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Monetary communication rules

Abstract

Is there a systematic mapping between the Federal Reserve's expectations of macro variables and the words it uses to talk about the economy? We propose a simple framework that allows us to estimate communication rules in the United States based on text analysis with regularized regressions. We find strong evidence for systematic communication rules that vary over time, with changes in the rule often being associated with changes in the economic environment or with the introduction of a new Fed chair. In the case of the fed funds rate, we also estimate the market's perception of the Fed's communication rule and use it to investigate how much of the disagreement between the market and the Fed come from disagreement about the communication rule.

Keywords: communication, expectations, monetary policy, NLP, text analysis
JEL codes: E52, E58, C49

Non-technical Summary

Monetary policy is commonly thought of as setting the policy interest rate according to a *policy rule*. This captures the notion that the central bank sets the interest rate in a way that is related to various economic variables in a systematic way. In this paper, we take this idea and apply it to central bank communication. We postulate that there may be a systematic relationship between what a central bank thinks about the economy and how it chooses the words of statements it releases to the public. In other words, central bank communication may be conducted via *monetary communication rules*.

We lay out a simple theoretical framework to measure monetary communication rules in practice and apply it to the Federal Reserve (Fed) for the time period 1999-2016 (or up to today, depending on data availability). The idea is to find the words (or sequences of words) from FOMC statements, the Fed's main communication device, that have the largest predictive power for the Fed's expectations (measured using Greenbook forecasts). Intuitively, what the procedure does is to identify what words the Fed regularly uses when it holds particular expectations of economic variables.

We find that Fed communication is very transparent in the sense that the FOMC statements use particular words consistently when describing their expectations on output growth, unemployment and the federal funds rate (FFR). This implies that hearing a particular FOMC statement allows one to infer the Fed's expectations on these variables very well. In the case of inflation, we find that the Fed's word choice more closely reflects its longer-run inflation expectations, which makes sense given that the Fed's mandate is formulated in terms of a long-run inflation target.

We also investigate the possibility that the Fed's communication rule may have changed over time. We do this by repeating our estimation on various subsamples, such as a pre- and post-Great Recession subsample, or the tenures of the Fed chairs Greenspan, Bernanke and Yellen. We find strong evidence for the communication rule changing. On the one hand, a new economic environment (such as the low-interest rate period following 2008) carries with it the introduction of new language associated with novel policy tools employed by the Fed. On the other hand, various Fed chairs also have individual communication styles that get reflected in the FOMC statements.

Lastly, in the case of the federal funds rate, where we have data on the public's expectations, we

repeat the same estimation procedure to obtain what we call the *perceived communication rule*. This captures the public's understanding of the communication rule of the Fed. Using a decomposition coming from our simple theoretical framework, we separate how much of the difference between the Fed's and the public's FFR expectations is due to differing views about the economy, and how much comes from different understandings of the communication rule, to find that both play an important role.

1 Introduction

Workhorse models of monetary policy imply that interest-rate setting is a systematic mapping between economic fundamentals, such as output and inflation, and the central bank's main interest rate. In this paper, we take up this view and apply it to monetary communication. In particular, we ask whether there is a monetary communication rule that maps what central bankers think about the economy to words in a systematic way.

We propose a simple procedure based on text analysis to estimate the communication rule used by the Federal Reserve, as well as the communication rule the market perceives the Fed to be using. The idea is to estimate the relationship between Fed expectations of standard macro variables, such as output, inflation, unemployment and the fed funds rate (FFR), and FOMC statements, and then in a second stage to map FOMC statements to the public's expectations of the same variables.

Figure 1 illustrates the idea in a schematic way. We think of monetary communication as a two-stage process. The first stage maps the Fed's expectations to an announcement that is communicated with the public. The announcement is a message using text that covers the policy rate as well as information about the Fed's expectations that is not necessarily precise. We refer to this mapping, the left arrow on the figure, as the "communication rule." In the second stage, captured by the right arrow on the figure, the announcement text maps into private sector expectations. We think of this second mapping as the market's decoding of what the Fed is saying, which is based on the market's understanding of how the Fed communicates. In other words, the market's interpretation of any particular Fed announcement comes from the market's "perceived communication rule." We can estimate both mappings using FOMC statements as well as measures of Fed and market expectations.

First, we estimate the Fed's communication rule under the assumption that the Fed kept the communication rule unchanged. We do this from 1999 through 2016 or to the

Figure 1: Estimating Communication Rules

Fed Expectations $\Longrightarrow$ Announcement Text $\Longrightarrow$ Market Expectations

present depending on the data availability of the macroeconomic variable of interest. Using our estimates, we back out implied Fed expectations as fitted values from our estimation. This object, which we refer to as "text-implied expectations," captures what expectations the systematic part of Fed communication induces, and need not coincide with measured expectations.

We find that this constant-over-time communication rule tracks the Fed's expectations of output, unemployment and the fed funds rate very closely, implying that the Fed seeks to be very transparent about its beliefs on these variables. In the case of inflation, instead, the text-implied expectations of the Fed, estimated on its short-run inflation expectations, mimic the Fed's measured long-run expectations of inflation. We interpret this as suggesting that the Fed's communication on inflation is more closely associated with its long-run inflation target rather than transitory inflation.

There are however episodes in which there are deviations between text-implied and measured expectations from data. Recognizing that such deviations could come from various sources, we here focus on the potential explanation that they are the result of the communication rule changing over time. We split the data into various subsamples, and reestimate the communication rules on those. We redo the same exercise for the tenures of various Fed chairs, exploring whether the chairs are associated with different ways of communication.

Indeed, we document substantial shifts between the text-implied Fed expectations coming from rules estimated on different subsamples. In particular, the communication rule seems to change starkly between September and December 2008, indicating that the Fed's move to the zero lower bound (ZLB) was accompanied by the introduction of new language that would be deployed throughout the recession. However, interestingly, we find that all communication

rules imply higher fed funds rates than the actual FFR much before lift-off took place in 2016. This suggests that throughout the 2012-2016 period the Fed was using language that in earlier communication rules was associated with rate hikes.

We also find that the Fed chairs in our sample (Greenspan, Bernanke and Yellen) are associated with different communication rules. In particular, all chair-specific communication rules, besides those for inflation expectations, are able to account for Fed expectations of macroeconomic variables in-sample. For the Greenspan rule, we find that his rule generally follows Fed expectations during his tenure as chair, but there is a lot of fluctuation, which likely reflects the fact that his FOMC statements were very short compared to his successors. We find that Bernanke's communication rule most closely matches the fixed communication rule and seems to suggest a nuanced word use that seeks to provide context for the monetary policy action. The rule under Yellen, by contrast, predicts a flat fed funds rate path, which makes sense given that the Fed was at the ZLB for most of Yellen's tenure.

We then double down on the difference between the Fed's and the market's perceived communication rule. In the case of the fed funds rate, we have data on the market's expectations, and can therefore estimate the market's perception of the Fed's communication rule, as well as construct the market's text-implied expectations. This allows us to do a "disagreement decomposition;" that is, to split the deviations between the Fed's and the market's measured FFR expectations into a part that comes from differences in text-implied expectations, as well as a residual term. We interpret these two components as capturing disagreement about the systematic component of communication on the one hand, and some residual disagreement on the other, which could come from differing priors on the economy or from "communication shocks" that capture episodes when the Fed is off its communication rule.

1.1 Related Literature

Our paper touches on three strands of literature. The first is the empirical literature on central bank communication. Within this group, a set of papers has looked at the response of the private sector to news about the economy. Such papers sometimes construct news shocks (Beaudry and Portier, 2006; Barsky and Sims, 2011), or look at the movements in various financial variables following monetary policy announcements (McQueen and Roley, 1993; Piazzesi, 2005). Others investigate different aspects of central bank communication. For example, (Ehrmann and Fratzscher, 2005, 2007) look at whether a central bank should embrace the multiplicity of views within its decision-making body in its communication, Romelli et al. (2021) quantify disagreement within the FOMC, and Ashwin (2022) explores what topics central bankers focus on.

A growing group of papers uses text analysis to measure communication and its effects. Most papers in this literature use text analysis of monetary policy documents in order to measure variables or concepts that are not available through other data sources. This includes papers that approximate de facto targets or objective functions of the Fed. For example, Romer and Romer (2004) use a narrative approach to identify the target federal funds rate to then measure monetary shocks. More recently, Shapiro and Wilson (2021) use a dictionary approach to estimate the Fed's inflation target and preferences from positive and negative sentiment words used in the transcripts of the FOMC meetings. Moreover, as the use of forward guidance has become an increasingly prevalent monetary policy tool, researchers are applying the text analysis toolkit to quantify and understand forward guidance and its effects (Campbell et al., 2012; Lunsford, 2020). Related to our paper, Stekler and Symington (2016), Ericsson (2017) and Byrne et al. (2021) use text analysis of central bank communication to understand central bank word use and forecasts of the macroeconomy. Relative to these papers, we focus on a different mode of communication - the FOMC post-meeting statements

- and we use a regularized regression approach to study the covariance of language and our macroeconomic variables of interest.

Other papers use text analysis or other computational approaches to quantify monetary policy shocks to study either the effect of central bank communication or changes to the policy rate on the economy. Some focus on measuring uncertainty within the central bankers' communication directly using text analysis (Hansen and McMahon, 2016) or audio-visual analysis (Gorodnichenko et al., 2021). Beyond policy documents, Husted et al. (2017) and Lüdering and Tillmann (2020) use the public's response to monetary policy in newspapers and on social media, respectively. Others measure shocks by the relationship between monetary policy text or central banker communication and changes to asset prices (?Handlan, 2020b; Gardner et al., 2021; Calomiris et al., 2022; Acosta, 2022; Gnan et al., 2022). Our contribution to this literature is that we approach communication as a systematic part of how monetary policy is conducted. We use timing restrictions and regularized regressions to approximate the mapping between words (and sequences of words) to the Fed's expectations that informed the text of the announcement.

The second is the macro-theoretical literature on the effects and benefits of policy communication. This question lies at the heart of the global games literature à la Morris and Shin (2002), Angeletos and Pavan (2007), Amador and Weill (2010) or Angeletos and La'O (2013). Recent papers that look at various facets of optimal communication design, such as transparency or optimal dynamic communication include Ou et al. (2022) and Gáti (2022). A paper that considers the interaction between policy advice (also a form of communication) and policy action is Basu et al. (1989). Related to our work, Doh et al. (2022) explore state-dependent forward guidance.

Lastly, our disagreement decomposition also situates our paper in the literature on disagreement between economic agents, and recalls the discrepancy decomposition in Reis (2020). Zooming in on disagreement between the central bank and the market, the pa-

per most closely related to ours is Caballero and Simsek (2022), which emphasizes that disagreement can drive the evolution of expectations and thus affect the conduct of optimal monetary policy. While Caballero and Simsek (2022) investigate disagreement from a theoretical standpoint, we use our estimates of monetary communication rules and how markets perceive them to decompose disagreement into a systematic and residual component. We thus provide an empirical lens on where such disagreement may be coming from.

The paper is structured as follows. Section 2 presents a simple framework that forms the backbone of our estimation strategy. Section 3 provides an overview of the data and the data cleaning. Section 4 estimates the Fed's communication rule both under the assumption that the Fed kept its communication rule unchanged over time, as well as that communication rules were time-varying. Section 5 estimates the market's perceived communication rule and provides our disagreement decomposition. Section 6 concludes.

2 A Model of Communication Rules

In this section, we lay out a simple model of monetary communication rules that guides our empirical work. We assume that the central bank (the Fed) communicates about the economy in the following way. Upon seeing data on various economic variables, summarized by y_t, the Fed forms its expectations of these variables, $\mathbb{E}_t^{Fed}[y_t]$. It then sends the private sector a message, $m_t \in M$. We think of the message as a weighted sum of tokens, w, as formalized in the following assumption.

Assumption 1 *Message as a weighted sum of tokens.*

$$m_t = \sum_w \gamma_w w. \tag{1}$$

In this bag-of-words formulation, the message m_t corresponds to an FOMC statement, which

itself is a frequency-weighted sum of particular tokens, w, for example words or sequences of several words.[1]

The novelty of our paper is to entertain the idea that there may be a systematic mapping between the Fed's expectations of economic variables, $\mathbb{E}_t^{Fed}[y_t]$, and the message it sends, m_t. This object is what we refer to as the *communication rule* and what we seek to estimate. To obtain a relation that we can take to the data, we make the following assumption.

Assumption 2 *The Federal Reserve is mean truthtelling.*

Letting m index the market, we assume that the Fed chooses m_t such that

$$\mathbb{E}_t^{Fed}[y_t] = \mathbb{E}_t^{Fed}[\mathbb{E}_t^m[m_t|y_t]]. \tag{2}$$

The interpretation is that the Fed selects the message to send that it thinks will induce the same market expectation of economic variables that it itself holds. In other words, the Fed has a goal of transparency. We think that this is a reasonable assumption given the recent push in central banking towards increased transparency.

Given the central bank's message, the market forms expectations of the current economic outlook. Using Bayes' rule, the market's posterior beliefs on y_t given the message m_t are

$$P^m(y_t|m_t) = \frac{P^m(m_t|y_t)}{P^m(m_t)} P^m(y_t). \tag{3}$$

Equation 3 has an intuitive interpretation. It says that the market's posterior distribution on y_t comes from its prior beliefs on the economy, $P^m(y_t)$, and on the possible messages it may receive, $P^m(m_t)$, as well as from $P^m(m_t|y_t)$, the market's best understanding of how the Fed maps the underlying economic fundamental into a message. We think of this latter

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[1] An obvious alternative would be to think of the individual tokens of the statement as separate messages. We follow a large part of the central bank communication literature in conceiving of the full FOMC statement as a single message.

object as the *perceived communication rule*, and note that it may deviate from the Fed's actual communication rule. In other words, the market may have a different view on *how* the Fed communicates than how the Fed actually does communicate.

Bayesian updating over time implies the following equation for the market's expectation of economic variables:

$$\mathbb{E}_t^m[y_t] = (1 - \kappa_1)\,\mathbb{E}_{t-1}^m[y_t] + \kappa_1 m_t, \tag{4}$$

which says that the market's expectation is a weighted average between its prior and the new information incoming from the Fed's message.[2] The weight, κ_1, is the Kalman gain, and its optimal value is given by the signal-to-noise ratio of the message. We extend this equation with the term $\mathbb{E}_t^{Fed}[y_t]$ to account for the fact that at the time that the FOMC statement is issued, the Summary of Economic Projections (SEP) is also released, giving the market information about the Fed's expectations. This gives rise to the following updating equation for the market:

$$\mathbb{E}_t^m[y_t] = (1 - \kappa_1 - \kappa_2)\,\mathbb{E}_{t-1}^m[y_t] + \kappa_1 m_t + \kappa_2\,\mathbb{E}_t^{Fed}[y_t]. \tag{5}$$

We now use this simple model to guide our quantification of the Fed's communication rules. As Section 4 spells out in detail, we derive our estimating equations from Equation 2 and Equation 5. These equations imply a relationship between Fed expectations and the message (the communication rule), as well as between the message and market expectations (the perceived communication rule). We thus use data on the Fed's expectations on various economic variables as well as FOMC statements as a measure of the message m_t to estimate the communication rule. Analogously, for the fed funds rate, where we have data on market expectations, we use those together with the FOMC statements to estimate the market's perceived communication rule.

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[2]This Kalman filter updating equation is optimal in the case of a linear and normal data-generating process.

Furthermore, having estimated the Fed's communication rule and the market's perception thereof, we zoom in on disagreement between the Fed and the market, as in Caballero and Simsek (2022). Subtracting the Fed's expectation from both sides of Equation 5 and rearranging, we obtain the following decomposition.

Proposition 1 *Disagreement decomposition.*

Differences between the market's and the Fed's measured expectations can be decomposed as follows:

$$\underbrace{\mathbb{E}_t^m[y_t] - \mathbb{E}_t^{Fed}[y_t]}_{disagreement} = (1 - \kappa_1 - \kappa_2) \underbrace{\left(\mathbb{E}_{t-1}^m[y_t] - \mathbb{E}_t^{Fed}[y_t]\right)}_{opinionated\ term} + \kappa_1 \underbrace{\left(m_t - \mathbb{E}_t^{Fed}[y_t]\right)}_{communication\ term} \qquad (6)$$

One can think of Proposition 1 as an empirical counterpart to Caballero and Simsek (2022)'s notion of "opinionated markets," except with the additional twist of focusing on a Fed communication rule, formalized as a systematic mapping between the Fed's expectations and its messages. What the decomposition is saying is that if the Fed has a communication rule and the market has its own perception this rule, then disagreement in measured expectations between the Fed and the market can come from two general sources.

The first is the "opinionated term," which captures deviations between the market's previous beliefs and the Fed's expectations as published in the current SEP. This stems from disagreement in terms of general views on the economy, and is independent from contemporaneous communication. In the language of Caballero and Simsek (2022), this disagreement comes form markets being "opinionated." The second term is the difference between the Fed's message and its expectations. When this difference is zero, so that the Fed's message provides no additional information on top of the Fed's expectations, the term drops out. In such a case, any disagreement in measured expectations comes from markets being opinionated.

This suggests that communication only drives disagreement in measured expectations

if the message provides the market with information that is not contained in the Fed's expectations. This can come from many sources. On the one hand, it can mean that the market misunderstands the Fed's communication rule, and therefore misinterprets the message. On the other hand, if the market understands the communication rule well, this term can capture "communication shocks," that is, cases when the Fed deviates from its communication rule, surprising the market. It can also mean that the Fed is changing the form of the rule, meaning that the systematic component is not stable over time. We will investigate these channels in turn.

3 Data

For the empirical analysis we use a variety of data from the Federal Reserve Bank System. We collect the FOMC post-meeting statements and summaries of economic projections from the Federal Reserve Board's website. For more recent meetings we work with the "Meeting Calendars and Information" page, and for older meetings we work with the "Transcripts and other historical materials" page. The Summary of Economic Projections (SEP) is available from the same web pages. From the projection materials we extract the expectations of the federal funds rate up to three quarters ahead for FOMC meetings since October 2007.[3]

Each FOMC statement is downloaded and the text is extracted and cleaned to remove any URLs, the release time, and the FOMC member voting records. We use a bag-of-words approach to represent the text of the FOMC statements. This means that we are looking at the counts of different words or sequence of words, which we call tokens. These counts are unordered, but by looking at sequences of up to four words in a row we can pick up on a sense of context. The results in this paper are for token counts and analysis with frequency and term-frequency-inverse-document-frequency (TFIDF) weighted counts will be added for

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[3]These federal funds rate forecasts are commonly referred to as the dot plots.

robustness. The other cleaning of the text includes the removal of stop words - that is, words that are so common that they are not informative about variation in information across documents in the sample such as "the" or "a". We add a few terms that are specific to FOMC statements, like "federal", "open", "market", and "committee". We also combine common multi-word concepts into a single term, e.g. "funds rate" becomes "fundrate" and "basis point" becomes "bp".

After removing numbers and punctuation, we then can represent each FOMC statement as a vector of token counts. The length of the vector is the number of unique tokens across all FOMC statements in the sample, also known as the vocabulary. We also drop tokens that occur in less than 10% of statements to remove outliers. This removes tokens that are used in fewer than 18 statements, which covers about two years of FOMC statements. In robustness exercises, we vary this threshold, and our results still go through if we remove tokens that occur in fewer than 5%-20% of statements as well. In dropping extremely infrequent tokens we are able to better focus on systematic communication. For the current version of the paper we will be working with quadgrams, sequences of four words, as our tokens. With this representation of text, we can look at how token use correlates with macroeconomic variables.

For forecasts of macroeconomic variables at each FOMC meeting, we use the Tealbook Data Sets (formerly the Greenbook Data Sets) from the Federal Reserve Bank of Philadelphia's website. These include quarterly forecasts by the staff at the Federal Reserve of up to nine quarters in the future for variables such as output growth, inflation, and unemployment.

For data on the target federal funds rate, we use the series from the Federal Reserve Bank of St. Louis's FRED website. For periods when the Federal Reserve has a target range, we look at the midpoint of the range. Depending on the section, we either work with the *realized* target federal funds rate values or the *expected* federal funds rate values. With the realized target federal funds rate we are able to study the relationship between

communication rules and policy rules, and with the expected federal funds rate we can quantify what the communication rule is signalling with respect to future policy, that is, forward guidance.

Additionally, we use data on prices of Fed funds futures contracts from Refinitiv's commodities dataset. We use end-of-day prices for futures contracts with up to twelve month maturities to calculate year-end expectations. Because our analysis is focused on short-run expectations, we do not expand to longer maturity assets.

For the remaining sections we will indicate when we are working with one-quarter-ahead forecasts with a $q+1$ in the variable name. Section 4 uses data from the Tealbook Data Sets and the FOMC statements. Section 5 uses the Summary of Economic Projections data and the Fed funds futures contract price data for expectation variables rather than the Tealbook data.

4 Estimating Monetary Communication Rules

To estimate the communication rules from the Fed's perspective, we use a ridge regression with the tokens of text from the FOMC statements as inputs and macroeconomic variables as the output of different specifications. For each output variable and section below, we find the penalty parameter α and vector of coefficients $\boldsymbol{\beta}$ that minimize

$$(Y_t - W_t\boldsymbol{\beta}) + \alpha||\boldsymbol{\beta}||_2^2 \tag{7}$$

where W_t represents the term-frequency-inverse-document-frequency (TFIDF) weighted count of quadrams from FOMC statement at meeting t. Quadrams from the text of the FOMC statement are sequences of four words in a row. We can then represent the FOMC statement as a vector of token counts which will make up W_t. Again, the length of the vector

is the number of unique tokens across all FOMC statements in the sample. The reason we use quadgrams instead of uni-, bi-, tri-, or quint-grams is that we found sequences of four words to have enough context within each observation without being so specific that they did not commonly occur throughout statements in our sample. The TFIDF weighting is standard in computational text analysis to downweight term frequencies for words and phrases that are more common across documents in the corpus and therefore are not as valuable in differentiating information content across documents. We conduct robustness to how we represent text by changing the size of n-grams, the text-weighting schemes, and other cleaning procedures which will be added to the appendix.

The Y_t represents the Federal Reserve Board's expectation of macroeconomic variables from the meeting materials given *before* the FOMC meeting actually occurs. The macroeconomic variables include realizations of the target federal funds rate and changes in the target rate, but also Federal Reserve forecasts of next quarters' real GDP growth, inflation, and unemployment as specified in the Greenbooks and Tealbooks.

We estimate different regressions for each macroeconomic output variable. This implies an implicit assumption that the communication rules that map expectations of particular macro variables to words are independent from the rules for other macro variables. This is a strong assumption that we make in order to simplify the estimation procedure and get a first pass notion of communication rules in the data. In a later draft, we will relax the assumption to allow for join communication rules.

For each regression specification, we proceed in a two-step estimation procedure where we first find the optimal penalty term, α^*. This is the regularization parameter that best controls, in an out-of-sample accuracy sense, for potential overfitting of the regression. We find α^* using stratified, k-fold cross validation. The data is split into five subsets with similar representation of observations that correspond to FOMC meetings under each Fed chair and changes to the target federal funds rate. We perform cross validation where one of the folds

(subsets of data) is used as a validation set and the other four folds are used to estimate the $\boldsymbol{\beta}$ coefficients for a given α penalty term. We fit different $\boldsymbol{\beta}$ as we go over a grid of candidate α parameters and calculate the prediction error (mean squared error) on the validation set. We then repeat this procedure four more times such that each of the folds is the validation set once. The α^* is the α associated with the lowest average out-of-sample mean squared error, where the average is taken across the five different cross validation splits. Then we estimate the $\boldsymbol{\beta}$ coefficients on the entire sample for the respective exercise using the selected α^*.

The next section, Section 4.1, covers estimating coefficients for all FOMC statements and macroeconomic variables for FOMC meetings from May 1999 to the present or through 2016, depending on when data is released to the public. Then Section 4.2 and Section 4.3 consider time-varying communication rules. The former looks at varying the time range of in-sample data around the zero lower bound period and the Great Recession. The latter focuses on estimating different communication rule for each chair of the Federal Reserve based on the FOMC statements released during their tenure as chair.

4.1 Fixed Communication Rule

Suppose that the Federal Reserve has used the same communication rule over our entire sample. This means that there is a single, stable mapping from expectations over macroeconomic variables and policy to words. The focus of this section is to estimate such rules. For each macroeconomic variable of interest, we estimate a different communication rule and thus a different α^*, as well as different token coefficients $\boldsymbol{\beta}$. We then sort coefficients for each regression to indicate tokens most associated with positive or negative forecasts of the macroeconomic variables.

First, we focus on how the text in the FOMC statements correlate with the announced
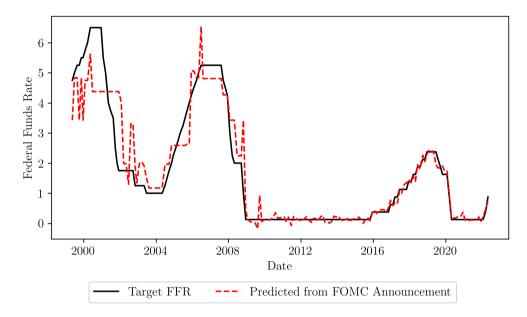
the target federal funds rate. Table 1 contains the tokens with the 20 largest positive and 20 largest negative coefficients. These tokens are considered the top 20 tokens associated with the higher and lower target federal funds rate (FFR) values, respectively.

Table 1: Top Words for Target Fed Funds Rate and Fixed Communication Rule

Rank	Higher Target FFR	Lower Target FFR
1	mainly toward condition generate	robust underlie growth productivity
2	weight mainly toward condition	exceptionally low level fundsrate
3	high level resource utilization	warrant exceptionally low level
4	raise target fundsrate bp	likely warrant exceptionally low
5	long_run inflation expectation remain	goal price stability sustainable
6	target range fundsrate assess	long_run goal price stability
7	inflation expectation remain well	inflation pressure inflation expectation
8	inflation item food energy	security agency mortgage_backed security
9	stability sustainable economic growth	maintain target range fundsrate
10	price stability sustainable economic	continue monitor implication incoming
11	fundsrate assess realize expect	wide range information include
12	size future adjustment target	account wide range information
13	range fundsrate assess realize	take account wide range
14	inflation expectation little change	assessment take account wide
15	long_run inflation expectation little	information receive since meet
16	survey base measure long_run	decide keep target fundsrate
17	base measure inflation compensation	growth information currently available
18	base measure long_run inflation	economic growth information currently
19	measure long_run inflation expectation	stance monetary_policy remain accommodative
20	recent month unemployment rate	maximum employment price stability

The tokens that have the largest negative coefficients, and thus are associated with lower levels of the target federal funds rate, almost all include language that is about mortgage backed securities, quantitative easing, and LSAPs. This is an example of the algorithm picking up on phrases used during the ZLB and using that to bring down its prediction of the target federal funds rate associated with the announcement. On the other side, the tokens that have the largest positive coefficients, and thus are associated with higher levels of the target federal funds rate, seem to have a mix of language about either raising rates or lowering rates. Likely this is picking up on phrases that were more common pre-2008 that are not used after the Great Recession. While for the time being we are assuming the Fed's communication rule is unchanged over time, this intuition already starts to motivate

a time-varying communication rule.

Figure 2: Fixed Communication Rule and Target Federal Funds Rate

We can also graphically represent the estimated communication rule. In Figure 2, the black line is the target federal funds rate over the sample period, and the red-dashed line is the target federal funds rate predicted from the FOMC announcement text with the estimated communication rule. The latter is what we call the "text-implied target federal funds rate expectation." Overall, the empirical text model is able to follow the general pattern of the target federal funds rate. However there is quite a bit of noise, especially during Greenspan's tenure. Greenspan's statements are shorter in length and vary more over time, and thus have greater variation in the token frequencies. But largely, the text is able to predict the target federal funds rate well. We interpret this as the communication rule being closely tied to the FOMC's interest rate rule, which is not surprising given that the FOMC announces the target rate in the statement.

Besides the level of the target rate, many economists focus on changes to the target federal funds rate. The results are largely similar to predictions to the target rate level in

Table 2: Top Words for **Changes** in Target Rate and Fixed Communication Rule

Rank	Increase Target FFR	Decrease Target FFR
1	gradual increase fundsrate fundsrate	holding agency debt agency
2	sizable level help maintain	seek foster maximum employment
3	since meet suggest economic	warrant exceptionally low level
4	however actual path fundsrate	policy accommodation take balanced
5	fundsrate stance monetary_policy remain	underlie growth productivity provide
6	inflation item food energy	employment inflation assessment take
7	inflation continue run below	measure labor condition indicator
8	accommodation take balanced approach	ensure inflation over time
9	condition evolve manner warrant	help ensure inflation over
10	rate resource utilization subdue	employment price stability expect
11	inflation expectation remain stable	economic growth information currently
12	receive since meet indicate	incoming information economic outlook
13	long_run goal maximum employment	measure long_run inflation expectation
14	future adjustment target range	base measure long_run inflation
15	begin remove policy accommodation	help make broad financial
16	determine timing size future	adjustment stance monetary_policy economic
17	appropriate policy accommodation economic	remove policy accommodation take
18	economic condition relative objective	judge consistent dual mandate
19	decide keep target fundsrate	include low rate resource
20	robust underlie growth productivity	implication incoming information economic

terms of accuracy and the most predictive tokens. The main differences are that we can more clearly see language related to the Federal Reserves' dual mandate with the communication rule estimated for changes to the target rate. Tokens associated with increases to the target federal funds rate frequently mention inflation. Meanwhile, tokens associated with decreases to the target rate mention economic activity, growth, and employment. As the top predictor of a rate decrease is still a token that mentions mortgage backed securities. Again, this makes sense given that the statement announcing the move to the zero lower bound is within the sample. The figure corresponding to this communication rule, showing the changes to the target rate against the text projection, is in the appendix (Figure B.1).

Next we look at the estimated communication rules for forecasts of real GDP growth and unemployment. Compared to the relationship between FOMC statement text and the target policy rate, the text is even more closely related to fluctuations in real-side macroeconomic variables. Figure 3 plots expected real GDP growth (black solid line) alongside the text projected real GDP growth (red dashed line). The black line does not continue beyond 2016
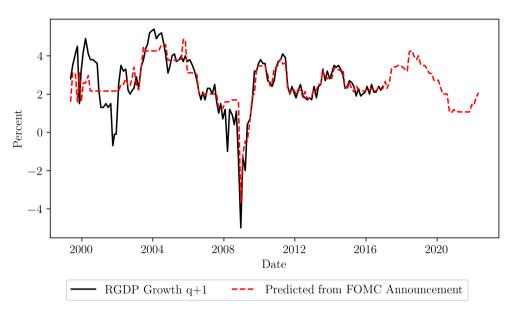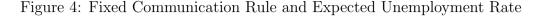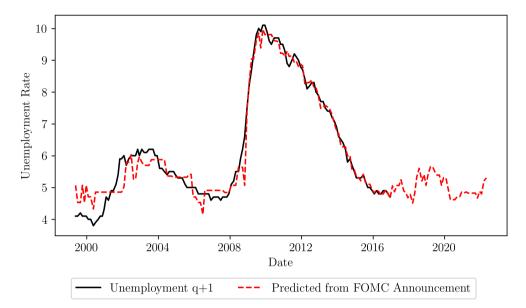
Figure 3: Fixed Communication Rule and Expected RGDP Growth

due to data availability because the Tealbooks that we use for the Fed's expectation are released on a five-year lag.

The close relationship between the macroeconomic variable and the text projection continues when we look at one-quarter-ahead forecasts of the unemployment rate, depicted on Figure 4. This corroborates that the language the Fed is using is closely tied to the Fed's expectations of the real side of the economy.

When looking at the predictions beyond 2020 and into the COVID-19 recession, it is interesting to note the lack of big movement. For real GDP growth expectations there is a small drop, but it does not compare to the magnitude one would expect. For next-quarter expectations of unemployment, there is even less of a bump and the unemployment rate is predicted to be at about 2006 levels. Even though the FOMC does talk about COVID-19 and the pandemic in their post-2020 statements, the communication rules we estimate were not trained on that language. That is, new language was introduced into FOMC statements - for example, the word "pandemic" was not used prior to 2020 - and the text model only knows mappings for tokens and output variables it has seen in training. This provides

Figure 4: Fixed Communication Rule and Expected Unemployment Rate
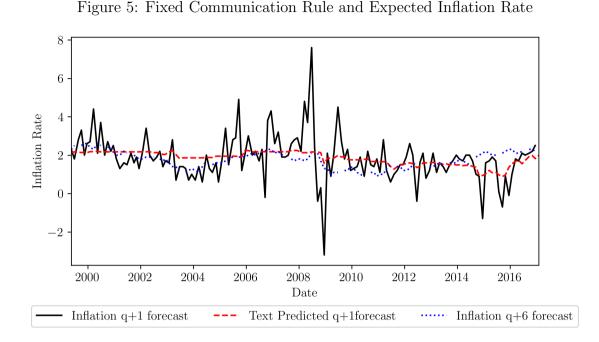
further motivating evidence for the idea that communication rules vary over time, possibly hand-in-hand with an evolving economic environment.

Next we look at the estimation of the fixed communication rule for inflation expectations (Figure 5). Unlike the estimated fixed communication rules for the federal funds rate and real macroeconomic expectation variables, the fixed communication rule for the Fed's expectation of the next quarter's inflation rate does not mimic the short-run volatility in inflation expectations. One possible interpretation of this is that the language the FOMC is using is not systematically correlating with the Greenbook/Tealbook forecasts of *next* quarter's inflation because the FOMC language has longer-run inflation developments in mind.

It is thus possible that the way the FOMC talks about inflation is actually about longer-run inflation expectations. In support of this, notice that the text-predicted inflation expectations are fairly stable around the Fed's target of 2 percent, the value to which the Fed seeks to anchor long-run expectations. To explore this, Figure 5 also has the six-quarter-ahead forecast of inflation from the Tealbook (blue dotted line) in addition to the one-quarter-ahead forecast and the text-implied inflation. Even though the communication rule was predicted

Figure 5: Fixed Communication Rule and Expected Inflation Rate

on the inflation expectations for next quarter, the text predicted rule, the red dashed line, clearly tracks more closely the medium-run inflation forecast. This lends support to the idea that the FOMC's language on inflation reflects longer-run inflation expectations rather than short-term ones.

4.2 Changing the Communication Rule and the ZLB

As the world changes and evolves, so too does language, and it is reasonable to suppose that monetary communication rules are also changing over time. The previous sections also provided some indication that evolving communication rules may fit the data better than the fixed rules we have so far estimated. In this section we therefore look at a counterfactual exercise where we estimate our communication rules up to a particular date and forecast forward what that communication rule would imply about Federal Reserve staff forecasts of macroeconomic variables. We focus on dates around the Great Recession and the beginning of the zero lower bound (ZLB) episode because these are periods where we know from anecdotal and descriptive evidence that there was a change in communication and policy.

For instance, around this time, FOMC statements became much longer and added previously absent information about LSAPs.
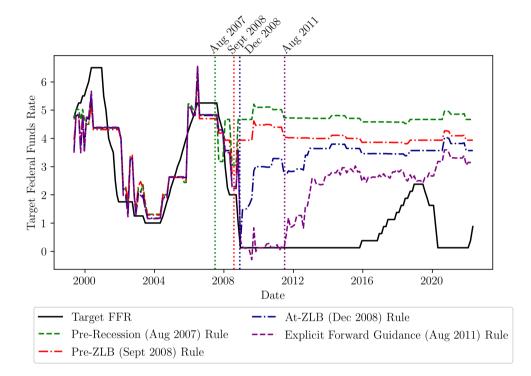
Figure 6: Time-Varying Communication Rule and Target Federal Funds Rate

We estimate four communication rules, each with a different stopping date for what is considered within sample for estimation. The first rule is an estimated communication rule for before August 2007, and we think of this as the pre-recession rule. The second is a communication rule for before September 2008, which we see as the pre-ZLB rule. The third is a rule trained through December 2008 when the FOMC set interest rates to the zero lower bound (ZLB) *and* issued forward guidance language that rates would be low for an "extended period of time." This third rule we consider the at-ZLB rule. And finally, the fourth rule is estimated on data through August 2011, at which time there was an explicit forward guidance announcement that the target rate would stay at the ZLB until at least mid-2013. For this reason we think of this rule as an explicit forward guidance rule. Past

studies of Fed communication and forward guidance highlight this as an example of explicit forward guidance that was very effective in moving expectations. Here we want to see if that new language - an updated communication rule - changed anything about the systematic revelation of Fed forecasts about the economy.

In Figure 6, we graph the predicted level of the target federal funds rate from each of the four communication rules along side the actual target federal funds rate. The vertical lines highlight the end of the training sample for each of the communication rules: August 2007, September 2008, December 2008, and August 2011. The first thing to notice is that, despite the small difference in the training sample, the difference in prediction between the September 2008 (red line) and December 2008 (blue line) communication rules is very large. We interpret this as a powerful shift in both the target rate and communication together: both the movement to the ZLB and introduction of new language that would be consistently used throughout the recession.

On the other hand, the forecasts from the pre-recession rule and the pre-ZLB rule parallel each other. This seems to indicate that the form of the communication rule did not change much between August 2007 and September 2008.

Another interesting conclusion from this figure is that we can measure when the FOMC began signalling lift-off from the zero lower bound. Across all rules, we see a forecasts for target rates above zero well before the end of 2015. This means the FOMC is using language in its announcements that is associated with higher target FFR levels based on its pre-2011 communication rules. This graph is not necessarily representing *intentional* signalling of lift-off (like forward guidance), but rather, the occurrences of words that in earlier communication were indicative of higher target FFR levels. Therefore, it seems that the optimism the FOMC was conveying about the economic recovery predated lift-off by a few years.

Conversely, when lift-off actually occurs and rates begin to rise, the communication rules

either predict no change in the target federal funds rate or even a slight decrease. This could be evidence that the FOMC was trying to use its language to counteract shifts to the public's expectations induced by increases to the target federal funds rate. During this period, increasing the federal funds rate was a positive signal that the economy was doing well and no longer needed support from accommodative policy. The more negative language could show a strategy of trying to curb public optimism.

In the appendix in Figure B.2, Figure B.3, and Figure B.4, we show the time-varying communication rules associated with changes to the target FFR and with staff projections for one-quarter-ahead growth in real GDP and the unemployment rate. The at-ZLB rule forecasts a more severe recession compared to the other communication rules in terms of lower target fed funds rate and lower output growth. However, the same rule predicts a faster labor market recovery. We interpret this as evidence of not only communication rules being different over time, but also that the communication rule is multi-dimensional. By this we mean that some words jointly predict several macro variables. For example, some words are both associated with improvements to labor and output, while some others are predictive of opposite movements. We leave investigating this multi-dimensional interpretation of communication for future work.

4.3 Chair-specific Communication Rules

Another way to think about communication rules changing over time is to split the full sample by Federal Reserve leadership. The idea that each Federal Reserve chair may be associated with a different communication rule is supported by Figure 7, showing the number of words used in FOMC statements over time. As the figure depicts, the length of FOMC statements over time varies with the Fed chair.

Starting in May 1999 when FOMC statements began being regularly released after policy
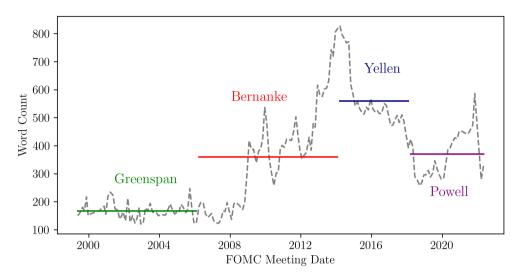
Figure 7: Fed Chair Communication Rules and Target Federal Funds Rate

meetings, the statements were very short and only about one paragraph. Once the target federal funds rate went to the ZLB, the length of FOMC statements gradually increased. This reflected in part the addition of a paragraph discussing the LSAP and QE programs and reinvestment policies. It also might reflect a substitution of policy tools: without the ability to move public expectations with the federal funds rate, the Fed appears to try to do so in language.

To further investigate chair-specific communication rules, we estimate rules in association with the target federal funds rate for Greenspan, Bernanke, and Yellen. We do this by restricting the sample to the chair's tenure and then following the previous estimation procedure. Figure 8 shows the target federal funds rate predicted from the text of actual FOMC statements according to the Greenspan, Bernanke, and Yellen communication rules. Figure B.5, Figure B.6, Figure B.7 and Figure B.8 in the appendix show the same exercise for inflation, changes to the target FFR, one-quarter-ahead GDP growth and the unemployment rate.

Unsurprisingly, we find that Yellen's communication rule predicts an almost zero target federal funds rate for the early sample. This is due to the minimal variation in the target
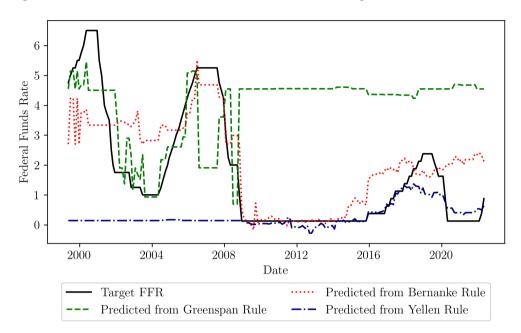
Figure 8: Fed Chair Communication Rules and Target Federal Funds Rate

federal funds rate during her tenure as Fed chair. The Greenspan and Bernanke rules seem to parallel each other in the early part of the sample, but have a level shift after 2009, such that the Bernanke rule captures the low target federal funds rate during the ZLB period. This is not surprising given that a large part of Bernanke's tenure was at the ZLB, so the algorithm is picking that up. Furthermore, with the Bernanke rule you can also see the signaling for early lift off starting around 2015 and a decrease around the actual lift off in 2016, matching what we found in the previous section.

5 Estimating Perceived Monetary Communication Rules

So far we have focused on estimating the Fed's communication rule. Now we turn to investigating how the market *perceives* the Fed's communication rule. Using the same methodology as previously, we now estimate the market's perceived communication rule from the FOMC statements and data on the market's FFR expectations. We back out market expectations of the FFR from Fed Funds Futures (FFF). For each FOMC meeting we use the FFF

contract that expires in December of that same year. As is standard, we use 100 less the FFF price to represent the expected FFR of the market. Given that FOMC meetings happen throughout the year, the FFF contracts we use for each meeting have different maturities. In our baseline, we are not doing any risk adjustment of the FFF prices because we want to make the market expectation comparable to the FOMC's expectations from the SEP, where uncertainty may be incorporated into the survey responses. Nevertheless, the results seem to be robust to risk-adjusted prices.

Figure 9 depicts the raw expectations measures of the Fed at various horizons and those of the market for the end of the current year. While the two comove in general, there are important disagreements. Most obviously, the Fed's expectations reflect much more optimism about the timing and speed of the interest-rate lift-off in the period between 2015 and 2018.
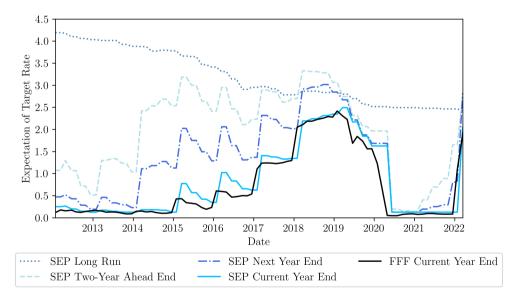
Figure 9: Expectation of Year-End Federal Funds Rate

We can dig deeper into these disagreements in several ways. First, we look at the top words for the communication rule and the perceived rule. Table A.3 shows the words most
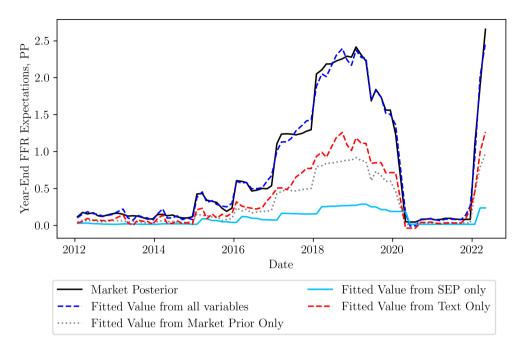
Figure 10: Communication Rule and Perceived Rule

predictive of FOMC forecasts and market forecasts. As a general pattern, we notice that the market seems to respond more to language about financial markets and labor markets - for example, expressions such as "credit" or "labor condition" figure prominently. Instead, the Fed's words feature a mix of state-based language (e.g. "accomodative stance monetary-policy until") and terms referring to the Fed's long-run objectives (e.g. "symmetric inflation goal").

We then turn to Equation 5 to look at how the market weights different information as it updates its FFR beliefs. Figure 10 plots the market's posterior beliefs in black, against a series of fitted values. These are constructed by plugging in our estimates for $\hat{\kappa}_1$ and $\hat{\kappa}_2$, and using measured expectations, as well as the FOMC statements. The blue dashed line is the standard fitted value from the regression, while the gray dotted, blue solid and red dashed lines all capture fitted values from just a subset of the regressors. We interpret these as the contribution to the posterior of the market's prior, the Fed's expectation (SEP) and the Fed's announcement, respectively.

The figure has two main messages. On the one hand, the market updating equation has a remarkable fit, which can be seen on the fact that the overall fitted value (blue dashed line) lies almost perfectly on top of the market's posterior (black line). The residual of the regression, depicted on Figure 11, can be interpreted as a communication shock, since it captures the not systematic element that goes into shaping market expectations. On the other hand, the market's prior beliefs and the message text are the biggest components of the market's posterior. This reflects that the market assigns considerable importance to the systematic component of Fed communication as it learns about the economic environment.
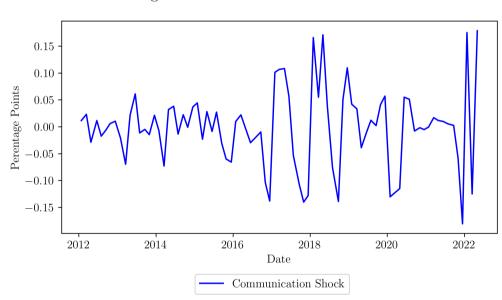
Figure 11: Communication Shocks

Lastly, our disagreement decomposition from Proposition 1 allows us to also construct the fitted values $(1 - \hat{\kappa}_1 - \hat{\kappa}_2)(\mathbb{E}_{t-1}^m[y_t] - \mathbb{E}_t^{Fed}[y_t])$ and $\hat{\kappa}_1(m_t - \mathbb{E}_t^{Fed}[y_t])$. Thus our estimation quantifies how much of the expectations difference between Fed and the market is due to the communication term, and how much to the opinionated term.

This is what is depicted on Figure 12. The black line is the full disagreement between measured expectations, in absolute value. The blue dotted line is the opinionated component,

capturing disagreement between the market and the Fed on the economy in general, while the red dashed is the communication component, both in absolute value. Usually the two components are fairly close to one another, suggesting that both forms of disagreement are important in explaining disagreements. But if anything, the text-based disagreement tends to dominate, providing corroborating evidence to Figure 10 that not only is Fed communication important in moving market beliefs, but disagreement about the Fed's communication rule is a significant driver of diverging beliefs.
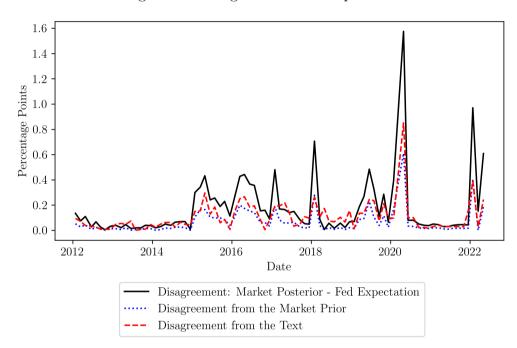
Figure 12: Disagreement Decomposition

6   Conclusion

Is there a systematic way that the Fed maps its expectations of macro variables into FOMC statements? To answer this question, we propose a simple procedure based on text analysis and regularized regression to estimate systematic monetary communication rules.

We first estimate such rules under the assumption that the Fed has a fixed communication rule for the full sample, and then we reestimate communication rules for various subsamples, as well as for the tenures of Fed chairs. We then explore differences between the Fed's and the market's expectations of the fed funds rate, estimating also the market's perception of the Fed's communication rule and contrasting it with our estimate of the actual rule.

Three main results emerge. First, while the language contained in the FOMC statements allows one to back out the Fed's expectation on real variables very well, it does not provide a good fit to the Fed's short-run inflation expectations. This may reflect the notion that the Fed talks more about long-run inflation expectations because that is the horizon where it thinks it can achieve its price stability objective.

Second, there is strong evidence for time-variation in the Fed's communication rule. Some of this is driven by changes in policy that necessitate new language (such as unconventional monetary policy and quantitative easing). Simultaneously, also different Fed chairs seem to have a considerable impact on how the Fed talks about the economy.

Third, estimating both the Fed's communication rule about the fed funds rate and the market's perception thereof, we find considerable and time-varying differences between the text-implied expectations of the Fed and of the market. We use this measure to quantify the sources of expectations differences between the market and the Fed in the data, and to decompose them into disagreement about the Fed's communication rule as well as disagreement about the economic environment.

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A Tables

Table A.1: Top Words for Target Policy Rate with Coefficients

Rank	Higher Target FFR		Lower Target FFR	
1	mainly toward condition generate	3.01	robust underlie growth productivity	-2.47
2	weight mainly toward condition	3.01	exceptionally low level fundsrate	-1.80
3	high level resource utilization	3.01	warrant exceptionally low level	-1.71
4	raise target fundsrate bp	1.41	likely warrant exceptionally low	-1.71
5	long_run inflation expectation remain	0.85	goal price stability sustainable	-1.51
6	target range fundsrate assess	0.75	long_run goal price stability	-1.51
7	inflation expectation remain well	0.68	inflation pressure inflation expectation	-1.50
8	inflation item food energy	0.65	security agency mortgage_backed security	-1.43
9	stability sustainable economic growth	0.59	maintain target range fundsrate	-1.31
10	price stability sustainable economic	0.59	continue monitor implication incoming	-1.31
11	fundsrate assess realize expect	0.49	wide range information include	-1.25
12	size future adjustment target	0.49	account wide range information	-1.25
13	range fundsrate assess realize	0.49	take account wide range	-1.25
14	inflation expectation little change	0.45	assessment take account wide	-1.25
15	long_run inflation expectation little	0.45	information receive since meet	-1.23
16	survey base measure long_run	0.42	decide keep target fundsrate	-1.18
17	base measure inflation compensation	0.39	growth information currently available	-1.17
18		0.39	economic growth information currently	-1.17
19	measure long_run inflation expectation	0.39	stance monetary_policy remain accommodative	-1.17
20	recent month unemployment rate	0.31	maximum employment price stability	-1.08

Rank	Higher Change in Target FFR		Lower Change in Target FFR	
1	gradual increase fundsrate fundsrate	0.60	holding agency debt agency	-0.39
2	sizable level help maintain	0.41	seek foster maximum employment	-0.22
3	since meet suggest economic	0.39	warrant exceptionally low level	-0.22
4	however actual path fundsrate	0.34	policy accommodation take balanced	-0.22
5	fundsrate stance monetary_policy remain	0.32	underlie growth productivity provide	-0.21
6	inflation item food energy	0.32	employment inflation assessment take	-0.21
7	inflation continue run below	0.29	measure labor condition indicator	-0.19
8	accommodation take balanced approach	0.23	ensure inflation over time	-0.19
9	condition evolve manner warrant	0.22	help ensure inflation over	-0.19
10	rate resource utilization subdue	0.22	employment price stability expect	-0.16
11	inflation expectation remain stable	0.18	economic growth information currently	-0.14
12	receive since meet indicate	0.18	incoming information economic outlook	-0.14
13	long_run goal maximum employment	0.18	measure long_run inflation expectation	-0.13
14	future adjustment target range	0.18	base measure long_run inflation	-0.13
15	begin remove policy accommodation	0.15	help make broad financial	-0.13
16	determine timing size future	0.15	adjustment stance monetary_policy economic	-0.12
17	appropriate policy accommodation economic	0.15	remove policy accommodation take	-0.12
18	economic condition relative objective	0.14	judge consistent dual mandate	-0.11
19	decide keep target fundsrate	0.13	include low rate resource	-0.11
20	robust underlie growth productivity	0.13	implication incoming information economic	-0.08

Table A.2: Top Words for Macro Forecasts with Coefficients

Rank	Higher RGDP Growth q+1		Lower RGDP Growth q+1	
1	assessment take account wide	2.48	gradual adjustment stance monetary_policy	-3.11
2	measure long_run inflation expectation	2.27	warrant exceptionally low level	-3.02
3	policy accommodation take balanced	2.19	time rate consistent dual	-3.02
4	monetary_policy economic activity expand	2.01	agency debt agency mortgage_backed	-1.78
5	include measure labor condition	2.01	fundsrate depend economic outlook	-1.57
6	consistent long_run goal maximum	2.00	since meet suggest economic	-1.52
7	base measure long_run inflation	1.83	over time rate consistent	-1.03
8	rate consistent dual mandate	1.65	reinveste principal payment holding	-1.03
9	roll over mature treasury	1.61	agency mortgage_backed security agency	-0.98
10	downward pressure long_run interest	1.51	judge consistent dual mandate	-0.97
11	economic condition include low	1.22	target range fundsrate assess	-0.89
12	underlie growth productivity provide	1.22	statutory mandate seek foster	-0.89
13	range fundsrate assess realize	1.12	principal payment holding agency	-0.88
14	toward maximum employment price	1.03	decide begin remove policy	-0.77
15	household spending business fix	1.03	decide keep target fundsrate	-0.70
16	approach consistent long_run goal	1.03	employment price stability reaffirm	-0.70
17	inflation expectation remain stable	1.03	economic condition relative objective	-0.70
18	level judge consistent dual	1.03	recovery help ensure inflation	-0.68
19	inflation assessment take account	1.03	target range fundsrate stance	-0.67
20	carefully monitor actual expect	1.02	background long_run goal price	-0.67

Rank	Higher Unemployment q+1		Lower Unemployment q+1	
1	security agency mortgage_backed security	2.40	depend economic outlook inform	-1.16
2	inflation expectation remain stable	2.12	inflation expectation reading financial	-1.12
3	since meet indicate labor	1.94	stable consistent statutory mandate	-1.12
4	assessment take account wide	1.39	rate consistent dual mandate	-0.95
5	likely remain time below	1.39	progress toward maximum employment	-0.80
6	long_run however actual path	1.38	goal price stability sustainable	-0.80
7	upside downside risk attainment	1.36	sustainable economic growth information	-0.75
8	level judge consistent dual	1.35	activity expand moderate pace	-0.60
9	gradual increase fundsrate fundsrate	1.35	warrant exceptionally low level	-0.60
10	determine timing size future	1.33	fundsrate likely remain time	-0.58
11	future adjustment target range	1.24	expect economic condition evolve	-0.58
12	return inflation determine timing	1.19	condition indicator inflation pressure	-0.58
13	expand moderate pace labor	1.19	information include measure labor	-0.58
14	level expect prevail long_run	0.99	timing size future adjustment	-0.54
15	expectation remain stable consistent	0.91	meet suggest economic activity	-0.52
16	however actual path fundsrate	0.90	condition relative objective maximum	-0.52
17	implication incoming information economic	0.90	meet indicate labor continue	-0.52
18	agency mortgage_backed security agency	0.90	mandate seek foster maximum	-0.47
19	compensation remain low survey	0.88	realize expect economic condition	-0.45
20	seek foster maximum employment	0.88	inflation goal expect economic	-0.44

Rank	Higher Inflation (CPI) q+1		Lower Inflation (CPI) q+1	
1	maintain accommodative financial condition	0.71	fundsrate likely remain time	-0.37
2	condition indicator inflation pressure	0.69	inflation expectation reading financial	-0.35
3	depend economic outlook inform	0.60	level judge consistent dual	-0.33
4	fundsrate fundsrate likely remain	0.44	inflation assessment take account	-0.33
5	ensure inflation over time	0.44	policy reinveste principal payment	-0.33
6	increase fundsrate fundsrate likely	0.40	expect prevail long_run however	-0.33
7	long_run goal maximum employment	0.39	include low rate resource	-0.33
8	implication incoming information economic	0.38	employment price stability expect	-0.32
9	economic recovery help ensure	0.38	time rate consistent dual	-0.32
10	mortgage_backed security roll over	0.37	holding long_run security sizable	-0.27
11	seek foster maximum employment	0.33	security roll over mature	-0.27
12	rate resource utilization subdue	0.30	return inflation determine timing	-0.27
13	mainly toward condition generate	0.24	since meet indicate labor	-0.27
14	decide begin remove policy	0.24	mandate seek foster maximum	-0.27
15	expect economic condition evolve	0.20	base measure inflation compensation	-0.27
16	principal payment holding agency	0.15	information include measure labor	-0.27
17	downward pressure long_run interest	0.13	level fundsrate extended period	-0.27
18	consistent statutory mandate seek	0.13	realize expect economic condition	-0.27
19	actual path fundsrate depend	0.13	foster maximum employment price	-0.27
20	survey base measure long_run	0.13	stability expect appropriate policy	-0.23

Table A.3: Top Words for Communication Rule vs. Perceived Rule

Rank	Higher FOMC Forecast	Higher Market Forecast
1	mortgage help make broad	begin remove policy accommodation
2	accommodative stance monetary_policy until	stance monetary_policy economic activity
3	decline energy price price	below level view normal
4	come month continue purchase	maximum employment inflation rise
5	solid average recent month	reflect policy measure support
6	fundsrate currently anticipate exceptionally	include measure labor condition
7	timing size future adjustment	economic outlook appear roughly
8	flow credit household business	incoming information economic outlook
9	after asset purchase program	advance while recovery housing
10	symmetric inflation goal expect	labor condition inflation pressure
11	ensure inflation over time	one two year ahead
12	condition indicator inflation pressure	goal assessment take account
13	year ahead project more	symmetric inflation goal expect
14	long unemployment rate remain	maximum employment inflation rate
15	anchored determine long maintain	expectation reading financial international
16	rate gradually decline toward	level expect prevail long_run
17	would prepare adjust stance	medium_run near_term risk economic
18	growth business fix investment	elevated household spending business
19	view realize expect labor	policy reinveste principal payment
20	household business path economy	inflation determine timing size

Rank	Lower FOMC Forecast	Lower Market Forecast
1	agency mortgage_backed security roll	inflation near symmetric objective
2	level fundsrate well under	asset purchase not preset
3	inflation expectation little change	timing size future adjustment
4	employment price stability expect	holding long_run security sizable
5	anticipate even after employment	determine timing size future
6	additional measure labor condition	support flow credit household
7	employ policy tool appropriate	maximum employment inflation assessment
8	financial international development light	month basis both overall
9	level consistent assessment maximum	light current shortfall inflation
10	objective maximum employment inflation	stability expect appropriate policy
11	even after employment inflation	outlook economic activity labor
12	closely monitor incoming information	preset course decision pace
13	labor condition inflation decide	treasury security least billion
14	decide maintain target range	until labor condition reach
15	maximum employment inflation currently	condition evolve manner warrant
16	appropriate policy accommodation economic	sector adversely affect pandemic
17	economic condition evolve manner	appropriate risk emerge could
18	stance monetary_policy appropriate risk	actual path fundsrate depend
19	rate remain above inflation	more accommodative turn promote
20	compensation remain low survey	appropriate considerable time after

Table A.4: Top Words for Opacity

Rank	Higher Opacity	Lower Opacity
1	information economic outlook would	remain elevated household spending
2	maximum employment price stability	treasury agency mortgage_backed security
3	inflation expectation little change	rate support mortgage help
4	until outlook labor improve	economic recovery help ensure
5	year ahead project more	over medium_run transitory effect
6	fundsrate likely remain time	appropriate determine long maintain
7	monetary_policy remain accommodative thereby	appropriate maintain target range
8	policy reinveste principal payment	billion per month maintain
9	month basis both overall	appropriate policy accommodation economic
10	include measure labor condition	over time rate consistent
11	time after asset purchase	condition sustained return inflation
12	view current target range	toward inflation goal expect
13	agency mortgage backe security	stance monetary_policy also consider
14	decide begin remove policy	above long_run goal long_run
15	medium_run near_term risk economic	realize expect economic condition
16	remain accommodative part reflect	continue well anchored determine
17	monetary_policy appropriate risk emerge	backe security least billion
18	business assess appropriate stance	average recent month unemployment
19	advance while recovery housing	economic condition time warrant
20	shortfall inflation carefully monitor	over mature treasury security

B Graphs
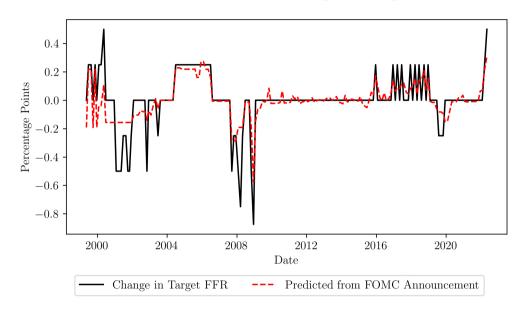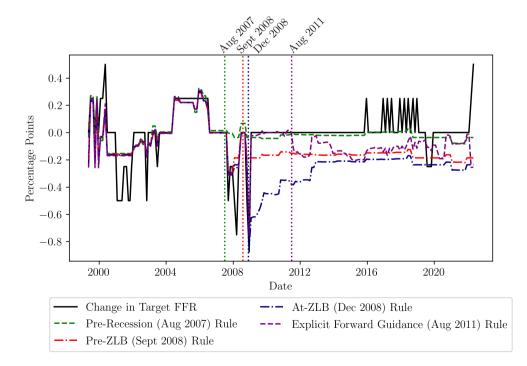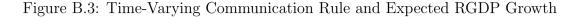
Figure B.1: Fixed Communication Rule and Changes to Target Federal Funds Rate

Figure B.2: Time-Varying Communication Rule and Changes to Target Federal Funds Rate

Figure B.3: Time-Varying Communication Rule and Expected RGDP Growth
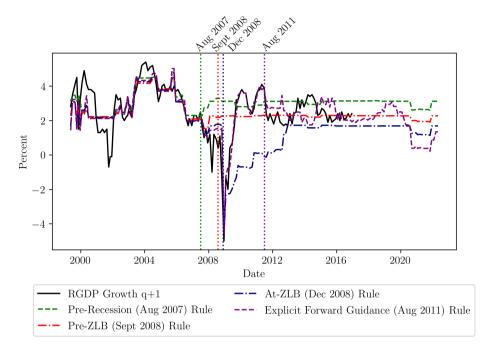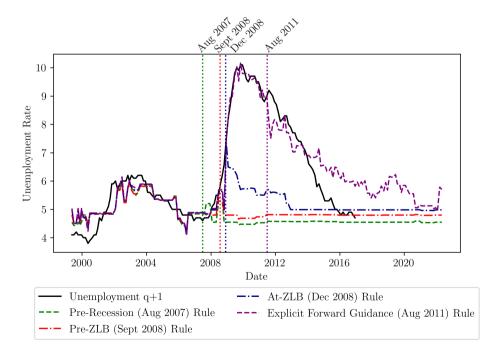

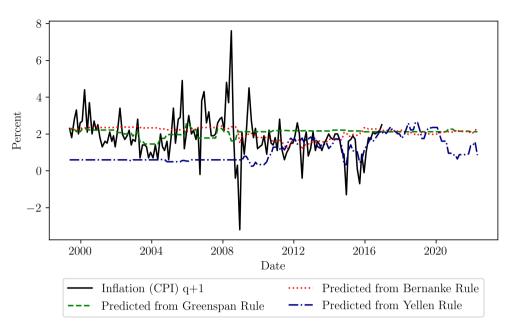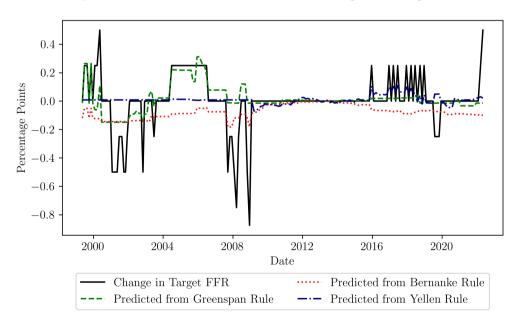Figure B.4: Time-Varying Communication Rule and Expected Unemployment Rate

Figure B.5: Chair-Specific Communication Rules and Inflation

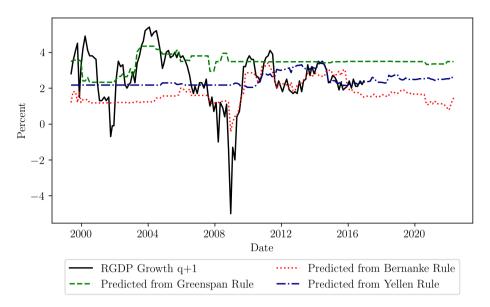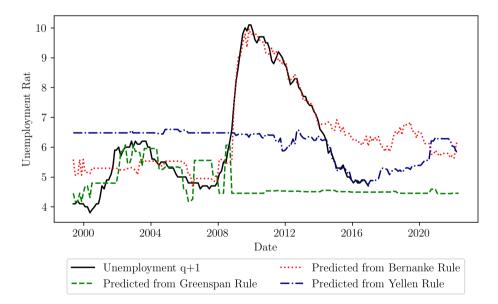Figure B.6: Chair-Specific Communication Rules and Changes to Target Federal Funds Rate

Figure B.7: Chair-Specific Communication Rules and Expected RGDP Growth

Figure B.8: Chair-Specific Communication Rules and Expected Unemployment Rate

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