Policymakers' Uncertainty

Preliminary

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We study how uncertainty affects decision-making in the context of monetary policy. We exploit the rich informational content of the Federal Open Market Committee (FOMC) meetings to construct text-based measures of uncertainty that policymakers confront as well as policy preferences they express. Our identification relies on the regular structure of the FOMC meetings, which separate discussions of the economic environment from policy deliberations. By distinguishing different sources of uncertainty related to inflation, the real economy, financial markets, and models in the economy round of the meeting, we show their distinct effects on policy preferences. In particular, heightened inflation uncertainty and, to some degree, uncertainty about the real economy lead to an amplification rather than attenuation of the monetary policy response to the macroeconomy. This fact presents a departure from certainty equivalence frequently assumed in monetary models and contrasts with the oft-referenced conservatism principle of policymaking under uncertainty. Instead, the evidence suggests that policymakers display some preference for robustness to avoid costly outcomes. We discuss quantitative implications of our findings for models of optimal monetary policy.

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I. Introduction

Alan Greenspan famously said, "(...) uncertainty is not just a pervasive feature of the monetary policy landscape; it is the defining characteristic of that landscape" (Greenspan, 2004). Yet, despite the ubiquitous emphasis on uncertainty in central bankers' speeches and statements, and the expansive literature on optimal monetary policy under uncertainty, we know little about how uncertainty affects monetary policy decisions. One well-known result frequently quoted to describe how policymakers should behave under uncertainty goes back to Brainard (1967), who has postulated a more conservative stance. However, the theoretical predictions about the effects of uncertainty are highly model-specific; depending on the assumptions about the structure of the economy and policymakers' preferences, uncertainty can induce more or less aggressive optimal policy response, or no response at all. On the empirical front, the challenges pertain to both measuring uncertainty that policymakers face and disentangling its effect from other confounders, most importantly, the first-moment beliefs about the state of the economy.

In this paper, we take a first step at characterizing the uncertainties that decision makers at the US Federal Reserve deal with and the effects that this has on their policy preferences. Our approach relies on the textual analysis applied to the deliberations of the Federal Open Market Committee (FOMC) that are captured in the transcripts of the scheduled FOMC meetings between 1987 and 2015.

Given the wealth of information that is available, the FOMC setting is uniquely suited to study the impact of uncertainty on decision making. At each meeting, we observe nearly verbatim statements by individual FOMC members and the Federal Reserve Board staff. In addition, through the so-called Greenbook/Tealbook forecasts prepared by the staff prior to each meeting, we also gain access to the baseline macroeconomic expectations that policymakers are equipped with before they enter the meeting. This content allows us to construct proxies for policymakers' beliefs, uncertainty, and preferences in a mutually consistent manner that is rarely feasible in other contexts. While the use of text to measure uncertainty is increasingly common in the literature following the influential contribution by Baker, Bloom, and Davis (2016), we can precisely attribute uncertainty language to actual decision makers and tie it to their policy preferences.

In terms of establishing causality from expressed uncertainty to policy, we exploit the typical structure of the FOMC meetings. With minor exceptions, the meetings during our sample

are comprised of two rounds, each serving explicitly different objectives. In the first round, which we refer to as the economy round, policymakers discuss the economic and financial market developments and the baseline outlook. This step lays the foundation for the second round—the policy round—which contains discussions about the appropriate policy choice and during which the policy decision takes place. Thus, we study how uncertainty manifest in the first round (which is plausibly exogenous with respect to the policy decision) affects policy preferences communicated in the second round. This approach helps alleviate concerns about reverse causality, i.e., policy choice at a given meeting causing policymakers' uncertainty about its feedback onto the economy.

Policymakers' uncertainty is a multifaceted object. Its various dimensions pertain to the distinction between risk and uncertainty as well as to the specific economic concepts toward which uncertainty is directed. We use the term "uncertainty" in a broad sense, which reflects the practical challenges associated with identifying and measuring uncertainty. Although the theoretical distinction between risk and uncertainty has been formalized by Knight (1921), separating the two concepts in practice is non-trivial. As such, the measurement challenges we face as econometricians parallel those encountered by decision makers, as depicted by Greenspan (2004):

> The term 'uncertainty' is meant ... to encompass both "Knightian uncertainty," in which the probability distribution of outcomes is unknown, and "risk," in which uncertainty of outcomes is delimited by a known probability distribution. In practice, one is never quite sure what type of uncertainty one is dealing with in real time, and it may be best to think of a continuum ranging from well-defined risks to the truly unknown.

To reflect these complexities, we adopt a two-pronged approach to characterize the properties of policymakers' uncertainty. In the first step, we measure overall uncertainty expressed in the economy round of the meetings using word embeddings—a tool from computational linguistics—for terms "risk" or "risks" and "uncertainty" or "uncertain." Our baseline policymakers' uncertainty index, which we label as the PMU, is a count of phrases related to risk and uncertainty relative to the overall count of tokens in the economy round of a given meeting. As such, it depicts the intensity with which policymakers express uncertainty when discussing macroeconomic situation. Crucially for our subsequent analysis, in the second step, we separate the uncertainty language into topic categories, distinguishing uncer-

tainty about inflation, real economy, financial markets, models and forecasts, and a residual ("other") category. For a precise attribution to a topic, we develop a set of algorithms that match uncertainty phrases with topic-specific phrases at a sentence level.

We first confirm Greenspan's claim by establishing that policymakers' perceptions of "risk" comove closely with their perceptions of "uncertainty." Therefore, for most of our analysis, we do not attempt to disentangle the two concepts. We then show that uncertainties related to inflation, real economy and financial markets account for the vast portion of uncertainty mentioned in the transcripts. The correlations between the topic-specific PMU indices are low across the board (e.g., inflation and real economy PMUs have correlation of 0.1), suggesting that our classification distinguishes largely orthogonal aspects of policymakers' uncertainty.

Our first set of results pertains to the variation of PMU over the business cycle. Contrary to various measures of public uncertainty in the literature, policymakers' uncertainty does not fluctuate in an evidently countercyclical manner. As one example, the highest readings of the PMU for the real economy precede the global financial crisis by about a year, coinciding with a still depressed VIX and a strong stock market; elevated uncertainty regarding the situation in financial markets likewise anticipates the financial crisis several months before it materializes in the VIX. Interestingly, the inflation PMU is in fact strongly procyclical. The fact that policymakers become uncertain about inflation when the economy is doing well suggests that they are concerned with demand-induced deviations of inflation from the target.

In general, uncertainty is a non-directional concept that should describe a perceived breadth of possible unknown outcomes. Different models (which we discuss below) introduce uncertainty in different ways as, for example, stochastic volatility of disturbances or a variance around unknown parameters. However, there is no guarantee that when policymakers talk about uncertainty in the meeting they actually think in this non-directional way, as opposed to expressing concerns about particularly undesirable outcomes. To cast light on this issue, we therefore complement the PMU indices with topic-specific measures of directional language, reflecting policymakers' views about the direction of inflation, real economy, and financial markets. We refer to the directional language broadly as sentiment. Together with the proxies for macroeconomic expectations in the Greenbooks, the sentiment indices serve

to control for the variation in the conditional means or, potentially, higher-order moments of the distributions (e.g., skewness) that policymakers perceive.

Examining potential drivers of policymakers' uncertainty, we establish several new results. First, while we fail to find a strong relationship between the PMU and the Greenbook forecasts or forecast updates (i.e., the conditional first moments), there is some evidence that inflation uncertainty increases after Greenbook forecast errors have become particularly large. One interpretation is that inflation uncertainty stems from the uncertainty about the correct model specification. Second, we document a tight link between uncertainty and the directional language. This link reveals an important asymmetry: the PMU comoves much more with the negative sentiment expressed in the meeting than it does with the positive sentiment. Such an asymmetric relationship is especially strong for inflation, whereby negative sentiment indicates rising inflation. We interpret this finding as consistent with policymakers' uncertainty reflecting a concern about particularly costly outcomes they perceive. We show that negative inflation sentiment in the meeting does not have any predictive power for future economic outcomes; as such, it is an expression of worry that does not materialize itself in the sample we study.

We then turn to the analysis of how uncertainty affects policy preferences. To this end, we develop a new textual measure of policy preferences based on the balance of hawkish and dovish language—the hawk-dove score—of the FOMC members in the policy round of the meeting. This approach allows us to span the entire 1987–2015 sample, including the zero-lower-bound period. We document that the hawk-dove score varies in an intuitive way and is a highly significant predictor of the federal funds rate (FFR) target. Importantly, its predictive power for the FFR is not subsumed by the Greenbook forecasts that are usually included in estimated Taylor rules, implying that policy preferences derived from the text capture primarily monetary policy news. Accordingly, we show that the hawk-dove score alone explains about a quarter of the variation of the Romer and Romer (2004) shocks. Its information content, however, goes beyond the current policy stance. Consistent with a forward-looking nature of policy discussions in the transcripts, the hawk-dove score has significant explanatory power for high-frequency monetary policy surprises based on market interest rates and it forecasts FFR target changes several meetings ahead.

Given the above properties, we use the hawk-dove score as the dependent variable describing the FOMC members' policy preferences and estimate various specifications of text-based

policy rules. Uncertainty in the economy round of the meetings predicts preferences when controlling for the variation in the Greenbook expectations and the directional language. The key new insights stem from our ability to distinguish between the types of uncertainty. We show that topic-specific components of uncertainty have distinct effects on policy preferences. As a starting point, a higher PMU for the real economy and financial markets both predict an easier policy stance. To the extent that these types of uncertainty influence the economy akin to a negative demand shock, this result is broadly consistent with the real option channel of uncertainty (e.g., Bloom, 2009). However, because the effect is not subsumed by the Greenbook controls, it also indicates that the staff forecasts (and perhaps the Fed models in general) do not fully take the impact of uncertainty on board.

The predictive power of inflation uncertainty for policy preferences reveals a new and separate channel at work that, to our knowledge, has not been widely discussed in the literature. In contrast to the economy and market PMU, higher inflation PMU predicts a more hawkish tilt of policy preferences. This directional effect coincides with increased model uncertainty also related to more hawkishness in the meeting. Taken together, this suggests that more inflation uncertainty is associated with policymakers' concern about model misspecification. To tie these empirical facts more closely to theoretical predictions regarding optimal policy under uncertainty, we estimate a version of a policy rule in which we allow uncertainty to affect the strength of the policy response to inflation and growth. We find that inflation uncertainty indeed leads to an amplification of the policy response to fluctuations in expected inflation. While absent inflation uncertainty, policymakers' response to inflation remains muted, an increase in the inflation PMU from the 5th to the 95th percentile leads to a tripling of the coefficient. At the same time, we fail to find any impact of inflation uncertainty on the strength of the policymakers' response to economic growth.

The amplifying effect of uncertainty on the Fed's reaction contrasts with the oft-referenced conservatism principle of Brainard (1967). It is, however, consistent with models in which policymakers face uncertainty about structural inertia in the inflation process (e.g., Söderström, 2002) or display robustness concerns (e.g., Giannoni, 2002). As a benchmark for our empirical estimates, we illustrate the implications of leading models in the literature and conclude that, for standard calibrations, their predicted impact of uncertainty on optimal policy remains economically small relative to the empirical findings.

The remainder of the paper proceeds as follows. In Section II, we lay out the different theoretical channels proposed in the literature through which uncertainty can affect monetary policy. In Section III, we discuss our empirical strategy, the measurement of uncertainty, and the construction of our PMU indices. In Section IV, we study the properties of topic-specific uncertainty over the business cycle, its link with macroeconomic expectations, and with the policymakers' directional language. In Section V, we introduce the text-based measures of policy preferences and use those proxies to analyze the effect of uncertainty on preferences. In Section VI, we illustrate the theoretical predictions of how uncertainty should affect policy in several popular modelling frameworks.

II. The Effects of Uncertainty on Monetary Policy

Policymakers spend a great deal of time reviewing the currently available data, evaluating the drivers of recent economic behavior, and then extrapolating to the likely future evolution of the economy. We can summarize policymakers' current assessment of the state of the economy (including its likely evolution) with Ω_t. In economic models, Ω_t is often a function of past economic conditions (Ω_{t-1}) as well as newly-realized structural shocks (such as demand shocks, price-markup shocks).

Suppose the central bank adjusts interest rates in reaction to economic conditions in order to achieve its objectives. A typical way to represent the policy behaviour is as a reaction function

$$i_t = \phi' \Omega_t + \epsilon_t^{MP}, \tag{1}$$

where i_t is the policy interest rate, ϕ is a vector of coefficients capturing the response of the policymakers to the state of the economy, and ϵ_t^{MP} represents monetary policy shocks.

The effects of uncertainty on monetary policy can be broadly classified into three types:

1. No effect of uncertainty: certainty equivalence;
2. Uncertainty as an economic shock (reflected in Ω_t) to which the central bank responds in its typical way;
3. Uncertainty changes the ϕ coefficients.

Below, we briefly discuss each in turn.

II.A. Certainty equivalence

Many classic models in monetary economics feature a linear-quadratic environment: the structure of the economy is linear and the policymaker's loss function is quadratic. A common assumption is that only the structural macroeconomic shocks (additive shocks to state variables in Ω_t) are stochastic, whereby rising uncertainty corresponds to an increase in the variance of these shocks. In such environments, optimal policy, captured by ϕ coefficients that minimise the policymaker's loss function, does not depend on the volatility of the structural shocks. This result—known as the certainty equivalence—implies that changes in uncertainty do not affect the coefficients of the optimal policy rule. As such, the central bank reacts to its assessment of the economy in the same way no matter if uncertainty is high or low.[2]

II.B. Uncertainty as economic shocks to which monetary policy reacts

A growing theoretical literature shows that fluctuations in uncertainty have real economic effects. In general, rising uncertainty acts akin to a negative demand shock. Uncertainty shocks cause a rapid drop, rebound, and overshoot in employment, output, and productivity growth, and these effects can arise through various theoretical channels. Bloom (2009) studies a real-option-value channel of employment and investment decisions driven by investment and employment adjustment costs and stochastic volatility. Basu and Bundick (2017) emphasise the role of sticky prices in generating the effects of uncertainty shocks. In the short run, output becomes determined by demand (rather than supply) and hence variation in demand (induced by uncertainty) gives rise to real effects. In a related way, Leduc and Liu (2016) suggest an option-value channel that arises from search frictions and interacts with a demand channel that arises from nominal rigidities.[3] Empirical evidence in these studies supports the interpretation of uncertainty shocks propagating like aggregate demand shocks that raise unemployment and lower inflation.[4]

[2]Of course, in a more 'uncertain' environment, larger shocks occur more frequently and policy responds to these shocks to the extent they are represented in Ω_t.

[3]Bianchi, Kung, and Tirskikh (2018) introduce both demand- and supply-side uncertainty shocks. Comparing the effects of the two sources of uncertainty, they find that supply-side uncertainty generates larger effect on inflation and investment because such shocks induce more severe recessions.

[4]For example, Baker, Bloom, and Davis (2016) find that an innovation to their economic policy uncertainty index (EPU) calibrated to the change from 2005/6 (before financial crisis) to 2011/12 (period of high EPU levels) causes a decline in industrial production of 1.1% and in employment of 0.35% (about one third of a typical business cycle variation in employment). Basu and Bundick (2017) show that an uncertainty shock

This literature emphasises uncertainty of economic agents outside the FOMC. In terms of the monetary policy response, since such uncertainty manifests itself as a structural shock, the Fed in line with its mandate reacts in the same way as it would to other demand shocks: The shock impacts the policymakers' assessment of the economy, Ω_t, which in turn leads to the usual monetary policy reaction induced by the change in the economic state. This logic does not overturn the certainty equivalence in that the optimal response coefficients do not change, but rather, uncertainty now has a direct effect on policy because it is itself a source economic fluctuations.

II.C. Changes in the optimal response coefficients

Several modelling approaches break away from certainty equivalence by allowing uncertainty to induce changes in the optimal response coefficients. In the language of equation (1), the ϕ parameters become a function of the policymaker's uncertainty. Different models, however, have different predictions as to whether uncertainty induces a more or less aggressive response to economic conditions (larger or smaller ϕ parameters).

A first source of departure from certainty equivalence stems from assumptions about the information that the policymaker has. In a classic example, Brainard (1967) considers uncertainty about specific parameters. The policy multiplier, which determines how policy affects the economy, is stochastic and the policymaker only knows the distribution from which it is drawn. In this scenario, optimal policy differs from the policy which would be pursued in a world of certainty. In particular, Brainard (1967) finds that policy should be less aggressive—a result known as the Brainard conservatism principle.

Söderström (2002) challenges the Brainard conservatism result, by introducing parameter uncertainty on a different set of parameters in a standard monetary model. For uncertainty about parameters that describe how the interest rate impacts the output gap and how the output gap impacts the next period inflation, the Brainard conservatism result holds. It also holds for uncertainty around the persistence of the output gap. However, introducing uncertainty about the persistence of inflation leads the central bank to become *more* aggressive in its policy. The intuition is as follows: When the dynamics of inflation are uncertain, the amount of uncertainty (i.e., the parameter variances) facing policymakers is greater, the

(measured using the stock market implied volatility index VXO) causes statistically significant declines in output, consumption, investment, and hours. Similarly, Leduc and Liu (2016) argue that unexpected increase in uncertainty (from the VIX) leads to a persistent increase in unemployment and decline in inflation.

further away the inflation rate is from its target. Consequently, to reduce the uncertainty about the future path of inflation, the optimal policy becomes more aggressive, pushing inflation closer to the target compared to the certainty case.

An alternative channel that can break the certainty equivalence is the policymakers' desire for robustness. The idea behind the robust control approach to monetary policy is that the policymaker is uncertain about their model of the economy and seeks a policy that is robust to the worst possible form of misspecification (Hansen and Sargent, 2001; Giordani and Söderlind, 2004; Hansen and Sargent, 2008). Rather than specifying a particular form of uncertainty, the robust policymaker solves for an optimal policy using a min-max approach: The optimal policy selects the minimum loss in the version of the distorted model that causes maximum expected loss (subject to limits on how distorted the alternative model can be). Certainty equivalence fails because, even with a linear-quadratic setup, the coefficients of the optimal policy function depend on the variance of the structural shocks. Generally, uncertainty manifests itself through a more aggressive reaction function (larger ϕ coefficients).

In summary, the theoretical predictions for the effects of uncertainty on policy behavior depend on the source of uncertainty and the reason why policymakers display uncertainty. In order to make progress on understanding how they actually respond to the uncertainty they face, we explore the issue empirically in subsequent sections.

III. Measuring Policymakers' Uncertainty

In this section, we detail how we use the FOMC transcripts to construct text-based measures of risk and uncertainty about various dimensions of the economic environment. The basic strategy is to exploit the local co-occurrence of terms that denote risk and uncertainty with terms that denote specific economic concepts like inflation and wages, or economic growth. The use of local co-occurrence patterns to build text-based proxies for economic phenomena has been pioneered by Mikael and Blix (2014) in the monetary policy context and by Hassan, Hollander, van Lent, and Tahoun (2019) to measure specific types of uncertainty in a corporate context. Our innovation is to apply these ideas to analyze the impact of perceived risk and uncertainty on policy preferences.

III.A. Transcript data and identification strategy

The main textual source we draw from is the nearly verbatim transcripts of Federal Open Market Committee deliberations, available online.[5] These transcripts contain a fully attributed, statement-by-statement account of meetings with very light editing, for example to remove the names of specific banks with which the Fed conducts open market operations. The sample period we consider consists of the 228 meetings from August 1987 (the first meeting of Alan Greenspan's Chairmanship) through December 2015 (the last meeting for which a transcript was available at the time of data processing).[6] Regular FOMC meetings occur eight times per year, with occasional special meetings convened via conference call during times of macroeconomic turbulence. Since the format of these calls is somewhat irregular, we only consider regular meetings in our analysis.

The typical composition of the FOMC consists of 19 members, of which twelve are regional Fed Presidents and seven are Governors. During our sample, a total of 75 unique FOMC members appear in the transcripts in at least one meeting. A number of Fed staff economists also participate in the meetings.

The first step in preprocessing the transcripts is to break each statement by each speaker into separate sentences using a standard sentence tokenizer. This yields 559,709 total sentences, which form the basic units of linguistic analysis for the algorithms we propose below.

An important concept in our framework is the exogenous uncertainty that policymakers face, as opposed to the endogenous uncertainty they may create among outside agents due to their policy actions. Separating out one from the other is crucial for establishing a causal link from uncertainty to policy preferences. We obtain such separation by exploiting the structure of the FOMC meetings—the sequencing of discussions of economic conditions prior to policy deliberations. The meetings follow a similar agenda during our entire sample period.

The first core part of FOMC meetings is the *economy round* during which staff economists at the Fed first present their forecasts of economic activity (contained in Greenbooks/Tealbooks) along with supporting contextual information. Each FOMC member in turn presents his or her views on economic developments, which can differ from the views of the staff. Importantly, during this part of the meeting neither Fed staff nor FOMC members explicitly discuss their policy preferences. Therefore, we assume that uncertainty language used during the

[5] See https://www.federalreserve.gov/monetarypolicy/fomc_historical.htm

[6] Only a small part of the May 1988 meeting was transcribed, so we treat it as a missing observation.

economy round of the meeting relates to the exogenous uncertainty that the Fed faces at the time of the meeting. Sentences in the economy round make up 43% of the total sentences in the transcripts, providing us with a relatively large corpus to measure uncertainty and its components.

The second core part of the meeting is the *policy round*. This round begins with the staff laying out different policy alternatives, after which FOMC members debate on which alternative to adopt before proceeding to a final vote. This section also includes a discussion of the public statement released along with the policy announcement. We use the policy round to derive text-based measures of policy stances, which we discuss in Section V.A. While uncertainty language might appear in discussion of economic conditions in relation to policy preferences, it also reflects other factors such as hesitance about the correct policy stance, or how to communicate uncertainty to the public. Moreover, policymakers can discuss how different alternatives endogenously impact uncertainty in the economy going forward. In practice, separating out these subtle differences is a formidable challenge and, for this reason, we do not use uncertainty language in the policy round to measure uncertainty.[7]

III.B. Obtaining risk and uncertainty terms from word embeddings

Our measurement strategy begins with the construction of term lists that denote risk and uncertainty. According to Greenspan (2004), as quoted in the introduction, both notions are relevant for the FOMC, so accounting for each is important.[8] We consider mentions of the terms 'risk' and 'risks' to be associated with objective probabilities and mentions of the terms 'uncertain' and 'uncertainty' to be associated with uncertainty in the Knightian sense.

To obtain other terms that convey similar meanings as the four root terms, we rely on a word embedding model to estimate a vector space representation of different terms, within

[7]The policy round makes up 24% of FOMC transcript sentences. The remainder of the transcripts, which we do not use, is largely made up of staff discussion of financial market conditions and discussion of special topics in monetary policy. The sectioning of meetings is done manually by us. One outlier in meeting structure is the September 2009 meeting, for which the policy and economic rounds were merged into one round. In this case, we manually classify sentences as either belonging to the economy round or the policy round. For further details on the structure of FOMC meetings and the composition of the committee, see Hansen, McMahon, and Prat (2018).

[8]Similarly, Bloom (2014) writes: "I'll refer to a single concept of uncertainty, but it will typically be a stand-in for a mixture of risk and uncertainty."

which we compute the nearest neighbors of the roots.[9] Specifically, we use the Continuous Bag-of-Words (CBOW) model (Mikolov, Chen, Corrado, and Dean, 2013) estimated on the set of FOMC sentences contained in the economy round to obtain a vector representation of each unique term in the sub-corpus relevant for exogenous conditions.[10] Tables A-1 and A-2 in Appendix A contain the fifty nearest neighbors for each of the roots, where similarity is computed using cosine similarity.[11]

Interestingly, the neighbors for 'risk' and 'risks' contain terms one would associate with the quantification of known probability distributions such as 'probability', 'likelihood', and 'odds'. Likewise, neighbors for 'uncertain' and 'uncertainty' include 'murky', 'unclear', 'skepticism', and 'anxiety' which suggest unquantifiable uncertainty and associated concerns. Still, the distinction is not perfect and all lists contain a mix of relevant and generic terms. We therefore further organize the lists using our domain expertise and, for each word in each list, explicitly assign it to either a risk or uncertainty term set, or remove it from the analysis altogether. The final sets include 18 terms that denote the general concept of risk, and 60 terms that denote uncertainty.[12]

III.C. Constructing policymakers' uncertainty (PMU) indices

Denote by $\mathcal{U}$ the list of phrases identified as pertaining to risk and uncertainty derived from the word embeddings approach. The most basic measure of policymakers' uncertainty aggregates the counts of terms in $\mathcal{U}$ from the economy round in each FOMC meeting t, and scales them by the number of total terms in the economy round of meeting t. More formally, let $\mathbf{w}_{t,s} = (\mathbf{w}_{t,s,1}, \ldots, \mathbf{w}_{t,s,N_{t,s}})$ be the list of terms in the sth sentence of meeting

[9]This approach follows an recent studies by Hanley and Hoberg (2019), Atalay, Phongthiengtham, Sotelo, and Tannenbaum (2020), Davis, Hansen, and Seminario-Amez (2020), and Bloom, Hassan, Kalyani, Lerner, and Tahoun (2021).

[10]We preprocess each sentence following standard steps of tokenization and stop word removal. We also replace a limited number of bigrams with a single term, e.g., 'downside risk' and 'upside risk.' We then remove all sentences that do not contain at least five terms from the estimation corpus. The embedding model is estimated with 200-dimensional embedding vectors and a window size of five, which are typical defaults in the natural language processing literature.

[11]The cosine similarity is the cosine of the angle formed by two vectors in a vector space. So, if two vectors point in the same direction, and have a zero angle between them, the cosine similarity is 1. If they point in opposite directions, and have an angle of 180 degrees, the cosine similarity is -1. Mathematically, the formula is the dot product of two vectors normalized to have unit length.

[12]Some of these terms are antonyms such as 'confident.' In these cases, we count appearances of such terms as indicative of risk/uncertainty when they are immediately preceded by a negation phrase, which is one of {'less', 'no','not', 'little', 'don't', 'doesn't', 'hasn't', 'haven't', 'won't', 'shouldn't', 'didn't'}.

t; $u_{t,s} = \sum_n \mathbb{1}(\mathbf{w}_{t,s,n} \in \mathcal{U})$ is then the sentence-level count of risk/uncertainty terms and policymakers' uncertainty is

$$PMU_t = \frac{\sum_s \mathbf{u}_{t,s}}{\sum_s |\mathbf{w}_{t,s}|} \tag{2}$$

where $|\mathbf{w}_{t,s}|$ is sentence length following a sequence of standard pre-processing steps including stopword removal. PMU_t is based on all sentences in the economy round, including those spoken by Fed staff in their opening presentation. This is because the Fed's staff internal assessment of economic conditions potentially informs policymakers' views in addition to their own personal views.[13]

While PMU_t captures overall perceptions of risk and uncertainty, policymakers face multiple types of uncertainty that reflect their different objectives as well as challenges inherent in modeling and forecasting the underlying economy. An important novel aspect of our analysis is to classify uncertainty into distinct types identified by the co-occurrence of terms in $\mathcal{U}$ in the same sentence as terms that lie in four distinct sets that correspond to economic topics: inflation (search phrases contained in Appendix Table A-3); real economy (Tables A-4 through A-6); financial markets (Tables A-7 through A-10); and models (Table A-11).[14] Such a taxonomy is naturally crude as, by focusing on endogenous variables, it does not reflect the primitive sources of uncertainty. However, as we show below, those four topics capture the bulk of uncertainty-related mentions in the transcripts and display significant heterogeneity in their variation over time.

For each of these four topics, we construct topic-specific uncertainty counts using the following procedure. For each sentence in each FOMC meeting:

1. Increase the topic k uncertainty count by $u_{t,s}$ if sentence s contains any term in the list associated with topic k. Thus, if a term from more than one topic set appears in sentence s, $u_{t,s}$ can be assigned to more than one topic.

[13]Since FOMC members speak after the staff in the economy round, one might argue that FOMC member speech captures the part of the staff views that is deemed important for policymaking. However, economy round discussions are to a large degree prepared in advance, so FOMC member statements do not incorporate any updated beliefs about uncertainty that arise as a result of the staff presentation.

[14]Here, we rely on a purely manual approach to phrase construction rather than the partially automated approach used to obtain risk/uncertainty synonyms. The reason is that the topical terms are largely made up of phrases, and sequence embeddings are substantially more complex to build than single word embeddings.

Figure 1. Distribution of phrases in topic-specific PMU indices. The figure presents key economic terms within each topic-specific PMU index. The size of the phrase reflects is relative frequency. All topic-specific PMU indices are obtained from the economy round of the FOMC meetings. The sample period is 1987:08–2015:12

2. If no term from any set of topic words appears in sentence s, assign $u_{t,s}$ to topic k if a topic-k term appears in sentence $s-1$ or sentence $s+1$ (whenever these sentences are uttered by the same speaker of sentence s).

3. If no topic k term appears in sentences $s-1$, s, or $s+1$ then leave $u_{t,s}$ unassigned.

As with PMU_t, we then normalize the topic-specific counts by the total number of terms in the economy round of the meeting. We refer to policymakers' perceived inflation uncertainty in meeting t as $InfPMU_t$; real economic uncertainty as $EcoPMU_t$; financial market uncertainty as $MktPMU_t$; uncertainty about models as $ModPMU_t$; and unclassified uncertainty as $OthPMU_t$.[15] Figure 1 presents the distribution of economic terms in each uncertainty topic.

[15]Note that, in general, $InfPMU_t + EcoPMU_t + MktPMU_t + ModPMU_t + OthPMU_t > PMU_t$, since the same risk/uncertainty term is associated with multiple topics whenever a trigger word for more than one topic is present in the same sentence as the risk/uncertainty term.

III.D. Sentiment measures based on directional language

A major challenge for identifying the causal effect of uncertainty on decision making is that uncertainty tends to be systematically correlated with the current or expected future state of the economy. At a more basic level, it is possible that when policymakers express views about risk or uncertainty they do not actually refer to second moments of a distribution, but rather to a particular (directional) outcome they fear or are concerned about.

To account for these confounding effects, we develop complementary measures based on the directional language used in the meetings to describe economic developments. These proxies are broadly construed in that they could reflect perceptions of current or expected economic conditions, or even higher order moments of a distribution (such as skewness). We refer to them as "sentiment." Specifically, we construct sentiment proxies for inflation, real economy and markets. Negative (positive) sentiment is associated with outcomes that policymakers would typically view as unfavorable (favorable), given their mandate. As such, we consider the discussions of rising inflation as indication of negative inflation sentiment (*InfNeg*), discussion of weakening growth as negative sentiment about real economy (*EcoNeg*), and discussion of deteriorating financial conditions as negative market sentiment (*MktNeg*). We reverse those relations to measure positive sentiment (*InfPos*, *EcoPos*, and *MktPos*). As a proxy for the overall sentiment, we define balance measures for each topic as the difference between the negative and positive sentiment, e.g., $InfSent_t = InfNeg_t - InfPos_t$. Increases in the balance indicate a negative tilt in the sentiment toward a given variable.

Appendix B.1 details the construction of the sentiment indices. The basic idea is to count the frequency with which topic-specific words (which generally overlap with those used for the topic-specific uncertainty) are preceded or followed by direction words that indicate positive or negative sentiment, respectively. Importantly, our sentiment proxies are based on the economy round of the meeting excluding sentences that we use to construct the PMU indices. This ensures that we avoid a mechanical relationship between uncertainty and sentiment.

III.E. Descriptive statistics

We conclude the section by providing some descriptive statistics related to PMU and its components. Figure 2 plots the overall PMU measure per meeting as well as an eight-meeting moving average. PMU reaches its highest point at the onset of the US-led invasion

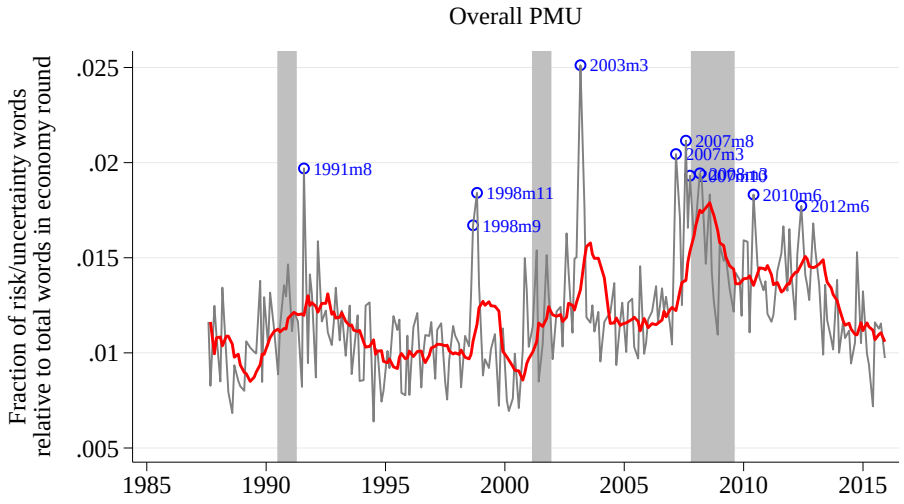


Figure 2. Policymakers' uncertainty index (PMU). The figure displays the PMU index obtained from the economy round of the FOMC meeting. The smoothed index is a moving average over the last eight meeting. The y-axis is expressed as the fraction of words contained in our risk/uncertainty dictionaries $\mathcal{U}$ relative to total words (after pre-processing) in the economy round of each FOMC meeting.

of Iraq in March 2003, when the risk- and uncertainty-related terms in $\mathcal{U}$ make up 2.5% of all terms (after pre-processing) spoken in the economy round. PMU also features notable spikes in the months preceding the global financial crisis.

An advantage of the FOMC setting is the ability to decompose the aggregate series into more granular cuts. Figure 3 shows time series for the four topical PMU indices, as well as the risk and uncertainty mentions we cannot classify with our topic word lists. The summary statistics for these series are reported in Appendix Table A-12. On average across the entire sample, we are able to classify 84% of mentions of terms in $\mathcal{U}$ into topics. Real economy, inflation, and markets PMU account for the bulk of topical uncertainty, with the model PMU contributing relatively little.

One concern might be that our topic-specific PMU indices are related to a common factor and, therefore, do not capture independent dimensions of variation. As seen in Appendix Table A-12, though, the partial correlations between each series are never higher than 0.36 in absolute value. Inflation PMU in particular shows little correlation with economy and market PMU. A principal components decomposition of the five time series also delivers the same message, with the first two components each explaining 30% of total variance and remaining components explaining at least 10%. In short, our topical PMU measures appear

to capture distinct dimensions of uncertainty, which we will explore in the remainder of the paper.

Finally, while not the focus of our paper, PMU can be disaggregated in alternative ways. Figure 4 shows speaker-level averages of overall PMU compared to the meeting-level averages of PMU in the meetings, in which those speakers served. Here again, one observes substantial heterogeneity, with some FOMC members referring much more frequently to terms in $\mathcal{U}$ than their colleagues.

IV. Properties of Policymakers' Uncertainty

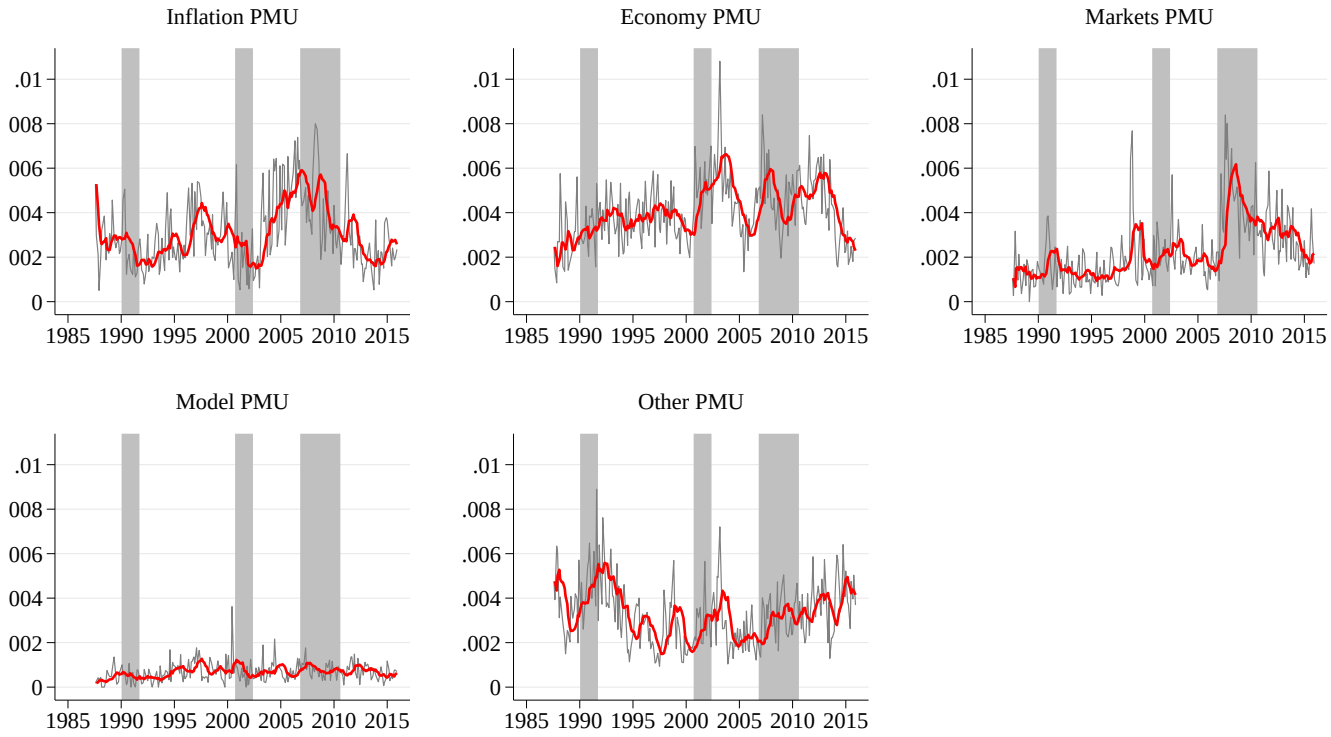
This section discusses the properties of our textual measures of policymakers' uncertainty. We analyze the variation in topic-specific PMU over the business cycle. We then study the relationship of the PMU measures with the Greenbooks forecasts and the topic-specific directional language.

IV.A. Topic-specific uncertainty over the business cycle

Figure 5, panels A and B, presents the time-series variation in the PMU indices for inflation and the real economy, juxtaposing them against the corresponding negative sentiment measures. A noteworthy feature of the PMU indices is a lack of a countercyclical behavior that is usually expected from uncertainty indicators (e.g., Bloom, 2014). Inflation PMU is strongly procyclical, suggesting that policymakers tend to express more uncertainty about inflation when the economy is doing well. Inflation concerns become prevalent from mid-2000s and reach their highest level in the first half of 2008. The procyclicality of inflation PMU is consistent with policymakers worrying primarily about the demand-driven increases in inflation. Indeed, inflation PMU comoves remarkably closely with the negative sentiment about inflation expressed in the meetings (i.e., sentiment related to increasing inflation).

Perhaps more surprisingly, the real economy PMU also fails to display obviously countercyclical dynamics. Its highest reading occurs during the March 18, 2003 meeting, driven by the uncertainty about the timing and extent of the Iraq war and about the underlying economic conditions. In another major episode, economy PMU becomes elevated in the first-half of 2007 before the start of the official NBER-dated recession. The transcripts of the March 21, 2007 meeting highlight rising concerns about growth outlook and heightened forecast

A. Topic-specific PMU time series



B. Coverage of topic-specific PMU

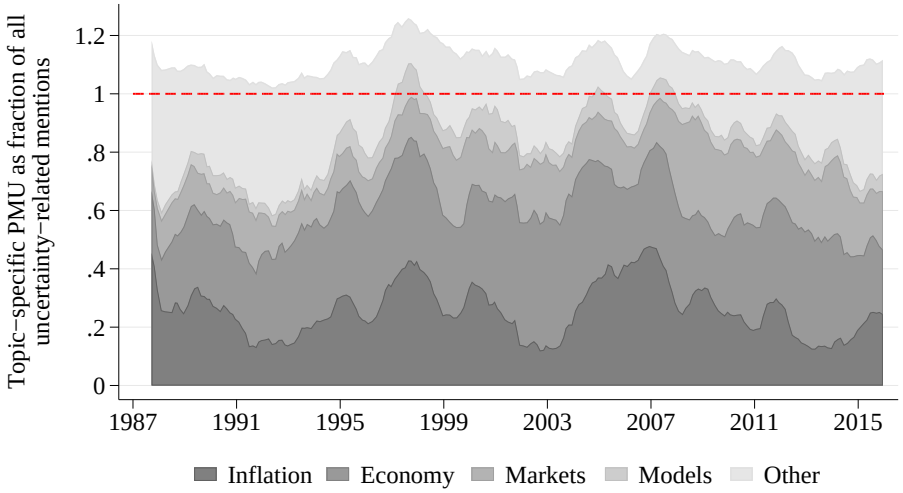


Figure 3. Topic-specific PMU. Panel A displays the PMU index obtained from the economy round of the FOMC meeting disaggregated into topics. The smoothed index is a moving average over the last eight meeting. The y-axis is expressed as the fraction of words contained in our risk/uncertainty dictionaries $\mathcal{U}$ classified into a particular topic relative to total words in the economy round of each FOMC meeting. Panel B displays the topic-specific uncertainty-related mentions as a fraction of all uncertainty-related mentions in the economy round of the FOMC meeting. The fractions are smoothed over the last eight meeting and stacked. The numbers do not necessarily sum up to one because one mention can belong to more than one topic.

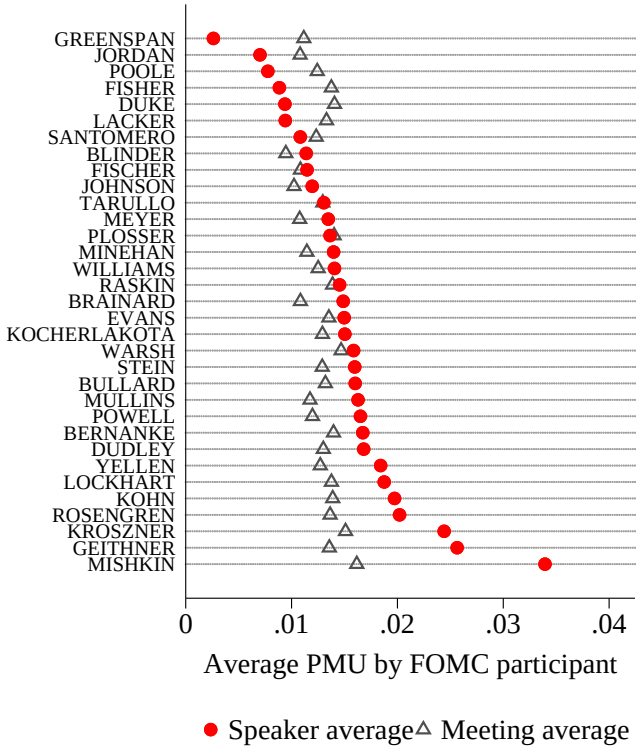


Figure 4. Speaker-level uncertainty. The figure presents the average speaker-level PMU. The index is the fraction of uncertainty-related phrases mentioned by a speaker relative to the overall number of words by that speaker in the economy round of the FOMC meeting. Circles represent speaker-specific average PMU. For reference, the triangles indicate the overall meeting-level PMU averaged across the meetings in which the speaker was present. The plot includes only those participants who were present in at least 8 meetings over our sample from 1987:08 to 2015:12, and who have spoken average number of words per meeting that is above the median.

uncertainty that are not yet associated with a direct downgrade of the economic forecasts. Interestingly, the uncertainty actually declines during the heights of the financial crisis even as the policymakers continue to express negative sentiment about the real economy. Compared to inflation, the economy PMU shows a weaker correlation with the negative sentiment (indicating weakening economy). For example, the economy PMU increases and remains persistently higher through the end of 2013, even when the negative sentiment about the economy subsides.

The bottom panels of Figure 5 display the financial markets indices. The market PMU is strongly positively associated with the negative market sentiment expressed during the meetings (panel C) and with the stock market implied volatility index (VXO, panel D). Importantly, the PMU reaches the highest level already in the early phases of the global financial crisis, in August 2007, preceding spike in the VXO (on October 29, 2008) by more

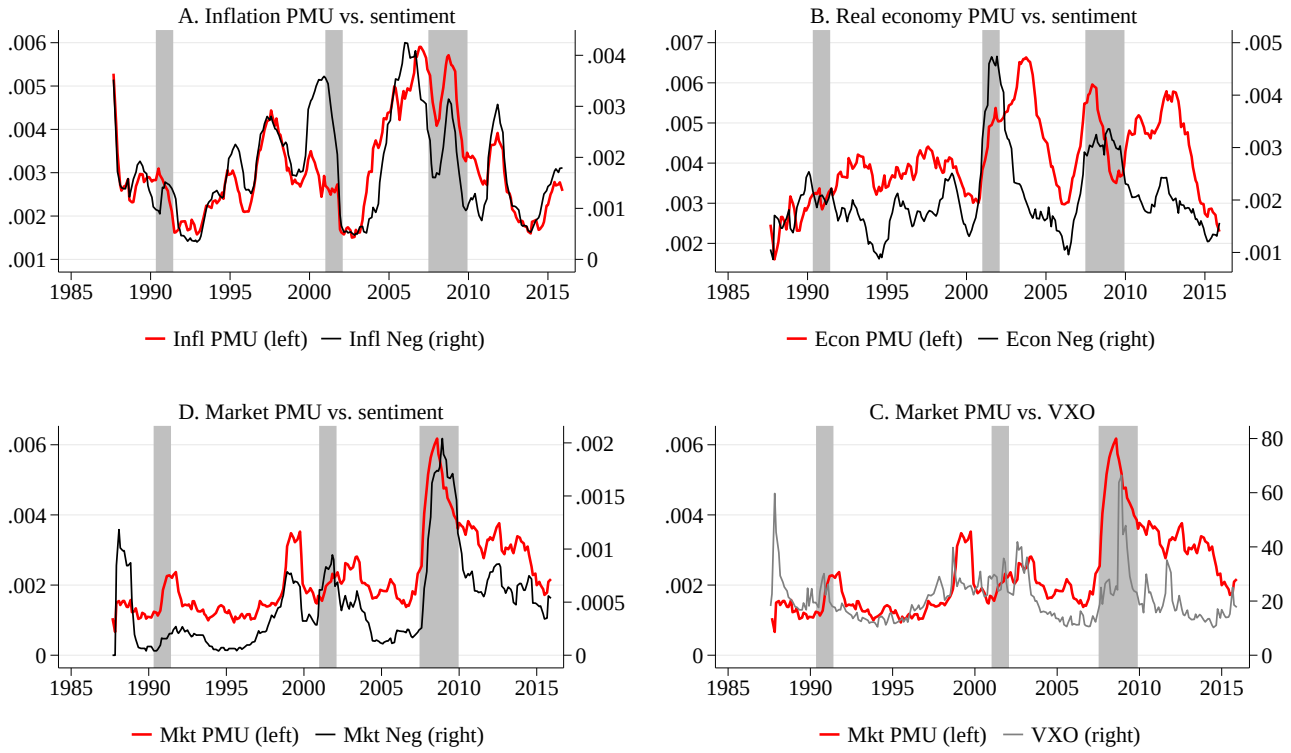


Figure 5. PMU over the business cycle. The figure presents topic-specific PMU indices superimposed against negative topic-specific sentiment. All text-based series are smoothed averages over the last eight FOMC meetings. VXO is smoothed with a 22-day moving average.

than a year. As such, policymakers' uncertainty increases long before the full extent of the financial crisis can be appreciated.

The results in Figure 5 point to an important asymmetry: an elevated topic-specific PMU coincides with a negative sentiment regarding that topic in the meeting. To test the asymmetry more formally, in Table I, we project our PMU indices on the sentiment proxies. The results show a significantly stronger link between uncertainty and negative sentiment than between uncertainty and positive sentiment. For inflation PMU, a one standard deviation increase in negative sentiment *InfNeg* (referring to an inflation increase) is associated with a 0.69 standard deviation increase in *InfPMU* (t-stat = 8.9); instead, a one standard deviation increase in positive inflation sentiment *InfPos* is associated with just 0.14 standard deviation increase in *InfPMU*. While this pattern is most pronounced for inflation, the economy and market PMUs also share a similarly skewed relationship with the sentiment.

	(1) *InfPMU*	(2) *InfPMU*	(3) *EcoPMU*	(4) *EcoPMU*	(5) *MktPMU*	(6) *MktPMU*
InfNeg	0.690***		-0.144**		-0.024	
	(8.93)		(-2.09)		(-0.39)	
InfPos	0.142**		-0.092		-0.006	
	(2.59)		(-1.38)		(-0.14)	
EcoNeg	-0.057		0.323***		0.002	
	(-1.00)		(5.40)		(0.04)	
EcoPos	-0.204**		0.125		-0.130**	
	(-2.26)		(1.54)		(-2.55)	
MktNeg	0.024		0.027		0.588***	
	(0.35)		(0.32)		(6.77)	
MktPos	0.138***		0.168**		0.182***	
	(2.66)		(2.42)		(2.97)	
InfSent		0.471***		-0.086		-0.095
		(4.29)		(-0.95)		(-1.27)
EcoSent		0.055		0.152		0.181*
		(0.51)		(1.39)		(1.83)
MktSent		-0.044		-0.042		0.392***
		(-0.48)		(-0.53)		(4.32)
$\bar{R}^2$	0.44	0.21	0.16	0.017	0.45	0.24
N	227	227	227	227	227	227

Table I. Asymmetric relationship between uncertainty and sentiment. The table reports regressions of topic-specific PMU indices on the corresponding sentiment measures. Sentiment proxies are based on sentences that do not contain uncertainty phrases. All measures are derived from the economy round of the FOMC meeting. The coefficients are standardized. HAC t-statistics with eight lags are reported in parentheses. The sample period is 1987:08–2015:12.

The regressions in Table I do now allow a causal interpretation of the relationship between PMU and negative sentiment. There are at least two possible interpretations of those correlations. For one, policymakers may downgrade their sentiment in response to an increase in uncertainty they perceive. Thus, negative sentiment in the meeting could be a reflection of policymakers' worrying about undesirable developments which may not materialize. Alternatively, negative shocks to expectations about the future could lead policymakers to express more uncertainty in the meeting. While in the latter case, one would expect negative sentiment to forecast future outcomes, in the former case, predictability is not warranted. Therefore, to distinguish between these two interpretations, we study the predictability of future inflation and real growth with the corresponding sentiment proxies. We find that real GDP growth up to a year ahead is strongly predictable with negative sentiment expressed in the meeting. In contrast, there is no such predictability for future inflation. (Details of these results are reported in Appendix Table A-13.) This suggests that the nature of the link between PMU and sentiment for inflation is different from that for the real economy.

Specifically, the nearly one-for-one co-movement between inflation PMU and sentiment is likely to encapsulate policymakers' concerns about increases in inflation that do not come to fruition.[16]

The above results indicate substantial differences in the nature of policymakers' uncertainty across the state variables. This heterogeneity leads to a broader question about the drivers of uncertainty in the meetings. It is natural to expect that uncertainty is affected by the magnitude of forecast errors, or the extent to which economic outcomes have diverged from the Fed's expectations. We therefore explore the relationship between uncertainty expressed in the meeting and the past forecast errors, using the Greenbook forecasts prepared by the Fed staff several days before the meeting. Table II reports regressions of PMU indices on the absolute and signed forecast errors for inflation and real GDP growth.[17]

To summarize financial market developments, we also include lagged stock market returns realized over the past two intermeeting periods, following Cieslak and Vissing-Jorgensen (2021) who document that policymakers pay significant attention to recent stock market developments. The results in Table II panel A show that past absolute forecast errors (but not signed errors) are predictive of Inflation-PMU: policymakers become more uncertain about inflation after experiencing large inflation surprises (in either direction). At the same time, inflation PMU is negatively related with absolute errors about real GDP growth. The negative relationship is consistent with the procyclical variation in inflation PMU and the fact the real GDP growth errors are most pronounced in recessions. There is much less evidence of a systematic relationship between forecast errors and uncertainty about the real side of the economy. Policymakers tend to emphasize economic uncertainty more when growth turns out lower and inflation higher than expected, but past forecast errors explain at most 4% of variation in the economy PMU. Finally, stock market declines are associated with significant increases in the market PMU, in line with the evidence that policymakers pay attention to recent stock market developments. In summary, while a link exists, a significant part of PMU variation remains unexplained by the magnitude and direction of past surprises to Fed's macro expectations and financial markets.

[16]The predictability results are unlikely to be endogenous to policy, given the known lagged effects of monetary policy on macro variables.

[17]We do not include unemployment forecast errors because of their high correlation with the forecast errors about the real GDP growth, making the interpretation of the coefficients less transparent. The forecast errors $|FE|$ are averages across horizons from one-quarter-ahead to four-quarters-ahead. As such, all errors are known at the time of the meeting t, but the forecast are formed at different meetings. In this way we consider lookback period of up to one year.

A. Absolute forecast errors

	(1) *InfPMU*	(2) *EcoPMU*	(3) *MktPMU*
$\lvert\overline{FE}(RGDP)\rvert$	-0.277***	0.011	0.012
	(-3.68)	(0.15)	(0.21)
$\lvert\overline{FE}(CPI)\rvert$	0.390***	-0.080	0.106
	(4.51)	(-0.95)	(1.43)
$\lvert rx^{SP500}_{t-2,t}\rvert$	-0.140*	0.053	0.169***
	(-1.82)	(0.47)	(2.76)
$\bar{R}^2$	0.14	0.00	0.041
N	227	227	227

B. Forecast errors

	(1) *InfPMU*	(2) *EcoPMU*	(3) *MktPMU*
$\overline{FE}(RGDP)$	0.079	-0.193**	-0.167**
	(0.82)	(-2.55)	(-2.20)
$\overline{FE}(CPI)$	0.210*	0.171**	0.154*
	(1.89)	(2.29)	(1.74)
$rx^{SP500}_{t-2,t}$	-0.032	0.027	-0.229**
	(-0.33)	(0.33)	(-2.54)
$\bar{R}^2$	0.042	0.038	0.093
N	227	227	227

Table II. Predicting uncertainty with past forecast errors. The table reports regressions of topic-specific PMU indices on past forecast errors in the Greenbooks. The coefficients are standardized. HAC t-statistics with eight lags are reported in parentheses. The sample period is 1987:08–2015:12.

IV.B. Risk vs. uncertainty decomposition

Our approach allows us to construct separate PMU indices based on phrases associated with "risk" and "uncertainty," as explained in Section III.B. While policymakers may draw a distinction between the two, in practice the identification of which type they face is hard to achieve. We decompose topic-specific PMUs into the two components in Figure 6. Risk and uncertainty indices are highly correlated with each other and appear with a similar frequency in policy deliberations. The largest discrepancies are visible for the economy PMU for which mentions referring to uncertainty are 50% more frequent than those referring to risk. Overall, however, their overlap is consistent with the statement by Greenspan that the two notions are closely related and challenging to disentangle in practice. Therefore, in most of our subsequent analysis, we use the overall PMU indices encompassing both risk- and uncertainty-related mentions.

IV.C. Relationship of PMU with public perceptions of (policy) uncertainty

While our goal is to gauge how policymakers perceive uncertainty about the state of the economy and how they respond to it, it is nevertheless worth connecting the PMU to measures of public perceptions of policy uncertainty proposed in the literature. In an influential study, Baker, Bloom, and Davis (2016, BBD) develop an index of economic policy uncertainty (EPU) based on the frequency of articles in ten leading newspapers that mention both uncertainty and economic policy. In addition, they also introduce sub-indices tailored for specific policies, including monetary policy. Husted, Rogers, and Sun (2020, HRS) adopt a

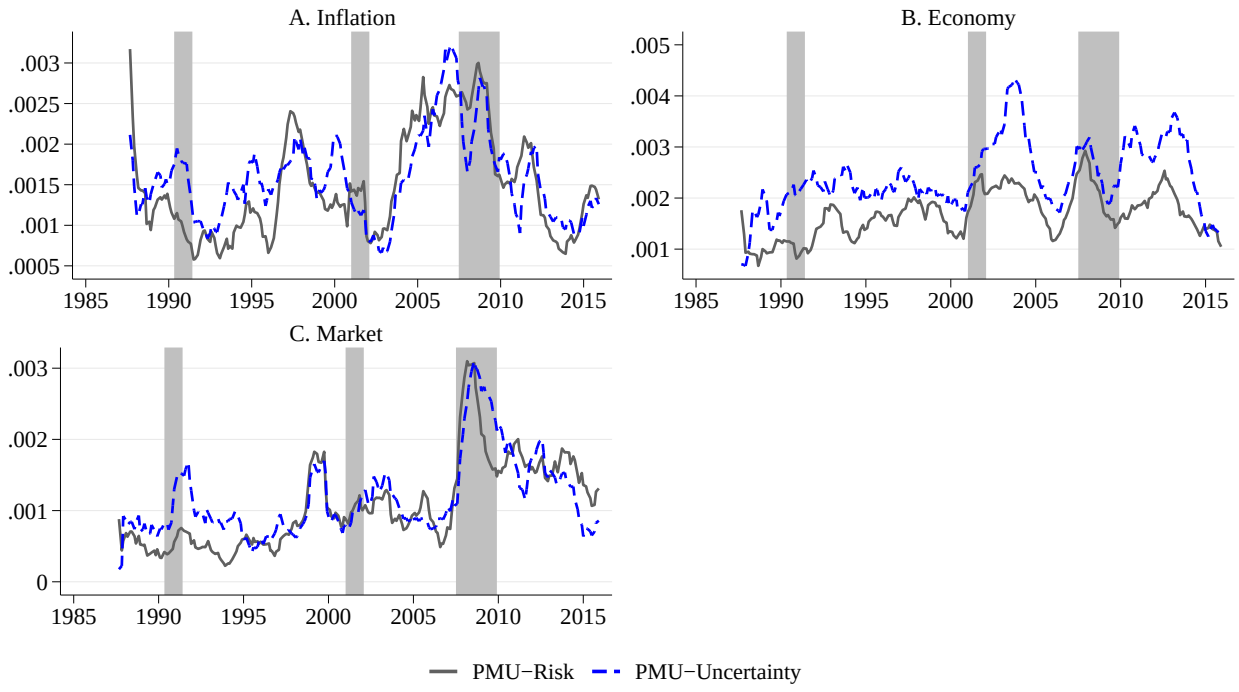


Figure 6. Risk vs. uncertainty. The figure presents a decomposition of PMU indices (from Figure 3) into risk and uncertainty components. All text-based series are smoothed averages over the last eight FOMC meetings.

related newspaper-based approach to construct a monetary policy uncertainty index (MPU) specific to the US monetary policy. These monetary-policy proxies aim to reflect the degree of uncertainty that the public perceives about the Fed's policy actions and their consequences. However, public perceptions of policy uncertainty should arise from the policymaking process itself. Thus, it is natural to ask how these perceptions correlate with the types of uncertainty that policymakers discuss in the meeting.

To illustrate the co-movement, Table III presents regressions of the BBD and HRS proxies on the overall *PMU* as well as its topic-specific components, including controls for the policymakers' directional language in the meeting. The correlation between public and policymakers' uncertainty is positive (columns (1), (5) and (7)), but the significance of the relationship depends on the specific proxy. The disaggregated PMU indices reveal that the positive relationship is not uniform across topics. The positive co-movement between policymakers' and public's uncertainty arises from the discussions of economic uncertainty in the meeting, and in the case of the BBD indices, from other uncertainty (*OthPMU*) not

	BBD EPU				BBD MPU		HRS MPU	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PMU	0.339***				0.340***		0.152	
	(3.06)				(4.11)		(1.34)	
InfPMU		-0.281***		-0.303***		-0.188***		-0.165**
		(-5.15)		(-4.11)		(-3.25)		(-2.03)
EcoPMU		0.221**		0.237***		0.284***		0.178
		(2.10)		(2.86)		(2.74)		(1.31)
MktPMU		0.156		-0.006		-0.063		-0.075
		(1.48)		(-0.06)		(-0.86)		(-0.65)
ModPMU		-0.040		-0.026		-0.035		0.127*
		(-0.85)		(-0.50)		(-0.86)		(1.91)
OthPMU		0.276***		0.200**		0.076		0.007
		(3.46)		(2.57)		(0.96)		(0.06)
InfSent			-0.224***	0.019		0.053		0.014
			(-2.73)	(0.26)		(0.88)		(0.17)
EcoSent			0.349***	0.299***		0.341***		0.121
			(4.02)	(4.10)		(5.67)		(1.13)
MktSent			0.202**	0.168**		0.285***		0.239***
			(2.57)	(2.32)		(3.85)		(2.89)
R^2	0.12	0.32	0.27	0.43	0.12	0.39	0.023	0.14
$\bar{R}^2$	0.11	0.30	0.26	0.41	0.11	0.37	0.019	0.10
N	227	227	227	227	227	227	227	227

Table III. Public perceptions of uncertainty. The table reports regressions of public measures of policy uncertainty on PMU indices: BBD EPU is the economic policy uncertainty index from Baker, Bloom, and Davis (2016), BBD MPU is their subindex for monetary policy uncertainty, and HRS MPU is the monetary policy uncertainty index from Husted, Rogers, and Sun (2020). The sample period is 1987:08–2015:12. All variables are scaled by their standard deviations. HAC t-statistics with eight lags are reported in parentheses.

subsumed by our explicit PMU categories.[18] Interestingly, the inflation PMU is strongly negatively related with the public's uncertainty, with the negative sign reflecting the fact that inflation PMU is procyclical while public uncertainty proxies are countercyclical (Bloom, 2014). Indeed, the public uncertainty proxies tend to be high precisely at times when policymakers express negative views about the economy and financial markets, as shown by the loadings on the sentiment measures.

[18] *OthPMU* contains uncertainty mentioned in the context of other (i.e., not monetary) policy. As such, it includes mentions of fiscal policy in the meeting which is an important category in the BBD index.

V. (How) Does Uncertainty Affect Policy Preferences?

V.A. Measuring policymakers' preferences with text

To study the effects of uncertainty on policymakers' preferences, we construct textual measures of the policy stance by exploiting statements by the FOMC members during the policy round of the FOMC meeting. Our goal is to focus on the preferences of actual decision makers, and thus, we exclude statements made by the staff during the policy round. The textual approach allows us to study the evolution of policy over a long sample, including the zero lower bound period during which short-term interest rates show little to no variation. Specifically, in each meeting, we measure the frequency of occurrence of the language indicating hawkishness and dovishness, scaled by the overall length (number of words) of the policy round. We denote the resulting scores in meeting t as $Hawk_t$ and $Dove_t$, respectively. Our classification of the hawkish and dovish language takes into consideration both conventional policy as well as the unconventional tools during the zero-lower-bound period. Appendix B.2 describes the details of the construction. We summarize the overall policy preference by taking the difference between the $Hawk_t$ and $Dove_t$ scores:

$$HD_t = Hawk_t - Dove_t. \tag{3}$$

The HD_t score therefore reflects the tilt in the policy preference that emerges during the meeting.

Figure 7 presents the time series of the *Hawk* and *Dove* scores, and their balance *HD*. The dynamics of these variables display intuitive properties, with the *Dove* score becoming elevated around recessions and in periods of financial turmoil, and the *Hawk* score increasing in expansions. Importantly, policy preferences derived from the text show substantial variation in the post-2008 sample when short-term nominal interest rates are constrained at zero.

V.B. Validation of the textual measures of policy preferences

To validate our textual proxies for policymakers' preferences, we analyze their relationship with variables used to describe the policy stance in the literature: measures based on the deviations of the policy rate from the Taylor rule and high-frequency monetary policy surprises obtained from changes in market interest rates around FOMC announcements.

In Table IV, panel A, we first project changes in the federal funds rate (FFR) target on the directional *Hawk*, *Dove* scores and the *HD* variable (columns (1)–(3)). While our textual

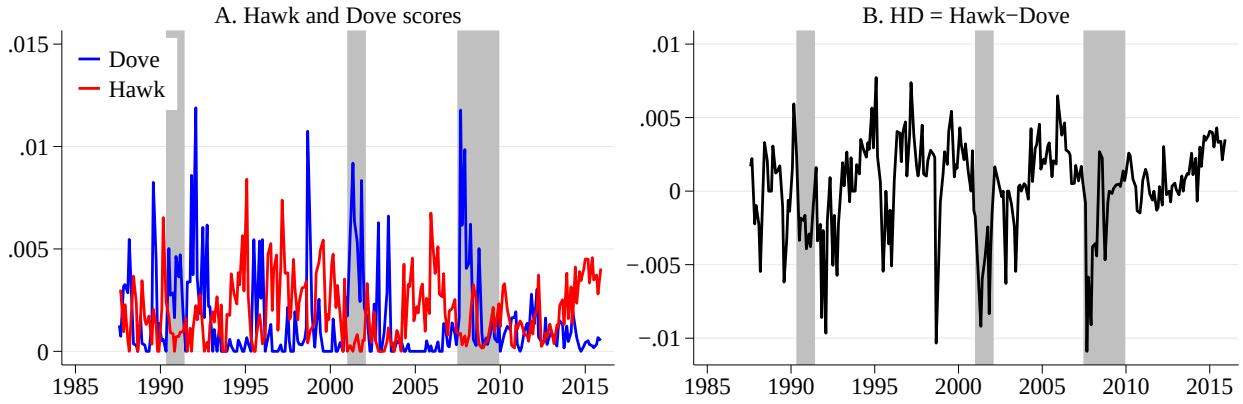


Figure 7. Textual measures of policy preferences. The figure presents textual measures of policy preferences derived from the statements of FOMC members during the policy round of the FOMC meetings.

policy proxies are available until 2015:12, we necessarily estimate these regressions on the pre-zero-lower-bound sample ending in 2008:12. Given the policy inertia over this period, we include two lags of the FFR (Coibion and Gorodnichenko, 2012).

The regression coefficients show strong predictive power of the policy language in the transcripts for the actual policy choice. The signs are intuitive with a more hawkish (dovish) tone predicting a FFR target increase (decrease) in column (1). The *HD* variable has effectively the same explanatory power for the target (column (2)) as the two directional measures considered separately. A one standard deviation increase in *HD* is associated with an approximately 0.5 standard deviation increase in the FFR target (about 14 basis points) with a t-statistic of 6.8. Importantly, the predictive power of *HD* is preserved when included in a Taylor-rule-type specification along with Greenbook forecasts and forecast updates for inflation and real GDP growth in column (3). In column (3), we also control for a slow-adjustment in the inflation target over our sample by including a trend inflation variable, τ^{CPI}.[19] The coefficient on *HD* remains economically and statistically significant with a one standard deviation increase in *HD* corresponding to a 0.3 standard deviation increase in the target (t-statistic of 5.3).

[19]The τ^{CPI} variable is constructed as the discounted moving average of past core inflation following Cieslak and Povala (2015). Including trend inflation allows the regression to capture the effect of deviations of expected inflation from the target on the policy rate. As Greenbook forecasts we use the four-quarter ahead expected inflation and the current quarter real GDP growth because these forecast horizons tend to best explain the variation in the FFR target, as confirmed with Bayesian information criterion.

We present analogous results using a measure of monetary policy shocks proposed by Romer and Romer (2004) in columns (4)–(6).[20] Since Romer-Romer shocks are constructed from changes in the policy rate at each meeting purged of Fed's information (Greenbooks), it is not surprising that the results in column (4)–(6) are very similar to those based on FFR target in columns (1)–(3). Our *HD* score alone explains a quarter of variation in Romer-Romer shocks.

In Table IV, panel B, we further explore the relationship between the textual policy proxies and monetary policy surprises identified from high-frequency changes in interest rates around the FOMC announcements. As these surprises differ in terms of types and maturities of interest rates involved and sample periods used to construct them, we consider proxies from several recent studies: Swanson (2018) who extends and updates the estimates of target and path factors in Gürkaynak, Sack, and Swanson (2005, GSS), Gertler and Karadi (2015, GK), and Nakamura and Steinsson (2018, NS). Across the board, we find a positive relationship with the *HD* score, whereby the relationship is generally stronger for surprises identified from longer-term interest rates. This fact indicates that policy language in the meetings encompasses forward-looking views by policymakers that pertain not only to the current decision but also to the intended policy path. Indeed, we find that the text-based policy preferences predict the path of policy rates several quarters ahead. We report auxiliary regressions documenting this fact in Appendix Table A-14.

Overall, the consistent explanatory power of our textual measures across a spectrum of policy indicators implies that deliberations in the meetings contain key information for understanding the nature of monetary policy shocks. This information is forward looking and goes beyond the content of the Greenbook forecasts, thus reflecting the non-systematic component of the policy reaction function.

V.C. Quantifying the impact of uncertainty on policy preferences

We rely on the textual proxies to explore the relationship between the uncertainty facing policymakers and their policy preferences. Our identification of the effects of uncertainty on policy exploits the timing and the structure of deliberations during the FOMC meetings. All PMU indices are estimated from the economy round of the FOMC meeting (including

[20] We obtain the Romer-Romer shock series from the data set accompanying Valerie Ramey's handbook chapter on propagation of macro shocks (Ramey, 2016). The shocks are available during the pre-zero-lower-bound sample 1987:08–2007:12.

A. FFR target changes and Romer-Romer shocks

	(1) ΔFFR	(2) ΔFFR	(3) ΔFFR	(4) RR shock	(5) RR shock	(6) RR shock
Hawk	0.287***			0.253**		
	(4.07)			(2.54)		
Dove	-0.316***			-0.359***		
	(-6.42)			(-3.70)		
HD		0.497***	0.334***		0.506***	0.601***
		(6.83)	(5.30)		(4.95)	(5.04)
$E(CPI_{4q})$			0.523***			0.115
			(2.97)			(0.73)
$E(RGDP_{0q})$			0.456***			-0.085
			(5.75)			(-1.14)
τ^{CPI}			-0.226**			0.043
			(-2.06)			(0.26)
$Updt(CPI_{3q})$			0.022			0.088
			(0.39)			(1.30)
$Updt(RGDP_{1q})$			0.092			-0.168**
			(1.32)			(-2.55)
L.FFR	1.807***	1.766***	-0.091			
	(3.35)	(3.18)	(-0.15)			
L2.FFR	-1.851***	-1.801***	-0.159			
	(-3.64)	(-3.40)	(-0.29)			
$\bar{R}^2$	0.45	0.45	0.59	0.25	0.25	0.30
N	169	169	169	163	163	163

B. Market-based measures of monetary policy surprises

	(1) GSS target	(2) GSS path	(3) GK MP0	(4) GK ED12m	(5) NS news
HD	0.169	0.178***	0.382***	0.409***	0.290**
	(1.33)	(2.74)	(4.00)	(4.92)	(2.33)
R^2	0.028	0.032	0.15	0.17	0.084
N	196	196	190	199	154

Table IV. Validity of textual measures of policy preferences. The table reports regressions of various measures of monetary policy stance on textual *Hawk*, *Dove*, and *HD* variables. The textual measures are derived from the policy round of the FOMC meeting transcripts. Panel A reports regressions of changes in the FFR target and Romer-Romer shocks on the textual proxies, with and without Greenbook controls (forecasts $E(\cdot)$ and forecast updates $Updt(\cdot)$). The τ^{CPI} variable controls for the perceived inflation target. Results in columns (1)–(3) are based on the 1987:08–2008:12 sample, i.e., excluding the zero-lower bound episode. Columns (4)–(6) are based on the 1987:08–2007:12 sample, when Romer-Romer shocks are available. HAC t-statistics with eight lags are reported in parentheses. The sample period is 1987:08–2015:12. Panel B reports analogous regressions of monetary policy surprises on the *HD* variable. Columns (1) and (2) contain high-frequency target and path surprises following the approach of Gürkaynak, Sack, and Swanson (2005) as updated by Swanson (2018) (1991:07–2015:10 sample). Columns (3) and (4) use shocks from Gertler and Karadi (2015) obtained from the current month fed fund futures (MP0, sample 1988:11–2012:06) and 12-month ahead Eurodollar futures (ED12m, sample 1987:08–2012:06). Column (5) is based on surprises from Nakamura and Steinsson (2018) (sample 1995:02–2014:03). Robust t-statistics are reported in parentheses. All regressions are estimated at the frequency of FOMC meetings. The coefficients are standardized.

statements by the staff and FOMC members). They are, therefore, predetermined by the time the policy round begins, and from which we derive policy preferences of FOMC members.

We start with a simple predictive specification and then extend the analysis to allow for more complex interactions between uncertainty and macro variables, which we ultimately tie to the predictions from the theory.

Table V reports results of predicting the policy preference score *HD* with the PMU indices with and without controlling for variation in the first moments (Greenbook forecasts) and sentiment in the transcripts. We first report results for the overall *PMU* index that aggregates all uncertainty into one combined measure, without distinguishing its type. These estimates serve as a benchmark, following much of the literature that focuses on uncertainty in general, not distinguish between the types. The negative loading on *PMU* indicates that more uncertainty expressed in the economy round of the meeting forecasts relatively less hawkishness in the policy round. *PMU* alone explains about 8% of the variation in the *HD* score. However, the significance of this effect is sensitive to whether we control for the directional sentiment (column (2)) and, to some extent, also for the Greenbook forecasts (column (4)). In particular, given that with sentiment controls the *PMU* index loses its significance, one might conclude that uncertainty has no independent effect on policy preferences. As subsequent results show, however, such a conclusion would be premature because the overall *PMU* masks the underlying type of uncertainty.

Columns (5)–(8) introduce a suit of topic-specific PMU indices to illustrate the importance of the uncertainty type. As the main empirical fact, and one that is camouflaged by the overall *PMU* regressions in earlier columns, the direction with which uncertainty predicts policy stance varies starkly by topic. Increased uncertainty about the economy and markets is associated with a less hawkish stance. Through the lens of theories laid out in Section II, this effect is consistent with a real-options channel whereby policymakers perceive heightened uncertainty as a negative demand shock. In contrast, more inflation and model uncertainty are in fact associated with a more hawkish stance. The same direction of the effect for inflation and model PMU suggests that when policymakers face more model uncertainty they particularly worry about persistently high inflation. Such an interpretation would be consistent with the positive link between inflation PMU and past Greenbook forecast errors in Table II. The signs of these relationships are largely preserved when we control for the first

moments using current meeting Greenbook forecasts as well as for the directional sentiment measures. Given the high correlation between the negative inflation sentiment and inflation uncertainty, it is not surprising that the loadings on *InfPMU* and *InfSent* interact with each other when included jointly in the regressions. In contrast, the sentiment about the real economy (*EcoSent*) contains independent predictive power for policy preferences in the presence of *EcoPMU*. This fact aligns with the evidence in Section IV.A documenting that the properties of PMU differ depending on the state variable to which they pertain. Finally, the residual uncertainty *OthPMU* contains no additional information for predicting policy preferences, indicating that our topic-specific indices span the key dimensions of policymakers' uncertainty.

V.D. Does uncertainty strengthen or weaken policymakers' reaction to the state of the economy?

While the above regressions serve as a starting point, the impact of uncertainty on policy is likely to be more complex than a linear specification would admit. Existing models of optimal policy, discussed in Section II, consider multiplicative effects whereby uncertainty alters the strength of the policy response to the state of the economy. However, since the theoretical predictions are highly model-dependent, it remains an open question whether uncertainty actually strengthens or weakens the policymakers' response, and whether its effects differ across state variables policymakers care about.

To cast light on these questions, we study the role of interactions between macro variables and the PMU indices in explaining policy preferences. We keep the specification parsimonious and focus on the two main types of uncertainty in variables that traditionally enter Taylor rules, the inflation and economy PMU. We analyze their interactions with Greenbook forecasts of inflation and the real GDP growth using the following specification:

$$\begin{aligned} HD_t = {} & \beta_0 + \beta_1 \tau_t^{CPI} + \beta_2 E_t(CPI_{4q}) + \beta_3 E_t(RGDP_{0q}) \\ & + \delta_1 (E_t(CPI_{4q}) \times InfPMU_t) + \delta_2 (E_t(RGDP_{0q}) \times InfPMU_t) \\ & + \delta_3 (E_t(CPI_{4q}) \times EcoPMU_t) + \delta_4 (E_t(RGDP_{0q}) \times EcoPMU_t) \\ & + \gamma_1 InfSent_t + \gamma_2 EcoSent_t + \varepsilon_t. \end{aligned} \tag{4}$$

The model above can be thought of as a forward-looking policy rule with time-varying loadings that change with the degree of policymakers' uncertainty. The coefficients on the

Dependent variable: *HD* policy preference score

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PMU	-0.296***		-0.092		-0.239***			
	(-3.94)		(-1.25)		(-2.68)			
InfPMU						0.231***	0.229***	0.154**
						(3.00)	(3.34)	(2.37)
EcoPMU						-0.200***	-0.181***	-0.186***
						(-2.74)	(-2.95)	(-2.75)
MktPMU						-0.219*	-0.089	-0.245**
						(-1.83)	(-0.97)	(-2.15)
ModPMU						0.155***	0.146***	0.094**
						(3.26)	(3.74)	(2.04)
OthPMU						-0.151**	-0.047	-0.027
						(-2.00)	(-0.69)	(-0.40)
InfSent		0.224***	0.217**				0.058	
		(2.61)	(2.53)				(0.75)	
EcoSent		-0.453***	-0.425***				-0.414***	
		(-4.95)	(-4.22)				(-5.18)	
MktSent		-0.088	-0.071				-0.034	
		(-0.94)	(-0.81)				(-0.47)	
$E(CPI_{4q})$				0.613***	0.559***			0.358**
				(3.64)	(3.66)			(2.00)
$E(RGDP_{0q})$				0.382***	0.328**			0.258**
				(2.99)	(2.51)			(2.26)
τ^{CPI}				-0.695***	-0.727***			-0.578***
				(-3.81)	(-4.95)			(-3.26)
$Updt(CPI_{3q})$				0.073	0.068			0.019
				(1.43)	(1.34)			(0.37)
$Updt(RGDP_{1q})$				0.152***	0.128**			0.134***
				(2.79)	(2.48)			(2.71)
$\bar{R}^2$	0.084	0.30	0.30	0.29	0.33	0.24	0.39	0.38
N	227	227	227	227	227	227	227	227

Table V. Predicting policy preferences with PMU. The table reports regressions of the policy preference score *HD* on topic-specific PMU indices as well as Greenbook forecasts and textual sentiment controls. The sentiment measures are defined in Section III.D. The *HD* variable is derived from the statements of FOMC members in the policy round of the FOMC meeting, while the PMU indices are based on the statements by the staff and FOMC members in the economy round of the meeting. All regressions are estimated at the frequency of FOMC meetings. The coefficients are standardized. HAC t-statistics with eight lags are reported in parentheses. The sample period is 1987:08–2015:12.

interaction terms describe how the sensitivity of policy preferences (measured with HD score as before) to inflation and real growth changes when uncertainty changes.

We report the estimates in Table VI. For reference, column (1) displays results when interactions are not included, only allowing for direct effects of uncertainty; column (2) adds sentiment controls. Columns (3) and (4) interact each of the Greenbook forecasts with PMU indices, with and without sentiment controls. All variables are expressed in units of standard deviations. The conditional character of the interaction regressions makes the interpretation

of the individual coefficients challenging.[21] Thus, we present the main marginal effects of interest graphically in Figure 8. The estimates, obtained with the delta method, illustrate how the slope coefficient on a given variable changes with the level of another variable. The graph contains 95% confidence bounds for the null hypothesis that each of the coefficients is different from zero.

The main finding is that the policymakers' response to expected inflation increases with the level of inflation uncertainty. The interaction term on $E(CPI_{4q}) \times InfPMU$ is positive and significant. Panel A of Figure 8 shows the change in the HD score given one unit change in $E(CPI_{4q})$ at different levels of $InfPMU$. The increasing pattern of the slope coefficients shows that policymakers tend to display relatively more hawkishness in reaction to expected inflation when inflation is accompanied by high uncertainty. When uncertainty is very low, the effect of expected inflation is not statistically different from zero. This result holds also when we account for the sentiment expressed in the meeting.

The economy PMU likewise tends to strengthen the Fed's reaction to growth, visible in Figure 8 panel B. The positive coefficient on $E(RGDP_{0q}) \times EcoPMU$ in Table VI means that policy preferences become more dovish when the economy is doing poorly and uncertainty is high. In contrast to inflation, however, the amplification due to economic uncertainty largely disappears when controlling for the sentiment. This indicates that the effect of economic uncertainty on policy preferences may be weak unless shifts in uncertainty are accompanied by simultaneous downgrades to growth expectations.[22]

Complementary to the above results, the middle panels of Figure 8 depict the impact of uncertainty on policy preferences at different levels of expected inflation and growth, respectively. By extending the baseline linear specification in column (1) of Table VI, these estimates help assess when, i.e., in which economic states, the effect of uncertainty on policy is likely to be the strongest. Inflation PMU is associated with a more hawkish stance when

[21] With interactions, the direct effect coefficients (βs and γs in equation (4)) capture the effect of a variable when keeping other variables it is interacted with at zero. As such, the direct effects may not be economically interesting or meaningful when considered on their own.

[22] Consistent with this interpretation, some of the largest spikes in economic uncertainty where not immediately associated with a policy reaction. One example is the meeting on March 18, 2003, when economy PMU reached its highest reading on record. Although the meeting statement emphasized the uncertainties, the policy remained unchanged. Another example is the meeting on March 21, 2007, the second biggest spike in the economy PMU. The transcripts of that meeting indeed point to elevated economic uncertainty, mostly related to the outlook for housing and business investment, which did not immediately lead to a policy action.

expected inflation is high, while economy PMU is associated with a more dovish stance when growth is weak.

The two bottom panels of Figure 8 summarize the cross-effects, i.e., inflation PMU altering the policy response to the real economy, and economy PMU altering the response to inflation. The prevailing pattern is that the cross-effects are economically and statistically small. Thus, while inflation uncertainty tends to amplify the response to inflation, it does not affect the response to growth, and vice-versa.

V.E. Discussion

Although the evidence above does not allow a full structural interpretation of how uncertainty affects policymaking, it casts light on which theoretical mechanisms are likely to be born out by the actual policymakers' deliberations. The main finding—the amplifying effect of uncertainty on the inflation response and, albeit to a lesser extent, on the growth response—goes against the Brainard's conservatism principle. Indeed, the literature has recognized that conservatism is not a uniform property of optimal policy as it is non-robust to the type of uncertainty that policymakers face. When uncertainty pertains to the degree of persistence of underlying state variables (e.g., inflation), a more aggressive policy response may be warranted. Such amplification has been qualitatively emphasized by Söderström (2002) in the context of a Bayesian policymaker. Alternatively, policymakers' concern about the worst case scenario may also lead to amplification of policy response as a way to avoid particularly costly outcomes.[23] This interpretation is broadly in line with the view expressed by policymakers themselves, e.g., according to Praet (2018),

> A more aggressive monetary policy response (...) is warranted when there is clear evidence of heightened risks to price stability, i.e. when it is established that the degree of inflation persistence is likely to be high and risks disanchoring inflation expectations. In this case, a forceful, frontloaded monetary policy response to weak or excess inflation may become necessary to signal the central bank's commitment to its objective, and thus nudge inflation expectations towards that objective and make them less backward-looking.

[23] We illustrate the different mechanisms proposed in the literature in the Section VI.

Dependent variable: *HD* policy preference score

	(1)	(2)	(3)	(4)
$E(CPI_{4q})$	0.35**	0.52***	0.057	0.45**
	(2.35)	(3.54)	(0.24)	(2.10)
$E(RGDP_{0q})$	0.39***	0.17**	-0.031	-0.081
	(5.55)	(2.37)	(-0.16)	(-0.47)
τ^{CPI}	-0.50***	-0.57***	-0.49***	-0.56***
	(-3.62)	(-4.50)	(-3.41)	(-4.18)
$E(CPI_{4q}) \times InfPMU$			0.18***	0.14***
			(3.16)	(2.73)
$E(RGDP_{0q}) \times InfPMU$			0.0034	-0.011
			(0.06)	(-0.22)
$E(RGDP_{0q}) \times EcoPMU$			0.16***	0.10*
			(2.68)	(1.89)
$E(CPI_{4q}) \times EcoPMU$			-0.015	-0.079
			(-0.27)	(-1.44)
$EcoPMU$	-0.25***	-0.15**	-0.43***	-0.13
	(-4.38)	(-2.55)	(-2.92)	(-0.96)
$InfPMU$	0.17***	0.18***	-0.21	-0.097
	(3.35)	(3.50)	(-1.29)	(-0.68)
$InfSent$		0.054		0.085*
		(1.13)		(1.81)
$EcoSent$		-0.39***		-0.38***
		(-5.57)		(-5.37)
R^2	0.34	0.44	0.37	0.46
$\bar{R}^2$	0.32	0.42	0.35	0.43
N	227	227	227	227

Table VI. Effect of uncertainty on policy preferences. The table reports estimates of regression (4), allowing for interactions between PMU indices and the Greenbook forecasts. The sample period is 1987:08–2015:12. All variables are scaled by their standard deviations. Robust t-statistics are in parentheses.

Our second set of results pertains to the direct effects, whereby uncertainty may influence policy preferences independently of its amplifying impact on the coefficients of the reaction function. Through the lens of the canonical linear-quadratic framework operating under the certainty equivalence principle, additive uncertainty should have no effect on optimal policy. Thus, the fact that the direct effects are present suggests that policymakers may systematically deviate from the linear-quadratic paradigm, for example, by displaying asymmetric preferences that overweight particular outcomes. Likewise, the significance of uncertainty in the presence of Greenbook forecasts suggests that the staff forecasts do not fully account for the effects of uncertainty on the economy that FOMC members perceive.

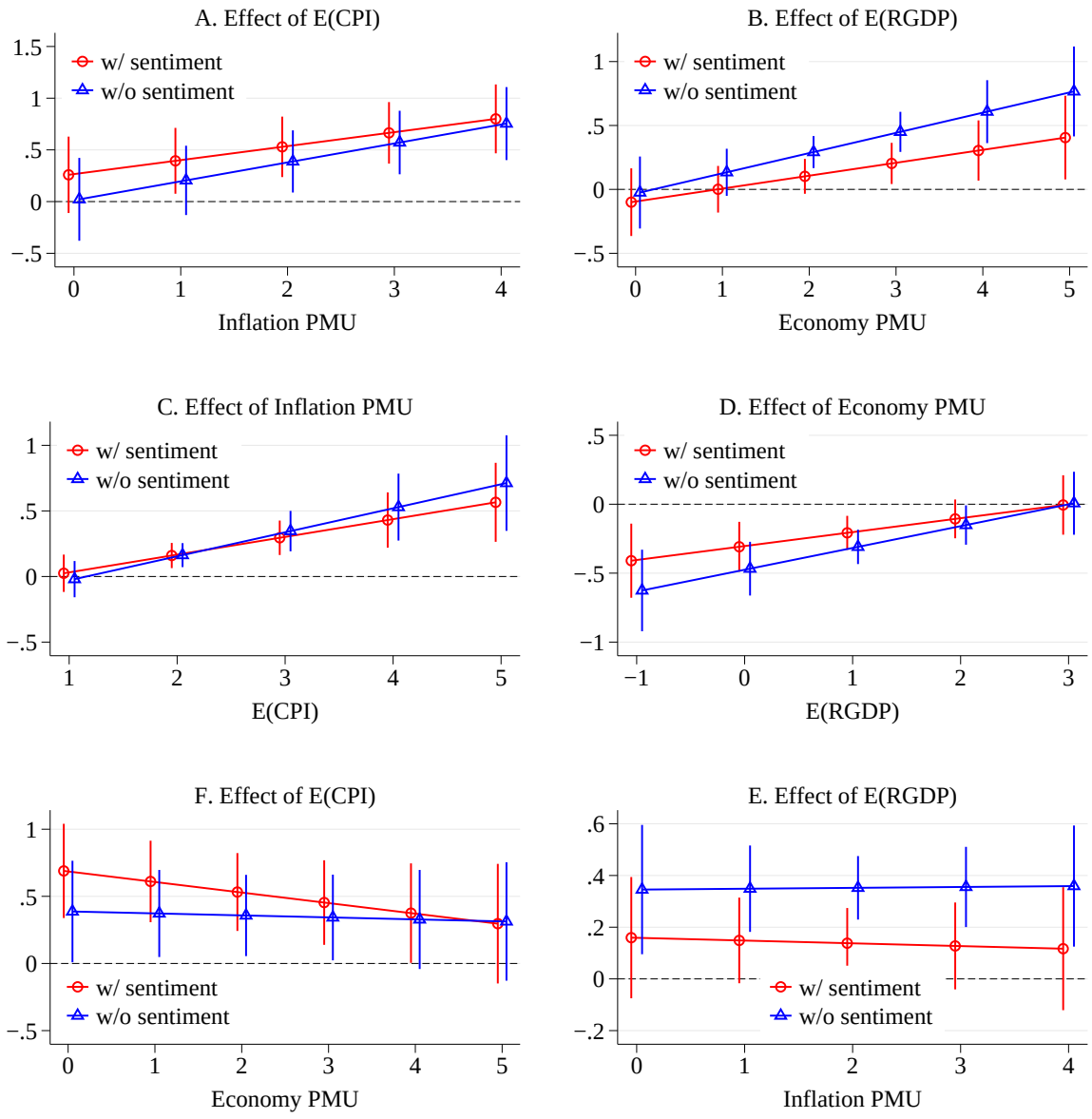


Figure 8. Marginal effects of PMU on policy preferences. The figure presents the marginal effects based on the estimates in Table VI, columns (3) and (4). The dependent variable is the *HD* policy preference score. Panel A shows how the *HD* variable changes with a one unit change in expected inflation holding inflation PMU at different values (and all other covariates at their means). Analogous interpretation applies to the other panels. All variables are expressed in units of their standard deviations. The range of values for the variables depicted on the x-axis is constrained between their 5th and the 95th percentile.

VI. Illustrating effects of uncertainty in monetary models

The empirical findings of the previous section highlight an amplifying effect of uncertainty on how policy preferences react to the macroeconomy. Especially in the context of the inflation response, several facts documented so far are consistent with policymakers behaving as if

they are unsure of the model that generates the data they observe. Inflation PMU increases following large forecast errors about inflation in the Greenbook and its predictive power for policy preferences goes in the same direction as the model PMU (more uncertainty about inflation and models is associated with more hawkishness).[24] As such, policymakers are likely to become more uncertain about inflation precisely at the time when their models fail, and concerns about changing economic structure become pertinent.

Below, we expand our discussion in Section II and revisit the theoretical literature on parameter uncertainty and preferences for robustness. We show how our empirical findings stand in contrast to the typical models of parameter uncertainty, though they are consistent with settings, in which policymakers face uncertainty about the persistence of inflation. Models with a desire for robustness more easily match the anti-conservatism response we find. However, even though the results are qualitatively similar, for standard calibrations the quantitative impact of uncertainty on optimal policy remains economically small relative to the empirical findings.

VI.A. Parameter uncertainty

In models where the policymaker lacks knowledge of the precise value of key structural parameters, the ϕ parameters of the policy rule (1) become a function of the parameter uncertainty. Typically, greater uncertainty reduces the ϕ loadings. To see this, consider a backward-looking Svensson (1999) type model with perfect knowledge of the parameter values $(\alpha, \beta, \delta, \gamma)$:

$$y_{t+1} = \alpha y_t - \beta \left(i_t - \pi_t\right) + \sigma_y \varepsilon^y_{t+1} \tag{5}$$

$$\pi_{t+1} = \delta \pi_t + \gamma y_t + \sigma_\pi \varepsilon^\pi_{t+1}, \tag{6}$$

where ε^y_{t+1} and ε^π_{t+1} are stochastic shocks. The central bank sets the optimal interest rate i_t by minimizing the following quadratic loss function:

$$\min_{\{i_{t+\tau}\}_{\tau=0}^{\infty}} E_t \sum_{\tau=0}^{\infty} \psi^\tau \left(\pi^2_{t+\tau} + \lambda_y y^2_{t+\tau}\right). \tag{7}$$

Optimal policy is a linear function of the current state variables:

$$i_t = \phi_y y_{t+1} + \phi_\pi \pi_{t+1}. \tag{8}$$

[24] As reported in Table A-12, model and inflation PMU have a correlation of 0.22 which is second highest among our measures.

The first row of Table VII shows the baseline parametrization of the model with the structural parameters known with certainty. The optimal policy coefficients ϕ_y, ϕ_π for $\lambda_y = 0.5$ and $\psi = 0.9$ are shown in the last two columns for the certainty case.

	$\bar{\alpha}$	$\bar{\beta}$	$\bar{\delta}$	$\bar{\gamma}$	σ^2_α	σ^2_β	σ^2_δ	σ^2_γ	ϕ_y	ϕ_π
Certainty	0.645	0.9	1	0.5	0	0	0	0	1.23	2.03
Baseline Uncertainty	0.645	0.9	1	0.5	0.0121	0.01	0.01	0.0169	1.20	1.98

Table VII. Effect of parameter uncertainty

Uncertainty in this model is introduced following Söderström (2002): The policymaker does not know the specific parameters but is aware that the coefficients $(\alpha_{t+1}, \beta_{t+1}, \delta_{t+1}, \gamma_{t+1})$ are random variables drawn independently each period from normal distributions with known means and variances. For instance, $\alpha_{t+1} \sim N(\bar{\alpha}, \sigma^2_\alpha)$.[25]

Optimal policy remains a linear function of the current state variables as in equation (8). The model exhibits certainty equivalence in the sense that increasing volatility of the stochastic shocks (ε^y_{t+1} and ε^π_{t+1}) does not affect the ϕ coefficients. However, certainty equivalence fails in a different sense; the ϕ coefficients are a function of the uncertainty about the parameter values (such as σ_α). The second row of Table VII shows that the introduction of uncertainty about all parameters leads the ϕ coefficients to both decrease very slightly in line with the original Brainard's conservatism result. This is because we use the baseline variance of δ from the Söderström (2002) calibration ($\sigma^2_\delta = 0.01$); if we instead use a larger calibrated value considered in Söderström (2002) ($\sigma^2_\delta = 0.1$), the ϕ coefficients increase very slightly overall.

To connect the model predictions to our empirical findings, we explore how different levels of uncertainty about the paramaters (σ_δ, σ_γ, σ_α and σ_β) impact the policy reaction function. We analyze the effect of each of these parameter uncertainty measures varying from 0.4 to 3 times the baseline standard deviation (Table VII reports the variances) and present the evolution of the ϕ coefficients in Figure 9. Two of the parameters directly affect inflation (δ and γ), and two directly affect output (α and β). We, therefore, analyse these together since our empirical measures do not distinguish whether higher uncertainty about inflation

[25] Specifically:

$$y_{t+1} = \alpha_{t+1} y_t - \beta_{t+1} (i_t - \pi_t) + \sigma_y \varepsilon^y_{t+1}$$
$$\pi_{t+1} = \delta_{t+1} \pi_t + \gamma_{t+1} y_t + \sigma_\pi \varepsilon^\pi_{t+1}$$

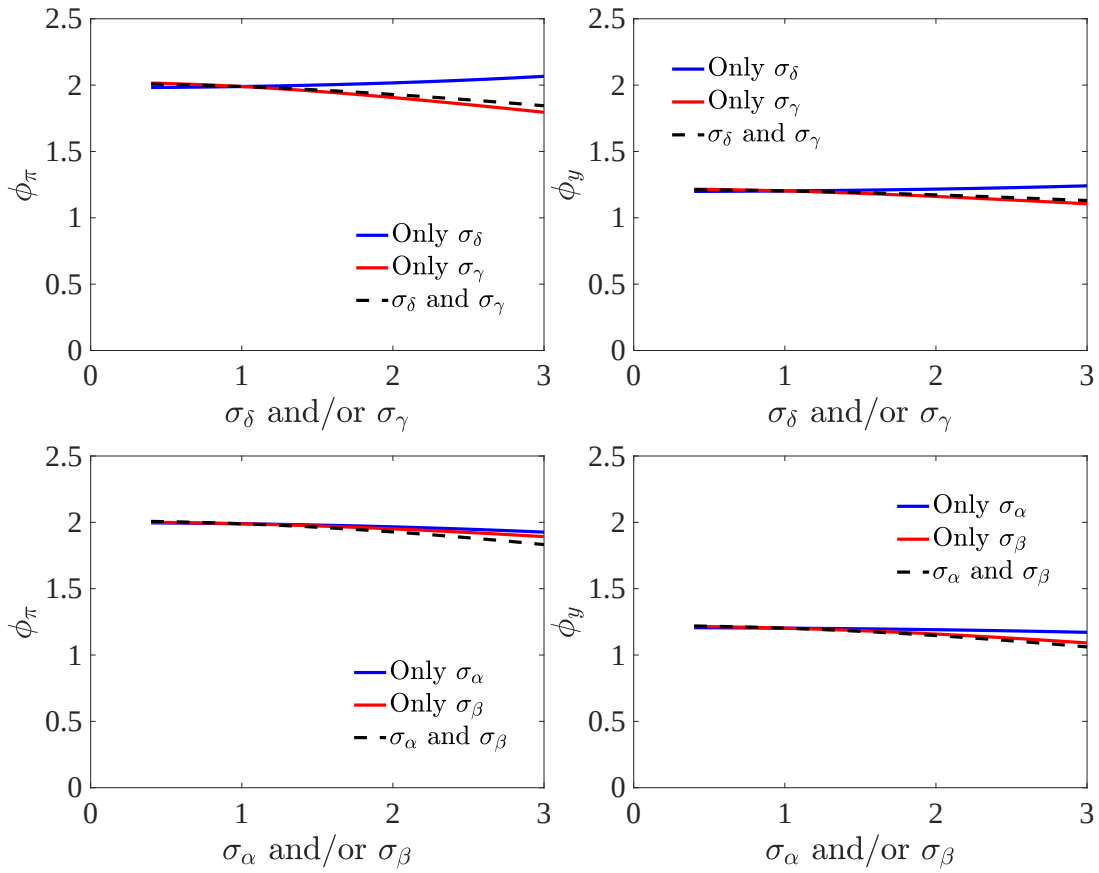


Figure 9. The effect of parameter uncertainty. The figure presents the effect of parameter uncertainty on the optimal ϕ_π and ϕ_y in the backward looking monetary model. The top row shows the effect of varying uncertainty about the two parameters of the inflation equation (σ_δ and/or σ_γ), and the lower row shows the effect of varying uncertainty about output equation parameters (σ_α and/or σ_β). In each case, the dashed line shows the effect of changing both together.

derives from uncertainty about δ or γ. The top row of Figure 9, shows the effect of varying the uncertainty around the inflation parameters, and the bottom row shows the same for the output parameters. In each case, we consider the effect of uncertainty about each parameter separately as well as jointly with the other parameter.

Uncertainty about inflation can, in principle, drive the ϕ_π coefficient upward so long as it is uncertainty about the persistence of inflation (as in Söderström (2002)). Nonetheless, with a threefold increase in σ_δ, the policy response ϕ_π only rises from 1.98 to 2.07. In the case of the other parameters, greater uncertainty leads to lower ϕ coefficients. Therefore, such a model of policymaker uncertainty has difficulties in explaining the amplifying impact of uncertainty on policy that we document empirically.

VI.B. Robust control

As an alternative to parameter uncertainty, a policymaker may display a desire for robustness. That is, in the face of uncertainty about the correct model specification, the policymaker seeks a policy function that is robust to the worst possible form of misspecification (Hansen and Sargent, 2001; Giordani and Söderlind, 2004; Hansen and Sargent, 2008). The robust min-max approach to optimal policy involves two stages. First, an imagined evil agent distorts the model in the most damaging possible way (maximize losses); second, the policymaker minimizes losses subject to the distorted model of the economy. Specifically, in the model described above, the evil agent can use shocks, υ_t^y and υ_t^π, to distort the model. The distorted model is:

$$y_{t+1} = \alpha y_t - \beta\left(i_t - \pi_t\right) + \sigma_y(\upsilon_{t+1}^y + \varepsilon_{t+1}^y) \tag{9}$$

$$\pi_{t+1} = \delta\pi_t + \gamma y_t + \sigma_\pi(\upsilon_{t+1}^\pi + \varepsilon_{t+1}^\pi) \tag{10}$$

The υ shocks can be related to the endogenous variables allowing them to capture broad types of misspecification including the more traditional parameter uncertainty. The evil agent is constrained via a budget in how much they can distort the model and will always exhaust their budget. The parameter θ is inversely related to the budget: $\theta = \infty$ precludes distortions completely and corresponds to the rational expectations solution, while a low value of θ allows the evil agent distort the model in a significant way.[26]

The monetary authority minimizes the loss from inflation deviations and output deviations. The robust control literature finds that the policymaker's preference for interest rate smoothing can be important for model predictions. Therefore, we assume that the policymaker's loss function is given by:

$$L_t = \sum_{\tau=t}^{\infty} \psi^{\tau-t}\left(\pi_t^2 + \lambda_y y_t^2 + \lambda_i i_t^2\right) \tag{11}$$

where $\lambda_i > 0$ activates a preference for interest rate smoothing.[27]

Optimal policy is a linear solution of the predetermined state variables. Certainty equivalence fails because the optimal ϕ coefficients change with the variance of the structural shocks (σ_y^2 and σ_π^2). As volatility of the structural shocks increase, it becomes harder for the agent to distinguish their baseline model from the distorted model and they adjust their optimal policy to account for this uncertainty. Therefore, evaluating the effects of uncertainty in the

[26] We do not present the evil agents optimisation problem in the interests of space.

[27] The theoretical justification for this welfare function is discussed in Woodford (2003, Chapter 6).

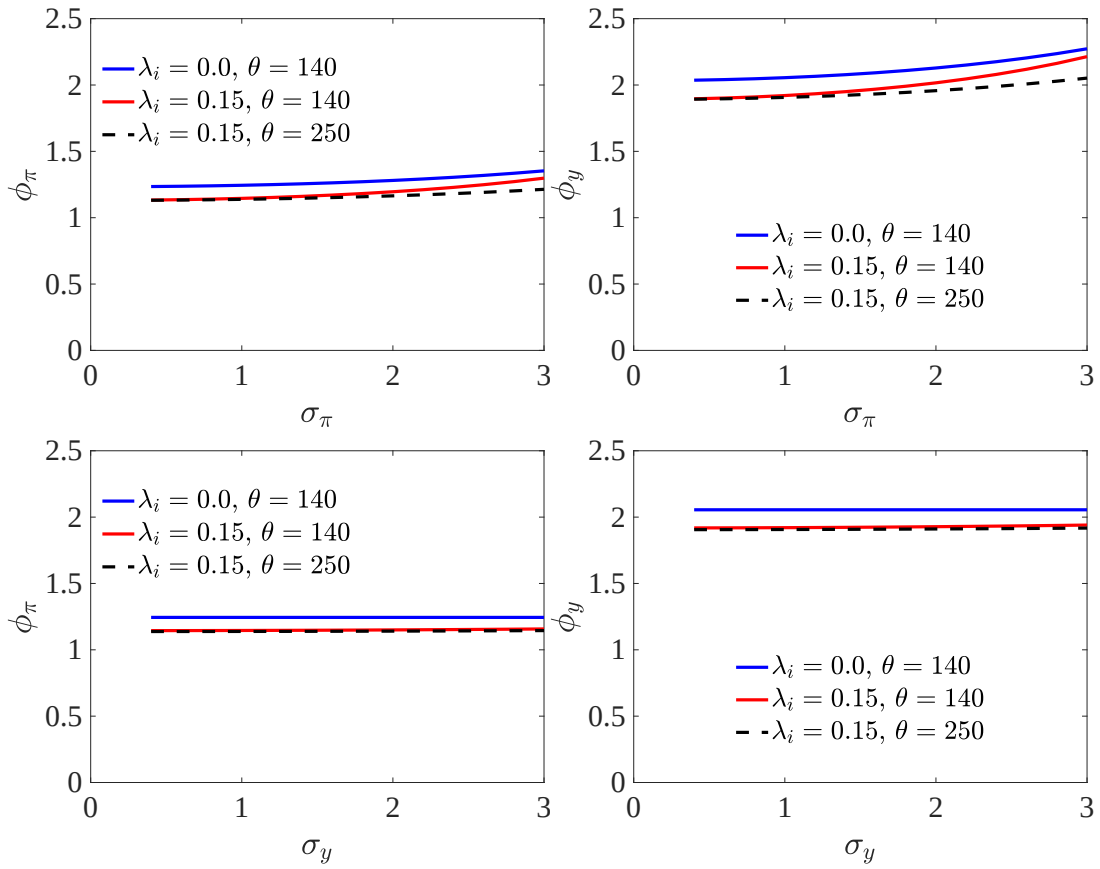


Figure 10. Backward-looking robust control model. The figure presents the effect on the optimal ϕ_π and ϕ_y of a policymaker who has a preference for robustness in the backward looking monetary model. The top row shows the effect of varying σ_π (volatility of the inflation shocks), and the lower row shows the effect of varying σ_y (output equation shock volatility).

robust control model is now directly related to examining the effect of σ_y^2 and σ_π^2 changing. There is no separate parameter uncertainty in this model.

In Figure 10, we evaluate the optimal ϕ parameters as σ_π (top row) and σ_y (bottom row) vary. The baseline in this model is $\sigma_\pi^2 = \sigma_y^2 = 1$ and, therefore, the relative volatility increase or decrease is expressed in terms of additional standard deviations. This allows us to compare Figure 9, Figure 10, and our empirical results. Each line in Figure 10 represents the effect of greater uncertainty for different key parameters; the basic calibration is the same as that in Table VII.

Generally, in this environment, uncertainty manifests itself through a more aggressive reaction function (larger ϕ coefficients). Higher inflation uncertainty σ_π^2, increases both ϕ_π and ϕ_y. The increase is greater when the policymaker has a preference for interest rate smoothing ($\lambda_i = 0.15$), though even this effect is offset if the policymaker's preference for robustness

(measured by the inverse of θ) is weaker. In contrast to inflation, the real uncertainty σ_y^2 has a negligible impact on the policy coefficients even when the smoothing motive is substantial.

VI.B.1. A forward-looking model with robustness

One concern is that the model presented above is backward-looking and lacks greater persistence, which can be important in generating quantitatively meaningful effects of uncertainty. This simplicity is useful for obtaining tractable solutions for optimal policy. However, to show that the main conclusions persist in richer settings, we now analyze how robustness affects policy in a forward-looking New Keynesian model comprising an IS curve (12) and a Phillips curve (13) as in Clarida, Galí, and Gertler (1999) and Giordani and Söderlind (2004). Both equations are subject to persistent shocks, g_t and u_t respectively:[28]

$$y_t = E_t y_{t+1} - \gamma \left(i_t - E_t \pi_{t+1}\right) + g_t \tag{12}$$

$$\pi_t = \alpha y_t + \beta E_t \pi_{t+1} + u_t \tag{13}$$

$$g_t = \rho_g g_{t-1} + \sigma_y \epsilon_t^y \tag{14}$$

$$u_t = \rho_u u_{t-1} + \sigma_\pi \epsilon_t^\pi \tag{15}$$

where $\epsilon_t^y \sim N(0,1)$ and $\epsilon_t^\pi \sim N(0,1)$ are i.i.d. disturbances. As before, the monetary authority minimises the loss from inflation deviations, output deviations and, if $\lambda_i > 0$, interest rate level variation. The evil agent can use shocks, υ_t^y and υ_t^π, to distort the model.[29]

We solve this model under the assumption that the central bank cannot commit to a policy rule as in Giordani and Söderlind (2004).[30] This has the advantage that every period, the policymaker can assess uncertainty and choose an optimal response. As such, it is closer in spirit to the comparative statics exercise we perform, in which we change the volatility of

[28] Ferrero, Pietrunti, and Tiseno (2019) present an analysis of optimal policy under parameter uncertainty in a forward-looking model similar to the one we consider. Their main finding is that the optimal response to uncertainty about the slope of the Phillips Curve depends on the the persistence of the cost-push shock. If the shock is not persistent, policy caution is the optimal response; with persistent cost-push shocks, optimal policy is more aggressive.

[29] The distorted model is:

$$y_t = E_t y_{t+1} - \gamma \left(i_t - E_t \pi_{t+1}\right) + \rho_g g_{t-1} + \sigma_y(\upsilon_t^y + \epsilon_t^y)$$
$$\pi_t = \lambda y_t + \beta E_t \pi_{t+1} + \rho_u u_{t-1} + \sigma_\pi(\upsilon_t^\pi + \epsilon_t^\pi)$$

[30] Giannoni (2002) solves a robust-control problem in the same type of model under the assumption of a commitment policy. We did not discuss this distinction when discussing the backward-looking model above as the discretion solution coincides with the commitment solution in that model.

structural shocks and solve for the optimal policy. The evil agent is similarly assumed to optimize every period and choose the worst-possible distortion. To simplify the solution, we follow Hansen and Sargent (2008) assuming that the private sector's loss function, reference model, and their degree of robustness are shared with the central bank.

The key parameters are the ρ_u and ρ_g persistence parameters, the degree of interest rate smoothing (λ_i), and the desire for robustness (θ). In Figure 11, as before, we evaluate the optimal ϕ parameters as σ_π (top row) and σ_y (bottom row) vary for different values of the other key parameters. When the policymaker's utility from interest rate smoothing is low, the impact of uncertainty is imperceptible; the blue line in the figure show the effects for $\rho = \rho_\pi = \rho_x = 0$, but the effect is little changed if $\rho = \rho_\pi = \rho_x = 0.5$ (not shown). Adding a desire for smoothing but no persistence does generate an increasing relationship between the ϕ coefficients and the volatility of the shocks, albeit so slight that it does not appear visible in the graph (red line). It is only when there is a desire for smoothing, alongside persistence, that the upward relationship begins to emerge.[31]

In summary, across the models we consider, while policymakers' parameter uncertainty and preference for robustness can generate amplification of the policy reaction to the state of the macroeconomy, the economic magnitudes of this effect appear quantitatively small and are sensitive to specific model assumptions. This contrasts with the relatively sizeable effects of uncertainty on policy preferences we document empirically.

VII. Conclusions

We study the properties of policymakers' uncertainty in the setting of the US Federal Reserve during the last three decades. We develop a new set of measures of policymakers' uncertainty and explore how uncertainty impacts decision-making.

To establish a causal effect of uncertainty on policy preferences, we exploit the sequential structure of deliberations in the regularly scheduled FOMC meetings, which separate discussions about the economic environment from discussions about the appropriate policy choice. Using the economy round of the meetings, we construct textual measures of uncertainty that policymakers are confronted with, distinguishing between types of uncertainty related to inflation, the real economy, financial markets, and models. Contrary to the common

[31] Although not plotted, increasing θ limits the budget of the evil agent and, as before, has a dampening effect on how higher volatility affects the ϕ coefficients.

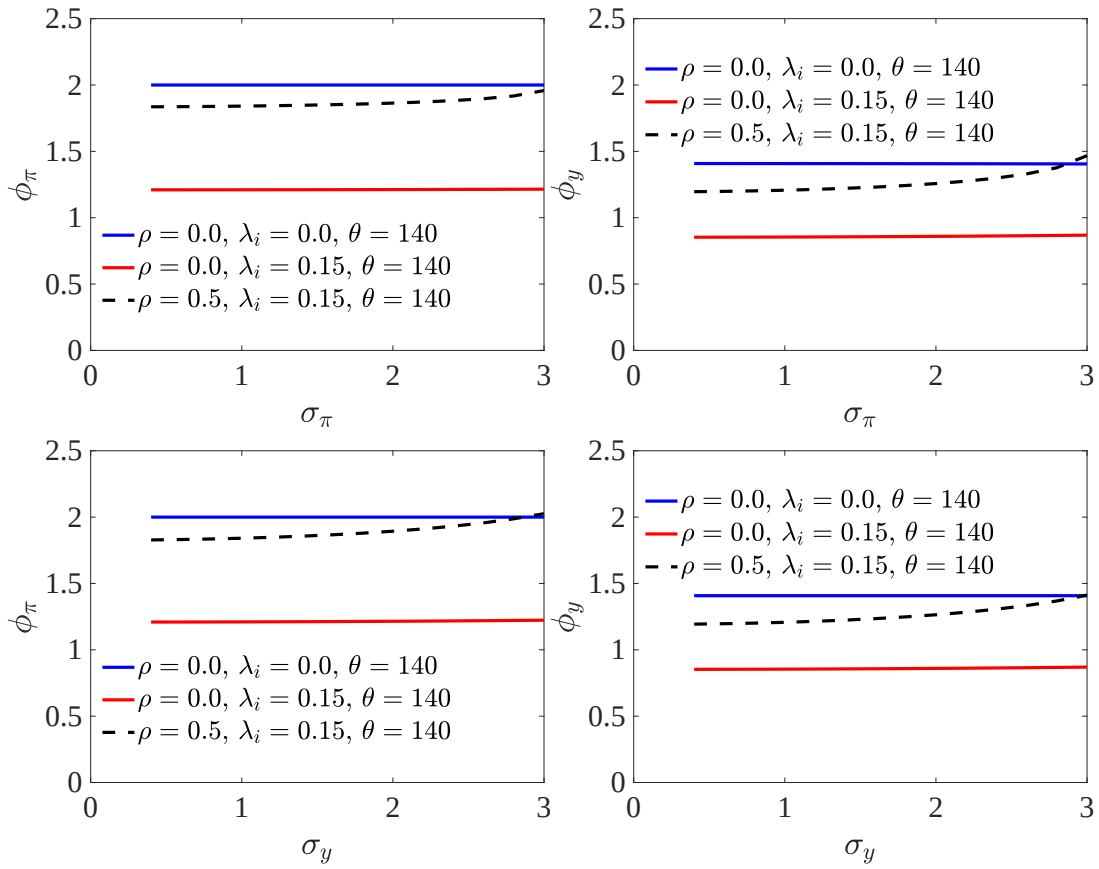


Figure 11. Forward-looking robust control model. The figure presents the effect on the optimal ϕ_π and ϕ_y of a policymaker who has a preference for robustness in the forward-looking monetary model. The top row shows the effect of varying σ_π (volatility of the inflation shocks), and the lower row shows the effect of varying σ_y (output equation shock volatility).

perception of how uncertainty evolves over the business cycle, policymakers' uncertainty is not countercyclical in an evident way. As one salient example, FOMC members report elevated uncertainty about the real economy and markets already about a year before the global financial crisis materializes in financial and macroeconomic data. On the other hand, inflation uncertainty displays a procyclical behavior over time and is negatively correlated with measures of public perceptions of policy uncertainty. We document a systematic and asymmetric relationship between policymakers' uncertainty and their concern about rising inflation during much of the 1987–2015 sample.

To connect uncertainty to decision making, from the policy round of the meetings, we obtain novel measures of policy preferences, which we show to be highly informative about the news component of monetary policy decisions. We find that uncertainty influences policy preferences in a non-trivial way, but the strength and direction of that effect depend on the uncertainty source. The impact of uncertainty on policy preferences is not subsumed

by the Greenbook/Tealbook forecasts, suggesting that these forecasts do not fully reflect the consequences of uncertainty for the economy (e.g., via the real-options channel) that the policymakers perceive. Moreover, heightened inflation uncertainty significantly amplifies the policy response to fluctuations in inflation. This fact presents a deviation from the conventional narrative following Brainard (1967) that uncertainty imparts a conservative policy behavior. Instead, it is consistent with policymakers' reacting to uncertainty about the persistence of inflation or displaying a preference for robustness to avoid costly outcomes. We conclude by discussing the implications of these findings for models of optimal policy.

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Internet Appendix for:

Policymakers' uncertainty

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A. Dictionaries for Risk, Uncertainty, Topics, and Sentiment

risk			risks		
Term	Similarity	Count in Econ Discussion	Term	Similarity	Count in Econ Discussion
risks	0.691266	3183	downside risk*	0.737511	1118
downside risk*	0.59828	1118	upside risk*	0.704978	585
threat	0.594511	135	risk	0.691266	3236
upside risk*	0.522107	585	threat	0.52743	135
danger	0.502593	121	skewed	0.501801	101
probability	0.484233	524	uncertainties	0.48339	505
possibility	0.475492	1010	~~downside~~	0.449301	707
likelihood	0.469565	224	~~tilted~~	0.448698	119
vulnerability	0.439843	72	danger	0.445836	121
dangers	0.406005	28	dangers	0.439822	28
~~headwind~~	0.402709	38	fatter	0.434411	14
chances	0.386979	65	~~outcomes~~	0.420205	291
fragility	0.374305	106	probability	0.412639	524
~~risktaking~~	0.373512	50	skew	0.40086	29
~~challenges~~	0.348706	174	~~challenges~~	0.395508	174
~~prospect~~	0.347213	242	~~juncture~~	0.393311	114
~~unwelcome~~	0.345361	42	modal	0.391584	131
sensitivity	0.343196	82	~~headwinds~~	0.385167	288
probabilities	0.342825	87	vulnerabilities	0.378889	59
~~breakout~~	0.34249	39	probabilities	0.375555	87
uncertainty	0.341431	2317	concerns	0.374206	628
~~consequences~~	0.339106	367	~~breakout~~	0.372844	39
concern* that	0.33652	678	possibilities	0.369255	98
odds	0.332704	190	uncertainty	0.362784	2317
fatter	0.331849	14	vulnerability	0.355743	72
concern	0.326579	1047	~~directive~~	0.355738	29
potentially	0.322536	275	tensions	0.35208	51
concerns	0.318465	628	~~crosscurrents~~	0.350524	49
tension	0.313301	101	odds	0.343869	190
~~spiral~~	0.312127	69	threats	0.33815	36
possibly	0.309975	290	fragility	0.337531	106
~~costly~~	0.309472	63	~~symmetric~~	0.336238	57
~~challenge~~	0.307298	179	~~asymmetry~~	0.333936	25
~~urgency~~	0.303853	28	skews	0.33296	14
~~instability~~	0.303578	91	~~urgency~~	0.3309	28
unease	0.303215	25	skewness	0.330203	7
vulnerabilities	0.302247	59	tension	0.325514	101
fear	0.299544	194	~~headwind~~	0.323167	38
skewness	0.298903	7	~~vigilant~~	0.319233	55
~~trap~~	0.297911	58	~~drags~~	0.31894	75
~~overshoot~~	0.296446	53	~~costpush~~	0.318601	4
~~problem~~	0.295296	1221	possibility	0.318443	1010
skew	0.29475	29	~~balanced~~	0.317706	646
worries	0.294228	132	tails	0.31724	28
threats	0.294017	36	~~challenge~~	0.316888	179
~~repercussions~~	0.289451	23	likelihood	0.315145	224
skewed	0.287008	101	imponderables	0.31498	10
volatility	0.284335	360	~~considerations~~	0.311688	184
doubts	0.283668	65	~~consequences~~	0.306922	367
~~juncture~~	0.283524	114	~~leaning~~	0.305052	38

Table A-1. Nearest Neighbors of Risk and Risks in FOMC Word Embeddings. This table shows the fifty nearest neighbors to the terms 'risk' and 'risks' for a word embedding model estimated from the subcorpus formed of the economic situation discussion of the Federal Open Market Committee deliberations. For each neighbor term, we report the cosine similarity in the word embedding space and the count of the term in the subcorpus. For each term, we then assign it to a risk dictionary (black); to an uncertainty dictionary (blue); or remove it for being too generic.

uncertain			uncertainty		
Term	Similarity	Count in Econ Discussion	Term	Similarity	Count in Econ Discussion
!confident	0.460385	367	uncertainties	0.65845	505
fragile	0.455998	157	anxiety	0.515023	70
!sanguine	0.442406	101	angst	0.433309	24
murky	0.43732	24	skepticism	0.430759	68
unclear	0.436552	57	tension	0.427094	101
wary	0.428437	41	uncertain	0.426752	399
uncertainty	0.426752	2317	~~caution~~	0.423748	445
unsure	0.423955	14	downside risk*	0.418226	1118
~~poor~~	0.411094	194	~~challenges~~	0.414084	174
~~dependent~~	0.406995	119	pessimism	0.411988	179
apprehensive	0.404002	11	fragility	0.401378	106
vulnerable	0.401095	203	gloom	0.380074	65
stressed	0.397458	53	~~conflict~~	0.370107	47
~~challenging~~	0.391555	71	risks	0.362784	3183
~~bullish~~	0.38583	65	volatility	0.359692	360
bleak	0.385454	52	concerns	0.359599	628
skeptical	0.384238	169	!clarity	0.352539	89
~~attuned~~	0.383523	15	sensitivity	0.348326	82
uncertainties	0.383365	505	unease	0.347682	25
~~vigilant~~	0.382641	55	~~publicity~~	0.346734	31
~~cautious~~	0.378045	537	fog	0.343423	20
grim	0.376893	34	~~headwinds~~	0.341591	288
~~jury~~	0.376789	20	risk	0.341431	3236
agnostic	0.375537	31	~~surrounding~~	0.340727	163
optimistic	0.372549	1249	worries	0.337692	132
~~muted~~	0.365712	87	!certainty	0.332492	91
unsettled	0.362423	22	doubts	0.328778	65
concern* about	0.361507	1634	concern	0.327687	1047
~~buoyant~~	0.360631	70	optimism	0.32465	498
~~disruptive~~	0.359961	50	~~pain~~	0.323275	31
~~depend~~	0.359918	198	ambiguity	0.322258	18
skittish	0.35904	18	error	0.320998	234
jittery	0.358658	11	skittishness	0.319675	9
precarious	0.357391	22	nervousness	0.319648	31
fog	0.357145	20	unknown	0.316516	32
fluid	0.357016	12	tensions	0.314929	51
!convinced	0.354622	173	imponderables	0.314825	10
pessimistic	0.354016	430	upside risk*	0.313048	585
!upbeat	0.352921	217	~~debate~~	0.312722	168
~~destabilizing~~	0.35242	22	~~awareness~~	0.312388	26
precise	0.352262	81	~~uncertaintyin~~	0.310427	3
uncomfortable	0.348358	102	~~disagreement~~	0.304366	57
~~assessing~~	0.345848	110	~~admits~~	0.302832	3
~~damaging~~	0.342869	39	~~science~~	0.29633	31
~~satisfactory~~	0.339921	66	apprehension	0.292553	16
anxious	0.33839	40	~~headwind~~	0.290777	38
worried	0.337316	410	~~instability~~	0.290598	91
ambiguous	0.335987	32	~~troubles~~	0.288294	35
problematic	0.33498	78	~~questions~~	0.288182	698
daunting	0.332674	19	worry	0.286513	402

Table A-2. Nearest Neighbors of Uncertain and Uncertainty in FOMC Word Embeddings. This table shows the fifty nearest neighbors to the terms 'uncertain' and 'uncertainty' for a word embedding model estimated from the subcorpus formed of the economic situation discussion of the Federal Open Market Committee deliberations. For each neighbor term, we report the cosine similarity in the word embedding space and the count of the term in the subcorpus. For each term, we then assign it to a risk dictionary (black); to an uncertainty dictionary (blue); or remove it for being too generic. An exclamation mark preceding a term indicates it is only associated with the dictionary when it is negated.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
commodity price*	1	2	*abated*	*acceler**
consumer energy price*	1	2	*adjust* downward*	*adjust* upward*
consumer food price*	1	2	*contract**	*advanc**
consumer price index*	1	2	*cool**	*bolster**
consumer price index* cpi	1	2	*deceler**	*boost**
consumer price inflation	1	2	*declin**	*elevat**
consumer price*	1	2	*decreas**	*expand**
core consumer price inflation	1	2	*down*	*fast**
core consumer price*	1	2	*downturn*	*gain**
core cpi	1	2	*downward*	*go* up*
core cpi inflation	1	2	*downward adjust**	*heighten**
core inflation	1	2	*downward revision*	*high**
core pce inflation	1	2	*drop**	*increas**
core pce price inflation	1	2	*eas**	*mov* higher*
core pce price*	1	2	*fall**	*mov* up*
core price inflation	1	2	*fell*	*mov* upward*
core producer price*	1	2	*go* down*	*pick* up*
cost basic material*	1	2	*limit**	*rais**
cost* goods and services	1	2	*low**	*rallied*
cost* health care	1	2	*moderate**	*rally**
cost* labor	1	2	*moderati**	*rebound**
cost* living	1	2	*mov* down*	*recoup**
cost* us goods and services	1	2	*mov* downward*	*revis* up**
crude oil price*	1	2	*mov* lower*	*rise**
disinflation	2	1	*pullback*	*rising*
disinflation* pressure*	1	2	*reduc**	*rose*
employment cost index*	1	2	*revis* down**	*run up*
energy prices	1	2	*slow**	*runup*
headline inflation	1	2	*slow* down*	*stop decline*
health care cost*	1	2	*soft**	*strength**
inflation*	1	2	*stagnate**	*strong**
inflation compensation	2	1	*stall**	*tick* up*
inflation expectation*	1	2	*subdu**	*up*
inflation level	1	2	*tick* down*	*upward*
inflation outlook	1	2	*tight**	*upward adjust**
inflation rate	1	2	*weak**	*upward revision*
inflation wage*	1	2	*weigh* on*	*went up*
labor compensation	1	2	*went down*	
labor cost pressure*	1	2		
labor cost*	1	2		
long* run inflation expectation*	1	2		
long* term inflation expectation*	1	2		
manufacturing price*	1	2		
material price*	1	2		
near* term inflation expectation*	1	2		
oil price*	1	2		
pce price index*	1	2		
pressure* inflation	1	2		
pressure* wages	1	2		
price index*	1	2		
price inflation	1	2		
price level stability	2	1		
price stability	2	1		
prices of durable goods	1	2		
prices of durables	1	2		
prices of manufacturing	1	2		
prices of material*	1	2		
producer price ind*	1	2		
producer price*	1	2		
real oil price*	1	2		
unit labor cost*	1	2		
wage gains	1	2		
wage inflation	1	2		
wage pressure*	1	2		
wage price pressure*	1	2		
wages	1	2		
inflation* pressure*	1	2		
price pressure*	1	2		

Table A-3. Noun Phrases and Direction Words Related to Inflation and Wages. The first column displays the phrases we associate with inflation and wage discussion in the FOMC transcripts. The second to fifth columns relate to the construction of inflation sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
aggregate demand	2	1	*adjust* downward*	*acceler**
aggregate inventory sales ratio	1	2	*adverse*	*adjust* upward*
aggregate spending	2	1	*contract**	*advanc**
building activity	2	1	*cool**	*better*
business activity	2	1	*cut**	*bolster**
business capital spending	2	1	*deceler**	*boost**
business confidence	2	1	*declin**	*elevat**
business demand capital equipment	2	1	*decreas**	*encourag**
business equipment investment	2	1	*deteriorat**	*expand**
business equipment spending	2	1	*disappoint**	*fast**
business equipment spending	2	1	*down*	*favor**
business equipment spending and industrial production	2	1	*downturn*	*gain**
business expansion	2	1	*downward*	*go* up*
business expenditure*	2	1	*downward adjust**	*heighten**
business fixed investment	2	1	*downward revision*	*high**
business fixed investment and household spending	2	1	*drag**	*improv**
business inventory investment	2	1	*drop**	*increas**
business investment	2	1	*eas**	*mov* higher*
business investment spending	2	1	*fall**	*mov* up*
business outlay*	2	1	*fell*	*mov* upward*
business outlays capital equipment	2	1	*go* down*	*pick* up*
business output	2	1	*held down*	*rais**
business purchas*	2	1	*hold down*	*rallied*
business purchases of transporation equipment	2	1	*increas* at slow* rate*	*rally**
business sector	2	1	*limit**	*rebound**
business sentiment	2	1	*low**	*recoup**
business spending	2	1	*moderate**	*revis* up**
business spending capital equipment	2	1	*moderati**	*rise**
business spending of transporation equipment	2	1	*mov* down*	*rising*
capacity utilization	2	1	*mov* downward*	*rose*
capital investment	2	1	*mov* lower*	*run up*
capital spending	2	1	*pressur**	*runup*
capital spending plan*	2	1	*pullback*	*stop decline*
civilian unemployment rate	1	2	*reduc**	*strength**
claim* unemployment insurance	1	2	*revis* down**	*strong**
construction activity	2	1	*slow**	*tick* up*
consumer confidence	2	1	*slow* down*	*tight**
consumer sector	2	1	*soft**	*up*
consumer sentiment	2	1	*stagnat**	*upward*
consumer spending	2	1	*stall**	*upward adjust**
consumption	2	1	*strain**	*upward revision*
consumption spending	2	1	*stress**	*went up*
current account deficit			*subdu**	
current account surplus			*take* toll on*	
disposable income	2	1	*tension**	
domestic components of spending	2	1	*tick* down*	
domestic demand	2	1	*took toll on*	
domestic economy	2	1	*weak**	
domestic final demand	2	1	*weigh* down*	
domestic spending	2	1	*weigh* on*	
domestic spending components	2	1	*went down*	
durable equipment	2	1	*worse**	
economic activity	2	1		
economic development*	2	1		
economic expansion	2	1		
economic growth	2	1		
economic outlook	2	1		
economic performance	2	1		
economic recovery	2	1		
economic situation	2	1		
employment	2	1		
employment growth	2	1		
employment rate	2	1		
excess capacity	1	2		
factory output	2	1		

Table A-4. Noun Phrases and Direction Words Related to Economic Growth (1). The first column displays a subset the phrases we associate with economic growth discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of growth sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction. Nouns with no number recorded in the second and third columns are used to contextualize uncertainty language but not for the construction of sentiment.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
final demand	2	1	*adjust* downward*	*acceler**
gdp growth	2	1	*adverse*	*adjust* upward*
global economic growth	2	1	*contract**	*advanc**
gross domestic product	2	1	*cool**	*better*
high tech equipment investment	2	1	*cut**	*bolster**
high tech equipment spending	2	1	*deceler**	*boost**
household spending and business fixed investment	2	1	*declin**	*elevat**
household* spending	2	1	*decreas**	*encourag**
housing activity	2	1	*deteriorat**	*expand**
housing construction	2	1	*disappoint**	*fast**
housing demand	2	1	*down*	*favor**
income growth	2	1	*downturn*	*gain**
industrial production	2	1	*downward*	*go* up*
inventories	2	1	*downward adjust**	*heighten**
inventory accumulation	1	2	*downward revision*	*high**
inventory investment	2	1	*drag**	*improv**
inventory liquidation	2	1	*drop**	*increas**
inventory sales ratio	1	2	*eas**	*mov* higher*
investment condition*	2	1	*fall**	*mov* up*
investment demand	2	1	*fell*	*mov* upward*
investment high tech equipment	2	1	*go* down*	*pick* up*
investment manufacturing	2	1	*held down*	*rais**
investment situation	2	1	*hold down*	*rallied*
investment spending	2	1	*increas* at slow* rate*	*rally**
job growth	2	1	*limit**	*rebound**
labor demand	2	1	*low**	*recoup**
labor force participation	2	1	*moderate**	*revis* up**
labor market*	2	1	*moderati**	*rise**
labor market condition*	2	1	*mov* down*	*rising*
labor market indicator*	2	1	*mov* downward*	*rose*
labor market slack	1	2	*mov* lower*	*run up*
labor productivity	2	1	*pressur**	*runup*
manufacturing activity	2	1	*pullback*	*stop decline*
manufacturing capacity utilization	2	1	*reduc**	*strength**
manufacturing output	2	1	*revis* down**	*strong**
manufacturing production	2	1	*slow**	*tick* up*
manufacturing sector	2	1	*slow* down*	*tight**
motor vehicle assembl*	2	1	*soft**	*up*
motor vehicle production	2	1	*stagnat**	*upward*
motor vehicle purchas*	2	1	*stall**	*upward adjust**
motor vehicle sales	2	1	*strain**	*upward revision*
motor vehicle sector	2	1	*stress**	*went up*
new construction	2	1	*subdu**	
new home sales	2	1	*take* toll on*	
new orders	2	1	*tension**	
nominal gdp	2	1	*tick* down*	
nonfarm business sector	2	1	*took toll on*	
nonfarm payroll employment	2	1	*weak**	
nonresidential construction	2	1	*weigh* down*	
nonresidential construction activity	2	1	*weigh* on*	
orders and shipments of nondefense capital goods	2	1	*went down*	
orders of nondefense capital goods	2	1	*worse**	
outlays business equipment	2	1		
outlays high tech equipment	2	1		
outlays transporation equipment	2	1		
outlook economic activity	2	1		
output gap				
output growth	2	1		
payroll employment	2	1		
pce	2	1		
personal consumption expenditure*	2	1		
personal income	2	1		
potential output	2	1		
potential output	2	1		
private expenditures business equipment	2	1		

Table A-5. Noun Phrases and Direction Words Related to Economic Growth (2). The first column displays a subset the phrases we associate with economic growth discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of growth sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction. Nouns with no number recorded in the second and third columns are used to contextualize uncertainty language but not for the construction of sentiment.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
private nonfarm employment	2	1	*adjust* downward*	*acceler**
private nonfarm payroll employment	2	1	*adverse*	*adjust* upward*
private sector investment	2	1	*contract**	*advanc**
private spending	2	1	*cool**	*better*
productivity	2	1	*cut**	*bolster**
productivity growth	2	1	*deceler**	*boost**
purchas* of motor vehicle*	2	1	*declin**	*elevat**
real activity	2	1	*decreas**	*encourag**
real business spending	2	1	*deteriorat**	*expand**
real consumer spending	2	1	*disappoint**	*fast**
real disposable income	2	1	*down*	*favor**
real disposable personal income	2	1	*downturn*	*gain**
real gdp	2	1	*downward*	*go* up*
real gdp growth	2	1	*downward adjust**	*heighten**
real gnp	2	1	*downward revision*	*high**
real personal consumption expenditure*	2	1	*drag**	*improv**
real spending	2	1	*drop**	*increas**
residential construction	2	1	*eas**	*mov* higher*
residential construction activity	2	1	*fall**	*mov* up*
residential investment	2	1	*fell*	*mov* upward*
resource use	2	1	*go* down*	*pick* up*
resource utilization	2	1	*held down*	*rais**
retail trade	2	1	*hold down*	*rallied*
shipments of nondefense capital goods	2	1	*increas* at slow* rate*	*rally**
spending and production	2	1	*limit**	*rebound**
spending business equipment	2	1	*low**	*recoup**
spending high tech equipment	2	1	*moderate**	*revis* up**
spending nonresidential structures	2	1	*moderati**	*rise**
spending transporation equipment	2	1	*mov* down*	*rising*
structural productivity	2	1	*mov* downward*	*rose*
total industrial production	2	1	*mov* lower*	*run up*
total nonfarm payroll employment	2	1	*pressur**	*runup*
unemployment	1	2	*pullback*	*stop decline*
unemployment insurance claim*	1	2	*reduc**	*strength**
unemployment level	1	2	*revis* down**	*strong**
unemployment rate	1	2	*slow**	*tick* up*
us economic activity	2	1	*slow* down*	*tight**
us economy	2	1	*soft**	*up*
outlook economy	2	1	*stagnat**	*upward*
inventory level*	1	2	*stall**	*upward adjust**
fiscal			*strain**	*upward revision*
deficit			*stress**	*went up*
surplus			*subdu**	
			take toll on*	
			*tension**	
			tick down*	
			took toll on	
			*weak**	
			weigh down*	
			weigh on*	
			went down	
			*worse**	

Table A-6. Noun Phrases and Direction Words Related to Economic Growth (3). The first column displays a subset the phrases we associate with economic growth discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of growth sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction. Nouns with no number recorded in the second and third columns are used to contextualize uncertainty language but not for the construction of sentiment.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
aaa spread*	1	2	*adjust* downward*	*acceler**
baa spread*	1	2	*contract**	*adjust* upward*
corporate bond spread*	1	2	*cool**	*advanc**
corporate spread*	1	2	*deceler**	*adverse*
cost of bank credit	1	2	*declin**	*bolster**
cost of bond financ*	1	2	*decreas**	*boost**
cost of capital	1	2	*down*	*deteriorat**
cost of credit	1	2	*downturn*	*edge* up**
cost of equity	1	2	*downward*	*elevat**
cost of external capital	1	2	*downward adjust**	*expand**
cost of funding	1	2	*drop**	*fast**
cost of raising capital	1	2	*eas**	*gain**
cost of raising capital through equity	1	2	*edge* down*	*go* up*
credit cost*	1	2	*encourag**	*heighten**
credit default swap*	1	2	*fall**	*high**
credit risk spread*	1	2	*favor**	*increas**
credit spread*	1	2	*fell*	*mov* higher*
debt securities spread*	1	2	*go* down*	*mov* up*
equity risk prem*	1	2	*improv**	*mov* upward*
expected real return equit*	1	2	*limit**	*pick* up*
expected return equit*	1	2	*low**	*pressure**
financing cost	1	2	*moderate**	*rais**
funding cost	1	2	*moderati**	*rebound**
risk prem*	1	2	*mov* down*	*recoup**
risk spread*	1	2	*mov* downward*	*revis* up**
risk spread* corporate bonds*	1	2	*mov* lower*	*rise**
spread* corporate bond*	1	2	*narrow**	*rising*
spread* investment grade bond*	1	2	*pullback*	*rose*
spread* speculative grade bond*	1	2	*reduc**	*run up*
			revis down**	*runup*
			*slow**	*stop decline*
			*soft**	*strain**
			*subdu**	*strength**
			take toll on*	*stress**
			tick down*	*strong**
			took toll on	*tension**
			*weak**	*tick* up*
			weigh on*	*up*
			went down	*upward*
				*upward adjust**
				went up
				*widen**
				*worse**

Table A-7. Noun Phrases Related to Financial Markets (1). The first column displays a subset the phrases we associate with financial market discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of market sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
appetite* risk taking	2	1	*adjust* downward*	*acceler**
appetite* risk*	2	1	*adverse*	*adjust* upward*
appetite* risk* asset*	2	1	*contract**	*advanc**
appetite* risk* investment*	2	1	*cool**	*bolster**
appetite* taking risk*	2	1	*deceler**	*boost**
condition* credit market*	2	1	*declin**	*eas**
condition* financial market*	2	1	*decreas**	*elevat**
credit condition*	2	1	*deteriorat**	*encourag**
credit growth	2	1	*down*	*expand**
credit market*	2	1	*downturn*	*fast**
credit market condition*	2	1	*downward*	*favor**
credit market demand	2	1	*downward adjust**	*gain**
development financial market*	2	1	*downward revision*	*go* up*
financial condition*	2	1	*drop**	*high**
financial development*	2	1	*fall**	*improv**
financial instabilit*	1	2	*fell*	*increas**
financial market condition*	2	1	*go* down*	*loos**
financial market confidence	2	1	*limit**	*mov* higher*
financial market development*	2	1	*low**	*mov* up*
financial market index*	2	1	*moderate**	*mov* upward*
financial market indic*	2	1	*moderati**	*normaliz**
financial market pressure*	1	2	*mov* down*	*pick* up*
financial market price*	2	1	*mov* downward*	*rais**
financial market sentiment	2	1	*mov* lower*	*rallied*
financial market*	2	1	*pressure**	*rally**
financial situation	2	1	*pullback*	*rebound**
financial stability	2	1	*reduc**	*recoup**
investor* appetite*	2	1	*restrictive*	*revis* up**
investor* appetite* risk*	2	1	*revis* down**	*rise**
investor* confidence	2	1	*slow**	*rising*
investor* risk appetite*	2	1	*soft**	*rose*
investor* sentiment	2	1	*stagnate**	*run up*
investor* sentiment toward risk*	2	1	*stall**	*runup*
investor* sentiment toward risk* asset*	2	1	*strain**	*stop decline*
liquidity	2	1	*stress**	*strength**
pressure* financial market	1	2	*subdu**	*strong**
risk appetite*	2	1	*take a toll on*	*tick* up*
bank credit	2	1	*tension**	*up*
bank lending	2	1	*tick* down*	*upward*
banking supervision			*tight**	*upward adjust**
banking system	2	1	*took toll on*	*upward revision*
consumer credit	2	1	*turbulent*	*went up*
credit availability	2	1	*weak**	
credit quality	2	1	*weigh* on*	
domestic credit	2	1	*went down*	
domestic nonfinancial debt	2	1	*worsen**	
financial outlook	2	1		
financial system	2	1		
foreign exchange				
foreign exchange market*				
foreign exchange valu*				
household balance sheet*	2	1		
market exchange rate*				
market liquidity	2	1		
mortgage refinancing activity	2	1		
non market exchange rate*				
nonfinancial debt	2	1		
private credit	2	1		
private credit market*	2	1		
seasonal borrowing	2	1		
total domestic non financial debt	2	1		
total domestic nonfinancial debt	2	1		
us dollar				

Table A-8. Noun Phrases Related to Financial Markets (2). The first column displays a subset the phrases we associate with financial market discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of market sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction. Nouns with no number recorded in the second and third columns are used to contextualize uncertainty language but not for the construction of sentiment.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
aaa yield*	1	2	*adjust* downward*	*acceler**
baa yield*	1	2	*contract**	*adjust* upward*
bond yield*	1	2	*cool**	*advanc**
corporate bond yield*	1	2	*deceler**	*bolster**
corporate debt yield*	1	2	*declin**	*boost**
corporate yield*	1	2	*decreas**	*elevat**
debt yield*	1	2	*down*	*encourag**
high grade corporate bond* yield*	1	2	*downturn*	*expand**
interest rate*	1	2	*downward*	*fast**
investment grade and speculative grade corporate bond* yield*	1	2	*downward adjust**	*gain**
investment grade corporate bond yield*	1	2	*downward movement*	*go* up*
long* term interest rate*	1	2	*downward revision*	*heighten**
long* term rate*	1	2	*drop**	*high**
mortgage interest rate*	1	2	*fall**	*increas**
real long* term interest rate*	1	2	*fell*	*mov* higher*
real long* term rate*	1	2	*go* down*	*mov* up*
speculative grade corporate bond* yield*	1	2	*limit**	*mov* upward*
yield* agency mortgage backed securities mbs	1	2	*low**	*pick* up*
yield* corporate bond*	1	2	*moderate**	*rais**
yield* corporate bonds and agency mbs	1	2	*moderati**	*rallied*
yield* mortgage backed securities	1	2	*mov* down*	*rally**
yield* private sector debt securities	1	2	*mov* downward*	*rebound**
comparable maturity treasury securities			*mov* lower*	*recoup**
discount rate*	1	2	*pullback*	*revis* up*
long* term treasury securities			*reduc**	*revision upward*
nominal treasury securities			*revis* down*	*rise**
real interest rate*	1	2	*slow**	*rising*
short* term interest rate*	1	2	*soft**	*rose*
us government securities			*stagnate**	*run up*
			*stall**	*runup*
			*subdu**	*stop decline*
			take toll on*	*strength**
			tick down*	*strong**
			*tight**	*tick* up*
			took toll on	*up*
			*weak**	*upward*
			weigh on*	*upward adjust**
			went down	*upward movement*
				upward revision
				went up

Table A-9. Noun Phrases Related to Financial Markets (3). The first column displays a subset the phrases we associate with financial market discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of market sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction. Nouns with no number recorded in the second and third columns are used to contextualize uncertainty language but not for the construction of sentiment.

Nouns	Match w/ direction words		Direction words	
	Positive	Negative	Group 1	Group 2
asset index*	2	1	*adjust* downward*	*acceler**
asset indic*	2	1	*adverse*	*adjust* upward*
asset market*	2	1	*burst**	*advanc**
asset price index*	2	1	*contract**	*bolster**
asset price indic*	2	1	*cool**	*boost**
asset price*	2	1	*deceler**	*edge* up*
asset valu*	2	1	*declin**	*elevat**
equities	2	1	*decreas**	*encourag**
equity and home price*	2	1	*deteriorat**	*expand**
equity and home valu*	2	1	*down*	*fast**
equity and house price*	2	1	*downturn*	*favor**
equity and housing price*	2	1	*downward*	*gain**
equity index*	2	1	*downward adjust**	*go* up*
equity indic*	2	1	*downward movement*	*high**
equity market index*	2	1	*downward revision*	*improv**
equity market indic*	2	1	*drop**	*increas**
equity market price*	2	1	*eas**	*mov* high**
equity market valu*	2	1	*edge* down*	*mov* up*
equity market*	2	1	*fall**	*mov* upward*
equity price index*	2	1	*fell*	*pick* up*
equity price indic*	2	1	*go* down*	*rais**
equity price measure*	2	1	*limit**	*rallied*
equity price*	2	1	*low**	*rally**
equity valu*	2	1	*moderate**	*rebound**
equaity wealth	2	1	*moderati**	*recoup**
financial wealth	2	1	*mov* down*	*revis* up**
home and equity price*	2	1	*mov* downward*	*rise**
house and equity price*	2	1	*mov* lower*	*rising*
household wealth	2	1	*plummet**	*rose*
household* net worth	2	1	*pressure**	*run up*
housing and equity price*	2	1	*pull* back*	*runup*
price* of risk* asset*	2	1	*pullback*	*stop decline*
ratio of wealth to income	2	1	*reduc**	*strength**
risk* asset price*	2	1	*revis* down**	*strong**
s p 500 index	2	1	*slow**	*tick* up*
stock index*	2	1	*slow* down*	*up*
stock indic*	2	1	*soft**	*upward*
stock market index*	2	1	*stagnate**	*upward adjust**
stock market price*	2	1	*stall**	*upward movement*
stock market wealth	2	1	*strain**	*upward revision*
stock market*	2	1	*stress**	*went up*
stock price indic*	2	1	*subdu**	
stock price*	2	1	*take* toll on*	
stock prices index*	2	1	*tension**	
stock val*	2	1	*tick* down*	
us stock market price*	2	1	*tight**	
wealth effect*	2	1	*took toll on*	
wealth to income ratio	2	1	*tumbl**	
			*weak**	
			weigh on*	
			went down	
			*worse**	

Table A-10. Noun Phrases Related to Financial Markets (4). The first column displays a subset the phrases we associate with financial market discussion in the FOMC transcripts (see other tables in sequence for other nouns). The second to fifth columns relate to the construction of market sentiment. An instance of positive sentiment occurs when a mention of one of the nouns with a 1 (2) recorded in the 'Positive' column is preceded or followed by a phrase from Group 1 (Group 2) within sub-sentences. Negative sentiment is constructed analogously. See Cieslak and Vissing-Jorgensen (2021) for full details of sentiment construction. Nouns with no number recorded in the second and third columns are used to contextualize uncertainty language but not for the construction of sentiment.

parameter*
model*
measurement*
forecast error*
relationship*
error band*
nairu
trend
confidence interval*
uncertainty band*
confidence band*

Table A-11. Noun Phrases Related to Model. The table contains phrases we associate with model discussion in the FOMC transcripts.

B. Algorithms for Sentiment and Preference Construction

B.1. Sentiment construction

Here we describe the construction of sentiment for topic k (which corresponds to economic growth, inflation and wages, and financial markets). The algorithm follows closely that in **?** which use a similar approach to build a stock market sentiment index. Here we expand this to additional topics.

Sentiment is built exclusively using economy round language. We first remove any sentence in the economy round that either contains an uncertainty flag word, i.e. a term in the 'Term' columns of tables A-1 or A-2 that is not struck through, as well as sentences that immediately precede or follow such sentences. This ensures that sentiment is constructed using a different set of input words than the uncertainty measures, which avoids a mechanical relationship between the two.

The next step is to break all remaining sentences in the economy round into sub-sentences based on the presence of words in {'and', 'because', 'but',' if', 'or', 'so','that', 'when', 'where', 'while', 'although', 'however', 'though', 'whereas', 'despite'}. Let $\mathbf{p}_{t,s}$ be the sth phrase in meeting t generated by this rule.

As described in the tables above, each topic is associated with a set of nouns. Let $g_{k,m}$ be the mth noun associated with topic k. This noun will be associated with a set of positive words $\text{Pos}_{k,m}$ and a set of negative words $\text{Neg}_{k,m}$ according to the group definitions in the tables. The positive and negative sentiment measures in meeting t begin with the tabulations

$$\tilde{S}^{+}_{t,k} = \sum_{s}\sum_{m}\sum_{n} \mathbb{1}(w_{t,s,n} = g_{k,m}) \left[\mathbb{1}(w_{t,s,n-1} \in \text{Pos}_{k,m}) + \mathbb{1}(w_{t,s,n+1} \in \text{Pos}_{k,m})\right]$$
$$\tilde{S}^{-}_{t,k} = \sum_{s}\sum_{m}\sum_{n} \mathbb{1}(w_{t,s,n} = g_{k,m}) \left[\mathbb{1}\big(w_{t,s,n-1} \in \text{Neg}_{k,m}\big) + \mathbb{1}\big(w_{t,s,n+1} \in \text{Neg}_{k,m}\big)\right]$$

That is, we count the number of times topic-k words are immediately preceded or followed by (word-specific) positive and negative terms.[†] To obtain our final sentiment measure, we scale these counts by the number of total tokens in the economy round.

B.2. Preference construction

We now describe the algorithm for constructing the measures of hawkishness and dovishness used in the main text to capture policy preferences. For all meetings, we measure generic monetary policy preferences using the procedure detailed below. For meetings conducted in 2009 and onwards, we additionally measure preferences over the size of asset purchases as part of the Fed's quantitative

[†]Since in preprocessing we remove stop words, adjacency in this definition can include separation by stop words.

easing program. The sentences we consider consist of those in the policy round since that is the section of the meeting pertaining to the articulation of preferences.

B.2.1. Generic monetary policy preferences

First, we exclude from the policy round any sentence in which the term 'increase' appears along with any of {cpi, inflation, yield*, treasury} to ensure we do not include language describing the direction of non-policy-related market prices and interest rates. We classify each remaining sentence as pertaining to monetary policy:

1. If it contains any phrase in the set {federal funds rate, funds rate, target rate, policy rate, interest rate, taylor rule, alternative a, alternative b, alternative c, directive, language, statement, symmetry, asymmetry, hawkish, dovish},
2. OR if 'policy' is in the sentence and NOT any phrase in the set {fiscal policy, supervisory policy, public policy, budget policy, tax policy, housing policy, regulatory policy, ecb policy, economic policy, government policy, inventory policy, health care policy, macro policy, macroeconomic policy, spending policy, legislation, law, regulation}.
3. OR if 'basis point' is found in the sentence AND any phrase in the set {[cut*, hik*, eas*, tight*, action*, moving, move, firming, recommendation, reduction, increase]}.

We define $Hawk'_t$ to be the count of terms in {tight*, hike*, increas*, hawkish, taper, liftoff} in policy sentences; and $Dove'_t$ to be the count of terms in {ease*, easing*, cut*, dovish, reduc*, decrea*}in policy sentences. Here we account for negation, and if any of the hawk (dove) terms is immediately preceded by one of {'less', 'no','not', 'little', 'don't', 'doesn't', 'hasn't', 'haven't', 'won't', 'shouldn't', 'didn't'}, it is counted as belonging to dove (hawk) set.

B.2.2. Quantitative easing preferences

We define policy round sentences beginning in 2009 as relating to quantitative easing whenever they contain the term 'purchase*' immediately preceded by a phrase in {mortgage backed securities, mbs, asset, treasur*, agency debt}.

We then define $Hawk''_t$ to be the count of terms in {reduc*, taper, stop, purchas*} within the set of QE sentences; and $Dove''_t$ to be the count of terms in {more, additional, further} within the set of QE sentences. We again account for negation.

B.2.3. Overall preference measure

Let NP_t be the overall number of terms in the policy round in meeting t. Our hawk measure is

$$Hawk_t = \begin{cases} \frac{Hawk'_t}{\mathrm{NP}_t} & \text{if meeting } t \text{ occurs prior to 2009} \\ \frac{Hawk'_t + Hawk''_t}{\mathrm{NP}_t} & \text{if meeting } t \text{ occurs during or after 2009} \end{cases}$$

and $Dove_t$ is defined analogously.

C. Additional Tables and Figures

C.1. Summary Statistics for PMU

A. Summary statistics for PMU indices

	Mean(%)	Median(%)	St.dev.(%)	P10(%)	P90(%)
PMU	1.201	1.163	0.295	0.847	1.587
InfPMU	0.305	0.266	0.158	0.135	0.539
EcoPMU	0.408	0.410	0.148	0.228	0.592
MktPMU	0.227	0.188	0.151	0.074	0.432
ModPMU	0.069	0.067	0.044	0.021	0.118
OthPMU	0.327	0.314	0.141	0.165	0.522

B. Correlations of topic-specific PMU indices

	InfPMU	*EcoPMU*	*MktPMU*	*ModPMU*
EcoPMU	0.10			
MktPMU	0.09	0.36		
ModPMU	0.22	0.14	0.06	
OthPMU	−0.37	0.02	0.18	−0.24

Table A-12. Descriptive statistics for PMU. The table reports summary statistics for the overall PMU and the topic-specific PMU indices. All PMU indices are derived from the economy round of the FOMC meeting and represent the share of uncertainty-related mentions (by topic) relative to the total number of words in the economy round of the meeting. The sample period is 1987:08–2015:12, covering 227 meetings. Panel A expresses the summary statistics for PMU in percentages (e.g., the number 1.2 for the mean overall PMU implies that on average uncertainty-related mentions constitute 1.2% of all words in the economy round). Panel B reports the pairwise correlations between topic-specific PMU indices.

C.2. Properties of Uncertainty, Sentiment, and Preference Measures

A. Dependent variable: Greenbook CPI inflation nowcast h meetings ahead

	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
InfNeg	0.084	0.110	-0.038	-0.153	-0.096	-0.091	-0.177*	-0.173*
	(1.46)	(1.33)	(-0.43)	(-1.34)	(-0.77)	(-0.88)	(-1.78)	(-1.76)
InfPos	-0.192**	-0.217*	-0.055	0.017	0.023	0.008	-0.059	-0.042
	(-2.13)	(-1.78)	(-0.58)	(0.20)	(0.25)	(0.12)	(-1.07)	(-0.64)
InfPMU	0.019	-0.020	0.022	0.065	-0.088	-0.106	0.027	0.056
	(0.31)	(-0.22)	(0.21)	(0.47)	(-0.49)	(-0.55)	(0.17)	(0.49)
$E_{0,0q}(CPI)$	0.571***	0.218	0.166	0.118	0.124	0.195	0.197*	0.163**
	(6.89)	(1.62)	(1.44)	(0.98)	(0.92)	(1.29)	(1.79)	(1.98)
$\bar{R}^2$	0.48	0.14	0.018	0.0012	0.014	0.036	0.038	0.019
N	226	225	224	223	222	221	220	219

B. Dependent variable: Greenbook real GDP growth nowcast h meetings ahead

	$h=1$	$h=2$	$h=3$	$h=4$	$h=5$	$h=6$	$h=7$	$h=8$
EcoNeg	-0.124***	-0.208**	-0.278***	-0.316***	-0.351***	-0.277***	-0.280**	-0.262**
	(-2.71)	(-2.55)	(-3.21)	(-3.42)	(-5.05)	(-2.96)	(-2.52)	(-2.58)
EcoPos	0.098**	0.192***	0.214***	0.196*	0.216**	0.255**	0.235**	0.221**
	(2.49)	(3.28)	(2.73)	(1.90)	(2.11)	(2.50)	(2.34)	(2.13)
EcoPMU	0.020	0.050	0.118**	0.131*	0.084	0.049	0.130	0.151
	(0.43)	(0.82)	(2.03)	(1.80)	(0.98)	(0.51)	(1.47)	(1.61)
$E_{0,0q}(RGDP)$	0.696***	0.423***	0.256***	0.170**	0.089	0.025	0.010	-0.018
	(8.82)	(4.50)	(3.39)	(2.00)	(0.90)	(0.22)	(0.09)	(-0.17)
$\bar{R}^2$	0.63	0.40	0.29	0.24	0.23	0.16	0.15	0.12
N	226	225	224	223	222	221	220	219

Table A-13. Predicting macro variables with textual measures of uncertainty and sentiment. The table reports predictive regressions of inflation and real GDP growth by textual PMU and sentiment indices derived from the economy round of the FOMC meeting transcripts. The regressions are estimated at the FOMC meeting frequency with the forecast horizon ranging from the next meeting ($h=1$) up to eight meetings ahead ($h=8$). To make sure that the timing of the depend variable is consistent with the timing of the meetings, we use Greenbook nowcasts at future meetings as the dependent variable. The regression is $E_{t+h,0q}(CPI) = \beta_0 + \beta_1 InfPos_t + \beta_2 InfNeg_t + \beta_3 InfPMU_t + E_{t,0q}(CPI) + \varepsilon_{t+h}$, where $E_{t+h,0q}(CPI)$ is the CPI inflation nowcast at meeting $t+h$, and analogously for the real GDP growth. The coefficients are standardized. HAC standard errors to account for the overlap are reported in parentheses. The sample period is 1987:08–2015:12.

Dependent variable: Change in FFR target over subsequent h meetings, $\Delta FFR_{t+h,t} = FFR_{t+h} - FFR_t$

	(1) $h=1$	(2) $h=2$	(3) $h=3$	(4) $h=4$	(5) $h=5$	(6) $h=6$	(7) $h=7$	(8) $h=8$
HD	0.326***	0.311***	0.335***	0.330***	0.290***	0.234***	0.194**	0.188**
	(3.45)	(3.02)	(3.08)	(3.28)	(3.23)	(2.83)	(2.35)	(2.30)
FFR	0.004	0.354	-0.358	-0.220	-0.196	0.092	0.027	-0.242
	(0.01)	(0.65)	(-0.69)	(-0.43)	(-0.36)	(0.20)	(0.06)	(-0.53)
L.FFR	-0.316	-0.743	-0.149	-0.377	-0.488	-0.839*	-0.827*	-0.614
	(-0.49)	(-1.35)	(-0.29)	(-0.74)	(-0.88)	(-1.80)	(-1.85)	(-1.43)
$E(CPI_{4q})$	0.328	0.283	0.356	0.397	0.459	0.460	0.438	0.423
	(1.11)	(0.81)	(1.03)	(1.18)	(1.34)	(1.29)	(1.21)	(1.15)
$E(RGDP_{0q})$	0.288**	0.255**	0.253**	0.260***	0.292***	0.281***	0.298***	0.315***
	(2.49)	(2.20)	(2.60)	(2.87)	(3.23)	(3.48)	(4.18)	(4.55)
τ^{CPI}	-0.034	0.043	0.064	0.100	0.109	0.140	0.188	0.234
	(-0.17)	(0.17)	(0.25)	(0.38)	(0.40)	(0.49)	(0.65)	(0.80)
$Updt(CPI_{3q})$	0.077	0.008	-0.028	-0.076	-0.052	-0.052	-0.033	-0.041
	(1.03)	(0.13)	(-0.43)	(-1.14)	(-0.80)	(-0.83)	(-0.55)	(-0.67)
$Updt(RGDP_{1q})$	0.140	0.130	0.179*	0.137	0.121	0.127	0.126	0.117
	(1.64)	(1.29)	(1.82)	(1.51)	(1.35)	(1.41)	(1.39)	(1.29)
R^2	0.43	0.42	0.41	0.44	0.47	0.49	0.51	0.52
N	170	170	170	170	170	170	170	170

Table A-14. Validity of textual measures of policy preferences. The table reports predictive regressions of changes in the FFR target rate over h meetings ahead by the textual measure of policy stance *HD*. The regressions are estimated at the frequency of FOMC meetings, controlling for Greenbook forecasts and trend inflation τ^{CPI} and two lags of the FFR target. All explanatory variables (except the lagged FFR target) are measured as of meeting t. The dependent variables (future changes in the FFR target) span the horizon from the next meeting up to eight meetings ahead. The coefficients are standardized. HAC standard errors to account for overlapping data are reported in parentheses. The maximum sample uses data over the 1987:08–2009:12 period.

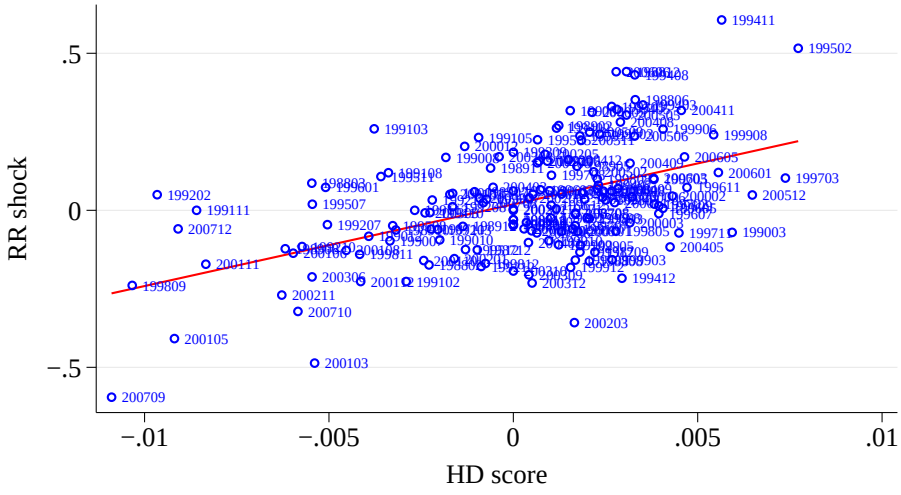

Figure A-1. *HD* measure of policy preferences vs. Romer-Romer shocks. The figure presents a scatter plot of the policy preferences *HD* against the Romer and Romer (2004) shocks. The *HD* measure is derived from the statements of the FOMC members during the policy round of the FOMC meeting.