructed by the University of Michigan. Finally, we control for the consumer sentiment index constructed by the University of Michigan.

In Panel C of Table 2, we include these additional control variables one by one in Columns (1) through (3) and all together in Column (4) in the specification from Equation (2), with $\ell = 1$. The relationship between MPU and corporate investment is robust to controlling for the role of expectations, and it holds in all specifications and at both firm and industry levels.

4.3 Real options vs. financial frictions

To further gauge how MPU affects corporate investment, we examine whether the negative effect of MPU on investment varies across firms in a way that is consistent with existing theories. We focus on the two theories that have been most widely studied and debated in the literature, namely, the real options theory and the financial frictions theory. We examine each of them in turn below.

**Investment irreversibility**

The real options theory postulates that uncertainty creates an incentive for firms to delay investment when the option to delay is available. Moreover, the theory predicts that investment irreversibility increases the incentive to delay. To gauge the role of real-options-induced delay effect, we examine whether investment irreversibility affects the relationship between MPU and corporate investment.

Our first measure of investment irreversibility is a proxy for asset tangibility, measured as the ratio of Property, Plant, and Equipment (PPE) to total assets. The rationale is that firms with higher ratios of fixed to total assets tend to rely heavily on physical capital, and would find it costly to divest as they would have to do so in large discrete amounts (Gulen and Ion, 2015). We also use three additional measures that proxy for sunk costs: sale of investment, rent expenses, and depreciation expenses (Kessides, 1990; Farinas and Ruano,
Intuitively, sunk costs (and hence investment irreversibility) are lower for firms that can sell their investments in a more liquid market, for firms that rent a higher proportion of their physical assets, and for firms with rapidly depreciating capital. For the sale of investment, we use the sum of the firm’s sales in the twelve quarters through the current fiscal quarter (Gulen and Ion (2015)). All the proxies are normalized by the beginning-of-quarter PPE. Although we exhaust the conventional measures of investment irreversibility, we acknowledge that these proxies are inevitably rough. Thus, for each investment irreversibility measure, we follow the convention and construct an indicator variable that takes a value from 0 to 9, corresponding to the firm’s respective decile rank in the cross section in a given quarter, and a higher value represents a higher level of investment irreversibility. As a robustness check, we find that our results are robust to using the levels of these measures as well.

We introduce the four proxies for investment irreversibility and their interactions with MPU into our baseline specification (Equation 2). The specification takes the following form.

\[
\frac{CAPX_{i,t}}{TA_{i,t-1}} = \alpha_i + \beta_1 II_{t-\ell} + \beta_2 MPU_{t-\ell} + \beta_3 MPU_{t-\ell} \times II_{t-\ell} + \beta_4 Q_{i,t-1} + \beta_5 \frac{CF_{i,t}}{TA_{i,t-1}} + \beta_6 SG_{i,t} + \beta_7 M_{i,t-1} + \epsilon_{i,t},
\]

where for each of the above investment irreversibility measure, \(II_{i,t-\ell}\) represents the firm’s investment irreversibility decile rank in the cross section at time \(t - \ell\), and we make sure that a higher value represents a higher level of investment irreversibility.

For expositional clarity, we present only the coefficient estimates for the interaction terms (\(\beta_3\)) in Table 3. Columns 1 through 4 correspond to the lead \(\ell\) between dependent variable and independent variables. For all the four measures discussed above, there is strong evidence that investment irreversibility enhances the influence of MPU on investment. Higher levels of investment irreversibility are associated with a significantly more negative effect of MPU on investment, and such effects also seem to persist over multiple quarters into the future. The results also hold when we run these tests at the three-digit SIC industry level.

**Financial frictions**

The financial frictions theory points out that increased uncertainty, seen as a mean-preserving spread in the distribution of future cash flows (and interest rates in the case of MPU), indicates higher likelihoods of default and therefore higher costs of debt financing (Greenwood and Stiglitz, 1990; Gilchrist, Sim, and Zakrajšek, 2014). Thus, the negative
effect of MPU on investment is expected to be stronger for firms that are more financially constrained. We use the most widely used measures of financial constraints to study to which extent financial frictions influence the relationship between MPU and investment.

First, we use the index of financial constraints developed by Kaplan and Zingales (1997), the most popular measure of financial constraints based on Google Scholar citation counts. Kaplan and Zingales (1997) use qualitative information in firms’ 10-K reports to classify firms on their financial constraints and estimate the effect of various firm characteristics. Lamont, Polk, and Saa-Requejo (2001) estimate an ordered logit model relating the degree of financial constraints according to Kaplan and Zingales’ (1997) classification and construct a financial constraint index as follows.

\[ KZ_{i,t} = -1.1001CF_{i,t} + 0.2826Q_{i,t} + 3.1392TLTD_{i,t} + -39.3678TDIV_{i,t} + -1.3147Cash_{i,t}, \]

where \( TLTD_{i,t} \) is the ratio of long term debt to total assets, \( TDIV_{i,t} \) is the ratio of total dividends to assets, and \( Cash_{i,t} \) is the ratio of liquid assets to total assets.

Second, we use the measure of financial constraints constructed by Hadlock and Pierce (2010), who update Kaplan and Zingales’ (1997) text-based approach by combing the 10-Ks of 356 randomly selected firms over the period 1995-2004 for evidence of firms identifying themselves as financially constrained. They create the index of financial constraints using the following classification:

\[ HP_{i,t} = -0.737Size_{i,t} + 0.043Size_{i,t}^2 - 0.040Age_{i,t}, \]

where \( Size \) is the firm size that equals the log of inflation-adjusted Compustat item \( at \), and \( Age_{i,t} \) is the number of years the firm is listed with a non-missing stock price on Compustat. In calculating the index, we follow Hadlock and Pierce (2010) and cap firm size at \((\text{the log of}) \$4.5 \text{ billion and Age at 37 years.} \)

The third measure we use is the financial constraint index constructed by Whited and Wu (2006), which proxies for the shadow cost of external finances based on the coefficients estimated from a structural model:

\[ WW_{i,t} = -0.091CF_{i,t} - 0.062DIVP0S_{i,t} + 0.021TLTD_{i,t} - 0.044LNTA_{i,t} + 0.102ISG_{i,t} - 0.035SG_{i,t}, \]

where \( DIVP0S_{i,t} \) is an indicator that takes the value of one if the firm pays cash dividends, \( LNTA_{i,t} \) is the natural log of total assets, and \( ISG_{i,t} \) is the firm’s three-digit industry sales
growth. For each of the above financial constraint indexes, a higher index value indicates a greater degree of the firm’s financial constraint and higher cost of external finances.

Lastly, following Ottonello and Winberry (2018), we also consider firm leverage, measured as debt-to-asset ratio \( \ell_{i,t} \), where debt is the sum of short term and long term debt, as higher leverage is tightly linked, empirically and theoretically, to a higher cost of external finance.

We include each of the four financial constraints proxies in our baseline specification and interact them with MPU in the following specification.

\[
\frac{\text{CAPX}_{i,t}}{\text{TA}_{i,t-1}} = \alpha_i + \beta_1 \text{FC}_{t-\ell} + \beta_2 \text{MPU}_{t-\ell} + \beta_3 \text{MPU}_{t-\ell} \times \text{FC}_{t-\ell} + \beta_4 Q_{i,t-1} + \beta_5 \frac{\text{CF}_{i,t}}{\text{TA}_{i,t-1}} + \beta_6 \text{SG}_{i,t} + \beta_7 \text{M}_{i,t-1} + \epsilon_{i,t},
\]

where following the convention, \( \text{FC}_{t-\ell} \) takes a value from 0 to 9, corresponding to the firm’s respective decile rank in the cross section at time \( t - \ell \) for each measure of financial constraints. A higher value of \( \text{FC}_{t-\ell} \) indicates a greater degree of financial constraints the firm faces.

As shown in Columns 1 through 4, which again correspond to the lead between dependent and independent variables, higher levels of financial constraints are associated with a more negative effect of MPU on investment, an effect that persists at least four quarters into the future. The results also hold when we use the \textit{levels} of all the four proxies of financial constraints and when we run these regressions with the industry fixed effect. Note that we control for EPU in all of our regressions; thus, our results provide information about the residual effect of uncertainty about monetary policy beyond that of general policy uncertainties.

Taken together, in the transmission of MPU, we document strong empirical support for both wait-and-see type of real options theory and financial frictions channel. The pattern that investment irreversibility and financial constraints magnify the negative effect of MPU on investment is robust across the proxies and holds at both firm and industry levels for at least four quarters into the future.

5 Conclusion

We develop new measures of uncertainty that the public perceives about Federal Reserve monetary policy actions and their consequences. We compare these new measures to exist-
ing proxies and argue that there are good reasons to prefer ours, especially over medium term horizons such as FOMC meeting intervals. Empirically, we note for example that market-based measures were well subdued — close to zero — during the ZLB while ours were elevated and fluctuating. Conceptually, differences exist between our measure and the market-based indicators. In theory, the latter reflect the average perception of individuals participating in options markets. Our news-based index reflects the average opinion of people reading newspapers (assuming that newspapers reflect the readership). Since relatively few households participate in options markets, the prices in these markets may not be particularly representative. In addition, in market-based indicators the perceived degree of uncertainty is contaminated with time-varying risk aversion and state-dependent marginal utility. Although we acknowledge (and try to control for) the potential state-dependency in newspaper coverage of central bank actions, we believe that our index is a preferable measure of monetary policy uncertainty, at least over the sample period and for the frequency we study.

We examine transmission of monetary policy uncertainty, showing that greater uncertainty raises credit costs and lowers output. Consistent with an investment channel of MPU transmission, we also present firm-level evidence that MPU significantly delays firm investment in ways that are consistent with both the “real options” theory and the financial frictions channel.
References


ysis,” The MIT Press.


Figure 1: Monetary Policy Uncertainty Index

MPU index, monthly frequency (January 1985 - June 2017)
Panel A: Overall MPU vs. human index

Panel B: Short-run MPU vs near-term human index

Figure 2: Human index vs. Computer index

Figure 3: Overall vs. short-run MPU around FOMC Meetings

Panel A: MPU vs. Survey (FFR)

Panel B: MPU vs. Survey (liftoff)

Figure 4: MPU index against uncertainty measures from FRBNY Survey of Primary Dealers
Panel A: MPU vs. swaptions volatility

Panel B: Percentage of MPU articles discussing unconventional monetary policy

Figure 5: Comparing MPU vs market-based measures

Panel A: Impulse responses to a MPU shock, identified using the baseline Cholesky identification.

Panel B: Impulse responses to a MPU shock, identified using external instruments.

Panel C: Impulse responses to a short-run MPU shock, identified using the baseline Cholesky identification.

Figure 6: Impulse responses to MPU shocks
Impulse responses to a short-run MPU shock, identified using the baseline Cholesky identification.
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Table 1: MPU and Investment
### Panel A: Conditioning on Investment Irreversibility

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| Quarter Fixed Effects           | Yes                     | Yes | Yes | Yes |
| Firm Controls                   | Yes                     | Yes | Yes | Yes |

### Panel B: Conditioning on Financial Constraints

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<td>-.007***</td>
</tr>
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<td></td>
<td>(.001)</td>
<td>(.000)</td>
<td>(.000)</td>
<td>(.000)</td>
</tr>
<tr>
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<td>528,221</td>
<td>512,427</td>
<td>498,638</td>
<td>485,064</td>
</tr>
<tr>
<td>R-Squared</td>
<td>.39</td>
<td>.40</td>
<td>.40</td>
<td>.40</td>
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<table>
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<tbody>
<tr>
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<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>-.007***</td>
<td>-.011***</td>
<td>-.007***</td>
<td>-.005***</td>
</tr>
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<td></td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.001)</td>
</tr>
<tr>
<td>N</td>
<td>494,343</td>
<td>484,999</td>
<td>476,642</td>
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<table>
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<tr>
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<th>Panel B4: Leverage</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MPU x Leverage</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>-.009***</td>
<td>-.013***</td>
<td>-.010***</td>
<td>-.008***</td>
</tr>
<tr>
<td></td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.001)</td>
</tr>
<tr>
<td>N</td>
<td>520,314</td>
<td>510,149</td>
<td>503,232</td>
<td>494,595</td>
</tr>
<tr>
<td>R-Squared</td>
<td>.39</td>
<td>.39</td>
<td>.39</td>
<td>.39</td>
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</tbody>
</table>

Table 2: Effects of MPU on investment: financial constraints vs. investment irreversibility
A Details on index construction

A.1 Baseline index construction

The MPU index reflects automated text-search results for the newsstand edition of three major newspapers: New York Times, Wall Street Journal, and Washington Post. We use the ProQuest Newsstand database to search the electronic archives of each newspaper from January 1985 to January 2016 for terms related to monetary policy uncertainty. In particular, the search identifies articles containing the triple of (i) “uncertainty” or “uncertain,” (ii) “monetary policy” or “interest rate” or “Federal funds rate” or “Fed fund rate,” and (iii) “Federal Reserve” or “Fed” or “Federal Open Market Committee” or “FOMC”. Based on these search criteria, we count in each newspaper how many articles contained the search terms above every day.

To deal with changing volume of newspapers over time, we normalize as follows. First, we divide, for each newspaper, in every inter-meeting period, the raw count of articles related to monetary policy uncertainty by the total article count mentioning the Fed. For each newspaper \( i \) in period \( t \), we calculate the share of articles containing monetary policy uncertainty terms as

\[
 n(i, t) = \frac{\text{#mpu_articles}(i, t)}{\text{#Fed_articles}(i, t)}.
\]

We then normalize the share of articles so that, for each newspaper, the resulting series has a standard error of one over the sample period. This normalization controls for the possibility that different newspapers mention monetary policy uncertainty with different frequency over time. That is, we denote the normalized share of articles using

\[
 nn(i, t) = \frac{n(i, t)}{\text{stdev}(n(i, 1985 : 2015))}.
\]

Finally, we sum the \( nn(i) \) series across newspapers and scale them so that the average value is 100 over the sample period. The scaling produces our monetary policy uncertainty index, denoted as MPU:

\[
 MPU(t) = \left[ \frac{\sum_i nn(t)}{\text{avg}(\sum_i nn(1985 : 2015))} \right] \times 100.
\]

A human reading of a sample of the articles suggests that the news-based approach used to construct the index can provide a reasonable indicator of monetary policy uncertainty. Newspapers typically cite uncertainties related to monetary policy in one of the following cases:

- Newspaper articles comment on the uncertainty resulting from Federal Reserve actions. For example, “FOMC reserve injection during the day is reversed at the overnight...
closing time to achieve an artificial 5.25%. This target Fed funds chicanery leaves the financial market with considerable uncertainty.”

- Newspaper articles discuss the implications of uncertainty regarding the Federal Reserve actions for the real economy and stock markets. For example, “Traders last week blamed uncertainty about the FOMC for the sharp ups and downs on the New York Stock Exchange.”

- Newspaper articles analyze uncertainties at home and abroad that affect monetary policy. For example, “Given the inherent uncertainty about future developments, policy actions often importantly depend on the flow of new information and the FOMC’s judgment about its implications.” “There are significant uncertainties about the Fed moving to boost the cost of borrowing in the U.S. as China’s economy has run into trouble and as financial markets have suffered significant losses.”

- Newspaper articles quote policy-makers, economists, political leaders, or industry experts who refer to uncertainties in relation to monetary policy in their speeches or interviews. For example, “The Federal Open Market Committee, the central bank’s top policymaking group, blamed the slowdown in growth largely on falling stock prices and ‘heightened uncertainty related to problems in corporate reporting and governance’.”

A.2 Proximity refinement

We examine the sensitivity of our baseline index by considering several adjustments to its construction. In one refinement, we narrow our search to articles in which the word uncertainty/uncertainties is in close proximity to Federal Reserve or monetary policy. Specifically, we restrict “uncertainty” or “uncertainties” to be within either 5, 10, or 20 words of the phrase “Federal Reserve” or “The Fed” or “monetary policy.” In order to better understand the trade-offs associated with using the proximity refinement and as part of a more general auditing of our automated search, we extracted and read a randomly selected sample of the search results (see Appendix A). The proximity search does appropriately filter out articles that mention all the keywords but do not really discuss monetary policy uncertainty per se.\(^\text{14}\) The trade-off, however, is that the proximity search misses articles that discuss issues related to monetary policy uncertainty but have a somewhat large gap between keywords.\(^\text{15}\) We conclude from these readings that the proximity search has smaller type II error but greater

\(^{14}\)For example, in articles that mention monetary policy or interest rate, “uncertainty” shows up in sentences like the following: “Concerns over Europe have also intensified, as political upheaval has bred uncertainty over whether the euro zone will be able to implement controversial austerity measures.”

\(^{15}\)With our 10-word search, for example, an article with the following sentence was not counted: “That the \textbf{Fed} can, if it chooses, intervene without limit in any credit market — not only mortgage-backed securities but also securities backed by automobile loans or student loans — creates more uncertainty and raises questions about why an independent agency of government should have such power.”
type I error relative to the baseline strategy, as it filters out more of both “false” articles and “correct” articles. The correlation between the baseline index and that constructed using the 10-word proximity search is 0.83 (see Husted, Rogers, and Sun (2016a)).

### A.3 Error rates in baseline MPU index

![Figure A.1: Type I error rate](image1)

![Figure A.2: Type II error rate](image2)

Type I and Type II error rates in MPU index

### B Additional data checks

Saiz and Simonsohn (2013) propose a number of data checks to examine whether an index is a useful proxy for the phenomenon of interest. We follow these conditions and check the validity of our index below.

1. Do the different queries maintain the phenomenon and keyword constant?

   Following Saiz and Simonsohn (2013), two data checks are used to assess the validity of this premise. First, we verify that our MPU index is expressed in terms of a relative frequency. Second, the keyword chosen be more likely to be employed following the occurrence than the non-occurrence of the phenomenon of interest. We verify this by calculating that 85% of the randomly selected articles from set $M$ (i.e., those included in our computer-automated index).

2. Is the variable being proxied a frequency?

   Our index is a frequency.
3. After sampling the contents of documents found: is the keyword employed predominately to discuss the occurrence rather than non-occurrence of phenomenon?

We verify this in our human auditing: 85% of the randomly selected articles from set $M$ (i.e., those included in our computer-automated index).

4. Is the average number of documents found large enough for variation in document-frequency to be driven by factors other than sampling error?

We verify this in two ways. First, we gain confidence in our human audit that (i) the average number documents found is sufficiently large for meaning variations and (ii) our index spike up on the days of notable events that are associated with rising monetary policy uncertainty, for example, 2003 Iraq invasion, 2013 Taper Tantrum, and 2015 December liftoff uncertainty, not only on the monthly basis but also on a daily frequency.

5. Is the expected variance in the occurrence-frequency of interest high enough to overcome the noise associated with document-frequency proxying?

Saiz and Simonsohn (2013) argue that one likely source of measurement error is keywords with multiple meanings leading to false positives; that is, to documents that do contain the key words but which are not actually about the phenomenon of interest. This can be easily fixed by replacing a keyword for a synonym with fewer other meanings. Our human audit and, in particular, our analysis of the error rate, show small measurement errors in our index and help alleviate this concern. In fact, our reading of both set $M$ (those articles included in MPU index) and set $E$ (a larger set that contains only words in category (iii)) suggests that our MPU index is rather conservative because of relatively restrictive search criteria.

6. After inspecting the content of the documents found: does the chosen keyword have as its primary or only meaning the occurrence of the phenomenon of interest?

The final aspect of data checks deals with a possible correlation of the index with covariates of other variables of interest: conditioning on occurrence-frequency, document-frequency should be uncorrelated with the covariates of interest (Saiz and Simonsohn (2013)). We address this by (i) scaling our index by the number of articles mentioning Fed (see more details in data check #8) and (ii) showing that our index is not correlated with other major economic outcome variables.

7. After inspecting the content of the documents found: does the chosen keyword also result in documents related to the covariates of the occurrence of interest?

See our response for data check #8.
8. Are there plausible omitted variables that may be correlated both with the document-frequency and its covariates? If so, control for the omitted variable with an additional placebo document-frequency variable.

We control for the potentially time-varying public attention on Federal Reserve (that may or may not be unrelated to uncertainty) by scaling our index by the total number of articles each month mentioning the Fed. In so doing, we control for the time variation in the volume of newspaper articles as well as that in concerns about the Federal Reserve in general. This is also a key difference between our index and that constructed by Baker, Bloom, and Davis (2016).

C Further Discussion of MPU

C.1 MPU around FOMC meetings, before and after December 2008

To see if enhanced FOMC communication policies such as the forward guidance that the FOMC relied upon increasingly once the policy rate reached its effective lower bound may have affected uncertainty, we conduct an event-study analysis by comparing baseline MPU around FOMC meetings in two sub-periods: February 1994-November 2008 and December 2008-January 2016. The results are depicted in Figure C.1. In both sub-periods, there is a rise in MPU in the days prior to FOMC meetings. In the earlier sub-period, MPU peaks on the day after the FOMC meeting, the first day of newspaper coverage. Comparing the two lines, we see that in the later sub-period, when the FOMC began to rely increasingly on forward guidance, this rise in MPU is greatly muted and uncertainty peaks one day sooner. Checking articles’ time-stamping indicates that this finding is not a mechanical result of earlier on-line availability of news in the latter sub-period. The evidence is thus consistent with the notion that enhanced communications policies helped ease uncertainty regarding monetary policy.\textsuperscript{16}

C.2 Does FOMC Communication Influence MPU?

Commentators on central banking have long emphasized factors such as transparency and credibility. Bernanke (2015) recently opined: “I hope that the Fed’s increased transparency will help it maintain its independence, even as it remains democratically accountable. The chair’s press conferences, the expanded economic and interest rate projections by FOMC participants, and the lively debate evident in Fed policymakers’ speeches continue to provide

\textsuperscript{16}Our index rises on the day after FOMC meetings in the earlier subperiod. We learned from human reading of these articles that on the day after meetings discussion often centers on (1) uncertainties in economic consequences of the Fed decision and/or (2) uncertainties in future monetary policy actions even though current uncertainty has abated.
the Congress, the public, and the markets with considerable information about the Fed’s strategy and its rationale. The days of secretive central banking are long gone. The Federal Reserve is not only one of the world’s most transparent central banks, it is also one of the most transparent government agencies in Washington.”

Indeed, it wasn’t always this way. Goodfriend (1986) notes that the Federal Reserve formerly held a strong penchant for secrecy. In an influential theoretical paper, Cukierman and Meltzer (1986) examine the implications of a central bank’s informational advantage for policymaker credibility and inflation. They establish conditions under which ambiguity and imperfect credibility are preferable to explicit formulation of objectives from the point of view of the policymaker. In an extension, Faust and Svensson (1999, 2001) study central bank transparency, credibility, and reputation. They derive the endogenously determined degree of transparency, show that an equilibrium with low transparency is a likely outcome of the model, and assert that it is (was) appropriate to characterize the Federal Reserve and Bundesbank in that way. However, the 1990s elicited fresh analysis from central banking theory, and was accompanied by a sea change of monetary policy making across the globe (Inflation Reports, inflation targeting). Woodford (2013) and Bianchi and Melosi (2012) both find advantages for a central bank that communicates explicitly about its future policy.17

In Table 2, we characterize the relationship between our indexes of monetary policy uncertainty and variables that proxy for the considerations noted above. These variables are discussed in detail in Appendix D. We focus on institutional or procedural features, including

---

17 Milton Friedman (1990) is perhaps most blunt about the FOMC and the long gone days referred to by Bernanke: “From revealed preference, I suspect that by far and away the two most important variables in their loss functions are avoiding accountability on the one hand and achieving public prestige on the other” (quoted in Fischer, 1990, footnote 52). More recently, in “The Fed’s Communication Breakdown,” Project Syndicate, November 13, 2015, Ken Rogoff echoes Faust-Svensson’s theoretical finding, remarking, “however good its intentions, the net effect of too much Fed speak has been vagueness and uncertainty.”
newly-constructed measures of “FOMC statement persistence” and “FOMC-revealed uncertainty” (displayed in Appendix D). We also include a dummy variable for the crisis period of 2008H2, as well as separate dummies for the terms of different FOMC Chairs. To allay concerns about endogeneity, we also control for U.S. macroeconomic uncertainty (Jurado, Ludvigson, and Ng (2015)), financial uncertainty (Ludvigson, Ma, and Ng (2016), and global geopolitical risk (Caldara and Iacoviello (2017)).

We estimate regressions of the form

$$MPU_t = \alpha + \beta X_{t-1} + \gamma Z_t + u_t,$$

where $X_{t-1}$ includes the prior-meeting values of the institutional variables statement persistence and FOMC-revealed uncertainty. Similarly, $Z_t$ represents current-period values of the control variables: macroeconomic uncertainty, financial uncertainty, and geopolitical risk. We also include separate dummies for each Fed chairperson. We pay close attention to the timing, e.g., associating dissenting votes at the current meeting with MPU over the following inter-meeting period.\(^\text{18}\)

As seen in Table 2, the regression coefficients are mostly of the anticipated sign. Statement Persistence is negative and significant while FOMC-revealed uncertainty is positive and significant. Greater similarity in the language used by the FOMC from meeting to meeting is followed by lower MPU, while greater uncertainty expressed by Committee members in the inter-meeting period is followed by higher uncertainty. Notice that these coefficients are significantly higher in the regressions for short-run MPU than overall MPU. We also find that greater financial uncertainty and geopolitical risk are robustly followed by higher MPU.

This analysis indicates that there is some significant effect of FOMC communications on MPU. However, at a deeper level the conceptual underpinning of our MPU index is potentially quite encompassing. Consider the increased importance of forward guidance, especially as interest rates hit the effective lower bound. Gurkaynak, Sack, and Swanson (2005) show that much of the surprise news about monetary policy at the time of FOMC announcements arises from signals about the central bank’s intentions about future monetary policy. Far future forward guidance has also been shown to be extremely powerful (e.g. Eggertsson and Woodford (2003), Del Negro, Giannoni, and Patterson (2012), Carlstrom, Fuerst, and Paustian (2015)): promises about far future interest rates have huge effects on current economic outcomes, and these effects grow with the horizon of the forward guidance. However, uncertainty also grows with the horizon of central bank promises, given limited central bank credibility and imperfect communication strategies. Episodes of financial turmoil, for example, around the Taper Tantrum of 2013 and prior to the October 2015 FOMC meeting, made apparent that a great deal of uncertainty exists regarding the timing of liftoff, for example.

\(^{18}\)We also tried several other controls, e.g., natural disaster and Ramey fiscal policy shocks, as well as dissenting votes at each FOMC meeting and Committee member turnover, but found them to be insignificant. Appendix D describes all of the variables used in this analysis.
Our MPU index is able to capture this uncertainty regarding the timing and path of future interest rates.

There is also a theoretical literature examining the effects of uncertainty on central bank communication and policy rules. An earlier part of the literature modeled uncertainty about the interest rate rule. Rudebusch (2001, 2002) considers uncertainty about the parameters in the central bank's policy rule, as well as real-time data uncertainty. Ehrmann and Smets (2003) examine implications of optimal monetary policy when the central bank follows a Taylor Rule but there is uncertainty about potential output. One result is that it is optimal to appoint a more “hawkish” central bank. Levin, Wieland, and Williams (2003) consider optimal monetary policy when the central bank does not know the “true” model of the economy and so considers several alternatives. They identify the key characteristics of policy rules that are robust to such uncertainty. In Eusepi and Preston (2010), agents have uncertainty about the interest rate path that the central bank will follow, while the central bank has uncertainty about the economic state. They show that, absent communication, the Taylor principle is not sufficient for macroeconomic stability, and analyze several different communication strategies for the central bank. More recently, Bianchi and Melosi (2012, 2016) model monetary policy under the assumption that agents have uncertainty about whether the central bank is following “passive” or “active” inflation stabilization.

C.3 Baker, Bloom, and Davis’ (2016) Monetary Policy sub-index of EPU

We begin by noting the relatively low correlation between MPU-HRS and MPU-BBD, which is .49 over the full sample and (.31) after 2008. Their index has more pronounced spike-ups than ours early in the sample, remained well below average throughout 2014 and into 2015, and is subdued relative to our index during the October 2015, December 2015, and January 2016 FOMC meeting intervals.

To try and understand this, we first examine the role of scaling. The correlation between MPU-HRS and MPU-(HRS terms, HRS papers, BBD scaling) is .85 (.92, post-2008). The correlation between MPU-BBD and MPU-(HRS terms, HRS papers, BBD scaling) is .46 (.46). These two cases, against the backdrop of the weak correlation between MPU-HRS and MPU-BBD, indicate that scaling does not matter much: in the former, we see that changing MPU-HRS only by adopting the BBD scaling maintains a high correlation with MPU-HRS, while the latter case indicates that this same strategy change leaves the resulting index weakly correlated with MPU-BBD.

Second, we examine the role of the keyword search. The correlation between MPU-HRS and MPU-(BBD terms, HRS papers, HRS scaling) is .75 (.76), while that between MPU-BBD and MPU-(BBD terms, HRS papers, HRS scaling) is .42 (.57). These two cases tell us that changing terms matters a little bit more than scaling. That is, the former says that changing
MPU-HRS only by using the BBD keyword search leaves a decently high correlation with MPU-HRS, though not super high, while in the latter case we learn that changing MPU-HRS only to use the BBD keywords leaves the resulting index weakly correlated with MPU-BBD (though notably higher post-2008).

Third, and finally, we examine MPU-HRS vs. MPU-(BBD terms, HRS papers, BBD scaling), and find correlations of .62 (.68), and MPU-BBD vs. MPU-(BBD terms, HRS papers, BBD scaling) with correlations of .39 (.72). These last two cases are more difficult to assess. For the most part they suggest that if all BBD were to do was use only our smaller set of newspapers, there would be a decent correlation with our MPU-HRS index and in the full sample period a poor correlation with what they compute from using the large set of newspapers. This indicates that newspaper choice matters. Baker, Bloom, and Davis (2016) use the Access World News database of over 2,000 newspapers, while we use the three major U.S. newspapers that are more tailored to national financial news.

We conclude from our reconciliation analysis that in order of importance, the factors explaining the weak correlation between MPU-HRS and MPU-BBD can be ranked: (1) Newspapers, (2) Keywords, and (3) Scaling. Given their significantly larger set of search terms and newspapers, it is likely that theirs captures a relatively larger global factor while ours is more U.S. centric.

Figure C.2: MPU Index vs. sub-category EPU

Baseline MPU index against monetary policy sub-index of Baker, Bloom, and Davis (2016).

D Proximate Determinants of MPU

D.1 Dissenting votes

The Federal Open Market Committee consists of the seven Federal Reserve governors and five Federal Reserve Bank presidents on a rotating basis. The FOMC ordinarily meets eight
Table D.1: Does FOMC Communication Influence MPU?

<table>
<thead>
<tr>
<th></th>
<th>MPU</th>
<th>SR MPU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Statement/Minute Uncertainty</td>
<td>0.118*</td>
<td>0.188*</td>
</tr>
<tr>
<td></td>
<td>(2.18)</td>
<td>(2.27)</td>
</tr>
<tr>
<td>Statement Persistence</td>
<td>-39.56†</td>
<td>-33.67†</td>
</tr>
<tr>
<td></td>
<td>(-1.92)</td>
<td>(-1.92)</td>
</tr>
<tr>
<td>Financial Uncertainty</td>
<td>17.87</td>
<td>112.7</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(1.25)</td>
</tr>
<tr>
<td>Macro Uncertainty</td>
<td>-192.3†</td>
<td>-116.2</td>
</tr>
<tr>
<td></td>
<td>(-1.77)</td>
<td>(-1.15)</td>
</tr>
<tr>
<td>Geopolitical Risk Index</td>
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<td>0.299**</td>
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<td></td>
<td>(1.70)</td>
<td>(5.14)</td>
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<tr>
<td>Constant</td>
<td>260.5**</td>
<td>96.02</td>
</tr>
<tr>
<td></td>
<td>(3.00)</td>
<td>(1.05)</td>
</tr>
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<td>Chair Dummies</td>
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<td>Yes</td>
</tr>
<tr>
<td>Dummy 2008H2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
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<td>128</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.108</td>
<td>0.227</td>
</tr>
<tr>
<td></td>
<td>0.181</td>
<td>0.212</td>
</tr>
</tbody>
</table>

times per year and at each meeting votes on a directive that governs monetary policy during the period between meetings. The policy directives are usually supported by a strong majority but voting often involves dissent (Figure D.2). Dissent could reflect fundamental disagreement about how to achieve the Committee’s objectives and could potentially represent shocks to the preferences of the monetary authority. The FOMC dissenting votes have been revealed in the postmeeting statements only since March 2002. However, they have been included in the minutes since the mid 1990s. Recalling that we lag dissenting votes by one period, it is not ill-designed to examine the relationship with MPU before March 2002.

In the first row of Table D.1, we show that there is a positive correlation between the percentage of FOMC dissenting votes at one meeting and the level of MPU during the following inter-meeting period. A “united front” of the FOMC participants does seem to convey to the public that a sudden deviation from the central bank’s reaction function due to preferences shocks is unlikely in the near term. The effect is not particularly significant, however.

D.2 Statement persistence

The Federal Open Market Committee’s postmeeting statements constitute one of the key vehicles through which the Committee communicates its assessment of the economy, its policy actions, and its thinking about future policy. In February 1994, Chairman Greenspan issued the first postmeeting statement following the FOMC’s decision to tighten monetary policy – the first increase in the target federal funds rate since 1989. For the next five years, a statement was released only after meetings in which the FOMC decided to change rates, but in May 1999 the committee began releasing statements at the conclusion of every meeting.
Using techniques developed in computational linguistics, Meade and Acosta (2015) construct a measure of how persistent the content of the statements has been, by calculating the correlation (similarity) of words used in two consecutive postmeeting statements. If identical words are used in consecutive FOMC statements, ignoring changes in word order, the similarity will equal unity. The addition or subtraction of words or the use of the same words in different proportions will reduce similarity between consecutive meetings.

The Meade-Acosta measure of statement persistence is displayed in Figure D.3, along with MPU. Meeting-to-meeting similarity rose between May 1999 through mid-2007. It then fell to an historic low (below 0.20) between the October 2008 and December 2008 meetings when the FOMC reduced the Fed Funds target rate to a range of 0 to 1/4 percent amid a widening crisis. Average persistence declined during the financial crisis and then rose to a very high level through 2014.

As shown in Table 1, we find a negative correlation between persistence in FOMC statements (from the previous meeting to the current) and monetary policy uncertainty perceived by the public (regarding the period up to the next meeting). When the semantic content of FOMC statements from one meeting to the next is similar, the public seems to perceive little change in the central bank’s policy stance and projects limited uncertainty going forward.

### D.3 Uncertainty perceived and conveyed by the central bank

“Part of the game is confidence, and looking clueless and uncertain doesn’t help.”

— Ben Bernanke (2015)

We conjecture that the public’s uncertainty regarding monetary policy is influenced by the degree of uncertainty the Federal Reserve itself perceives and conveys. To examine this, we construct indicators of uncertainty conveyed in publicly archived FOMC documents including statements, minutes, testimony, speeches, and the Chair’s postmeeting press conferences. We use automated text-search to calculate the frequency of words that suggest uncertainty, including synonyms that are taken from a thesaurus. Consistent with our conjecture, Table 1 shows that the degree of uncertainty conveyed in FOMC statements and minutes, displayed in Figure D.1, is positively correlated with contemporaneous monetary policy uncertainty that the public perceives, but only weakly so. Uncertainty conveyed in FOMC speeches and testimonies is also only weakly correlated with MPU.

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19Uncertain, ambiguous, ambivalent, dubious, erratic, hazy, hesitant, insecure, precarious, questionable, risky (this does not include the noun risk), unclear, undecided, undetermined, unpredictable, unreliable, unresolved, unsettled, unsure, and vague (and their derivatives). We sum instances of these words on a document-by-document basis and divide this raw count by the number of total words in the release. In the case of minutes and statements, the resulting observation is just an addition of these two measures on a meeting-date basis. In the case of the speeches and testimony, this is the summed linear combination of all of the speeches and testimony observations in the inter-meeting period.
D.4 FOMC member turnover

A significant turnover of FOMC members may lead to unanticipated changes in the central bank’s policy stance and introduce disparate and unknown voices at the Fed, making it difficult to convince the public with a coherent monetary policy message. Our measure of member turnover is the number of FOMC participants leaving or joining the FOMC for the first time at the current meeting. The coefficients on FOMC member turnover in Table 1 are positive as expected and yet only occasionally significant. One main challenge of identifying the effects of personnel turnover is that such changes are typically anticipated ahead of time (e.g., the recently announced resignation of Governor Tarullo will take place a couple of months hence), and it is difficult to pinpoint when turnover becomes public knowledge. Thus, we do not consider the lack of statistical significance here as dismissing the role of FOMC member turnover in affecting monetary policy uncertainty.

D.5 Endogeneity

Although we are careful about temporal considerations in correlating our measures with MPU in Table 1, and despite the intuitive appeal of the resulting correlations, inference is complicated by concerns of simultaneity and omitted factors. There likely exists hard-to-measure forces, each with varying degrees of quiescence, which simultaneously create, e.g., more monetary policy uncertainty and less agreement among FOMC members about policy prescriptions. We attempt to make progress by controlling for (reasonable proxies of) such hard-to-measure forces. To this end, we employ measures of U.S. macroeconomic uncertainty and financial uncertainty, geopolitical risk, U.S. defense spending shocks, and U.S. natural disasters. The potential importance of macro or financial uncertainty speaks for itself: uncertainty about FOMC policy actions could be high when the basis on which policy is made, the current and expected future state of the U.S. economy, is perceived as highly uncertain. The appealing feature of the latter three controls is that they are arguably orthogonal to the error terms in the MPU regressions that contain only the FOMC institutional/procedural variables. We briefly describe these controls in the following subsections.

D.5.1 Macroeconomic uncertainty and financial uncertainty

Imperfect information about the current and expected future state of the economy is another source of uncertainty regarding central bank policy. There is measurement error in the preliminary data available to the FOMC at the time it makes decisions. The actual position of the economy at any time is only partially known, as key information on spending, production, and prices becomes available only with a lag (and is furthermore continuously revised). Therefore, policy makers must rely on estimates of these economic variables when
assessing the appropriate course of policy, aware that they could act on the basis of incomplete or misleading information. Uncertainty about policy actions could be high when the basis on which policy is made is perceived as highly uncertain by the public. This in turn could be correlated with, e.g., FOMC-revealed uncertainty. To control for this, we use the macroeconomic uncertainty measure of Jurado, Ludvigson, and Ng (2015), an econometric estimate of whether the economy has become less or more predictable, and the financial uncertainty measure of Ludvigson, Ma, and Ng (2016), which is also estimated – from an iterative projection instrumental variables method.\footnote{We use their 12-month ahead measures as this is a better conceptual match with our MPU than the 1-month or 3-month horizons. Results are quite similar irrespective of which of their horizon-measures we use. We also find robustness to using Scotti’s (2016) alternative measure of macroeconomic uncertainty.}

Contemporaneous uncertainty about the financial state of the economy is positively, and often significantly, correlated with MPU. On the other hand, macroeconomic uncertainty contributes to uncertainty the public perceives about monetary policy in a way that is unstable over time. Prior to 2008, the estimated relationship (not displayed) is positive irrespective of other controls in the regression, while in the regressions that go through 2015 the estimate is negative and sometimes significantly so.


The geopolitical risk index (Caldara and Iacoviello 2017) is calculated using a methodology similar to that used in constructing our MPU index. They search over 11 major U.S. and British newspapers for mentions of the words: geopolitical risk(s), concern(s), tension(s), uncertainty(ies), war risk(s) (or risk(s) of war) and military threat(s), as well as mentions of terrorist threat(s). Our expectation that geopolitical risk will be positively correlated with MPU is confirmed, and indeed we see that it is quite significant statistically as well.

Ramey (2011) constructs a measure of “news” about future government spending, by reading news sources to gather quantitative information about expectations. Her defense news variable measures the expected discounted value of government spending changes due to foreign political events. The series was constructed by reading periodicals (e.g., Business Week) in order to gauge the public’s expectations. According to Ramey, the constructed series should be viewed as an approximation to the changes in expectations at the time. In calculating present discounted values, she used the 3-year Treasury bond rate prevailing at the time. We estimated all of our regressions with Ramey’s variable included. These specifications never produced estimates of her variable with a t-statistic greater than 0.50, and never had any material effect on the other estimated coefficients, so we do not report these results.

As a final control, we construct a measure of fatalities resulting from notable natural disasters that occurred in the United States. These include cyclones (Rita, Katrina), torna-
does, hurricanes, floods, blizzards, snow storms, earthquakes, and heat waves.\textsuperscript{21} We expect this also to be positively correlated with monetary policy uncertainty. In this case too, the estimated coefficients are not significant.

D.5.3 Instrumental variables

All of the OLS estimates displayed in Table 1 convey a consistent message: there is an important association between FOMC communications and monetary policy uncertainty, even when controlling for reasonable proxies of omitted factors that might account for some of this relationship. Of course, these additional controls are not playing the role of instruments. Hence, we also estimated regressions for MPU using both two-stage least squares (2SLS) and limited-information maximum likelihood (LIML). We tried a variety of instruments, alone and in combination with each other, including first lags of each of the $X$ variables and each of our control variables $Z_t$ (as well as the first lag of macro uncertainty). We found that these instruments are “weak”, however, leaving us without reliable IV estimates.\textsuperscript{22}

Angrist and Krueger (2001) note that finding good instruments is difficult in practice. They do discuss the popularity of using instruments derived from “natural experiments”. Analogous randomized experiments are not likely in our application, however. Just as it is not feasible to coerce a randomly chosen group of people, e.g., to quit smoking, randomization in something like the semantic content of FOMC statements is unthinkable.

D.6 Proximate determinants: plots of the series

The following three figures depict some of the variables described above, namely: “FOMC-revealed uncertainty” (against MPU), (ii) dissenting votes, and (iii) FOMC statement persistence (against MPU).

\textsuperscript{21}https://en.wikipedia.org/wiki/List_of_natural_disasters_in_the_United_States.

\textsuperscript{22}For example, in the 2SLS estimates we typically found F-statistics from first stage regressions in the neighborhood of 1.0 to 3.5 or lower, well below the recommended cutoff of 10 (Stock and Yogo (2005)). The most valid instrument, unsurprisingly, was lagged macro uncertainty instrumenting for itself.
Figure D.1: MPU and FOMC-Revealed Uncertainty

Baseline MPU index against the our measure of uncertainty revealed in FOMC Statements and Minutes.

Figure D.2: Dissenting Votes

Baseline MPU index against the percentage of FOMC members voting against the Committee decision.

Figure D.3: MPU and Statement Persistence

Baseline MPU index against similarity of FOMC statements from meeting to meeting (Meade and Acosta (2015)).
E VAR robustness

Figure E.1: MPU Shock, Cholesky, machine-learning EPU
References


Reserve System (US).


