

INTRODUCTION

The Federal Reserve System was created by an act of Congress in 1913, and they are tasked with a so called “dual mandate” to 1) promote full employment and 2) ensure price stability. In practice, the most traditional tool that they have to achieve these goals is by setting the interest rate at which large banking institutions can lend to each other overnight. This rate is known as the federal funds rate, and it is decided by the Federal Open Markets Committee (FOMC) in meetings that occur about every six (6) weeks. The decision is important because it ultimately filters through the economy, from the big banks, to consumers like you and me. It does so in the form of mortgage rates, credit card rates, interest rates on business loans, and so on, whereby the “cheaper” it is for banks to borrow money overnight, the lower the interest rate that they can afford to give consumers.

In between meeting dates, members of the Federal Reserve Board of Governors – a group that is always allowed to vote on the interest rate decision – may give speeches to the public during scheduled events. One might wonder, do these speeches contain information about their upcoming decisions?

After the financial crisis in 2008, the federal funds rate hit historic lows near what is now called the “zero lower bound”. This name alludes to the belief that interest rates could not effectively go below zero. In this new environment, the FOMC needed to engage in new and controversial monetary policy, since they couldn’t credibly lower the interest rate any more. “Forward guidance” was one such tool, whereby the FOMC would make statements about its future actions in order to spur the market to behave with confidence about what the future would hold. Thus, if they had a policy of telling the public what they would do in the future, are they effective with this new tool? More specifically, can we analyze their speech and learn information about their future interest rate decisions?

LIT REVIEW

Blei, Ng, and Jordan (2003) introduced the Latent Dirichlet Allocation (LDA) model for discovering hidden or “latent” topics from a corpus of text data. In short, LDA is a hierarchical Bayesian model where each text document is represented as words drawn from a mix of topic probabilities. These topics are often called “latent” since they are inferred rather than observed. Since its publication, it has been cited over 28,000 times, including in Hansen et. al. (2017) and Hansen and McMahon (2016), where they apply an LDA model to text data from the public transcripts of FOMCs meetings. In one paper, they exploit a policy change to examine how official communication changes under different levels of expected transparency. In the other paper, they look to see if the release of the FOMC meeting transcripts has any effect on macroeconomic indicators like stock market indices or bond yields. Perhaps most related to my work, Hayo et. al. (2010) explicitly try to explain FOMC interest rate decisions with communication indicators, although they do not employ any natural language processing techniques in their analysis. My proposed work will fill a gap in the literature by using a new set of publicly available data to explore if these interest rate changes can, to any degree, be forecasted based only on the text of official communications.

DATA

I scraped the Federal Board of Governors website and collected the text of every public speech given by a member of the Board from March 2006 to September 2019. Additionally, I gathered the interest rate decisions¹ made by the Federal Open Markets Committee in every meeting between March 2006 and September 2019.

¹ Measured in basis points.

Next, I processed the text data by removing all characters that were not letters, converting all remaining letters to lowercase, removing all “stopwords”², stemming the words according to the Porter Stemmer³, and finally making bigram phrases⁴. This process allowed me to reduce the dimensionality of the final vocabulary, while still maintaining more linguistic context than you get by just using the words themselves. Intuitively, this is because a bigram also contains information about the ordering and proximity of words.

Finally, I combined all speeches that occurred between consecutive meetings into a single “document”. For example, the FOMC met on July 31, 2019 to make an interest rate decision. About six (6) weeks later, they met again on September 18, 2019 to make another interest rate decision. In this case, I appended every speech given after July 31 but before the September 18th into a single text “document” that represented all of the FOMC’s communication before making that decision. While one may argue that various committee members each have a unique and separate opinions, it is therefore unjustified to combine them into a single document. In fact though, this is an advantage of my dataset as members of the Board of Governors make a conscious effort to have a unified message. Thus, while there will no doubt be some variation in topic and opinion, the members of the Board publicly make every effort to speak with a unified voice, so as to set clear expectations for the market. Figures 1 and 2 below shows a sample of raw text from a speech, and the corresponding, cleaned bigram, respectively.

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I will begin my remarks by posing a question: why are long-term interest rates so low in the United States and in other major industrial
countries? At first blush, the answer seems obvious: central banks in these countries are pursuing accommodative monetary policies to boost growth and reduce
slack in their economies. However, while central banks certainly play a key role in determining the behavior of long-term interest rates, theirs is only a proximate
influence. A more complete explanation of the current low level of rates must take account of the broader economic environment in which central banks are currently operating
and of the constraints that that environment places on their policy choices. Let me start with a brief overview of the recent history of long-term
interest rates in some key economies. Chart 1 shows the 10-year government bond yields for five major industrial countries: Canada, Germany, Japan, the United Kingdom, and
the United States. Note that the movements in these yields are quite correlated, with some differences in the economic circumstances and central bank mandates in the
two countries. Further, with the notable exception of Japan, the levels of the yields have been very similar—indeed, strikingly so, with long-term yields declining over
a time and currently close to 2 percent in each case. The similar behavior of these yields attests to the global nature of the economic and financial developments of a
recent years, as well as to the broad similarity in how the monetary policymakers in the advanced economies have responded to these developments. Of course, Japan's yield
is clearly a case apart, as Japan has endured an extended period of deflation, while inflation in the other four countries has been positive and generally close to
the stated objectives of the monetary authorities. But even Japanese yields have shown some tendency to fluctuate along with other benchmark yields, and they have also
declined over the period shown. In my comments, I will delve more deeply into the reasons why these long-term interest rates have fallen so low. This exami-
nation may be useful both for understanding the current stance of policy and also for thinking about how rates may evolve. In short, an expectation that as the economy recovers,
long-term rates will rise over time to more normal levels. A return to more normal conditions in financial markets would, of course, be most welcome. Many comments
have noted, however, that both an extended period of low rates and the transition back toward normal levels may pose risks to financial stability. In the final por-
tion of my remarks, I will discuss some aspects of how the Federal Reserve is approaching these risks. Why Are Long-Term Interest Rates So Low? So why are long-term
interest rates currently so low? To help answer this question, it is useful to decompose longer-term yields into three components: one reflecting expected inflation
over the term of the security, another capturing the expected path of short-term real, or inflation-adjusted, interest rates, and a real component known as the term
premium. Of course, none of these three components is observed directly, but there are standard ways of estimating them. Chart 2 displays one version of this decompo-
sition of the 10-year U.S. Treasury yield based on a term structure model developed by Federal Reserve staff.10 The broad features I will emphasize are similar to those
found by other authors using a variety of methods.11 All three components of the 10-year yield have declined since 2007. The decomposition attributes much of the decline in the yield since 2010 to a sharp fall in the term premium, but the expected short-term real rate component also moved down significantly. Let's
consider each component more closely. The expected inflation component has drifted gradually downward for many years and has become quite stable. In large part, the downward trend and stabilization of expected inflation in the United States are products of the increasing credibility of the Federal Reserve's commitment to
price stability. In January 2012, the Federal Open Market Committee (FOMC) underscored this commitment by issuing a statement—since reaffirmed at its January 2013 meet-
ing—on its long-term goals and policy strategy, which included a longer-run inflation target of 2 percent.12 And the anchoring of long-term inflation expectations near
2 percent has been a key factor influencing long-term interest rates over recent years. It almost certainly helped mitigate the strong disinflationary pressures imposed
suddenly following the crisis, while I have not discussed in detail, the expected inflation for other advanced economies, the picture would be very similar—though, except for Japan.
With the expected inflation component of the 10-year rate near 2 percent and the rate itself a bit below 2 percent recently, it is clear that the combination of
the other two components—the expected path of short-term real interest rates and the term premium—must be a small net negative contribution. The impact
of path of short-term real interest rates is, of course, influenced by monetary policy, both the current stance of policy and market participants' expectations of how
policy will evolve. The stance of monetary policy at any given time, in turn, is driven largely by the economic outlook, the risks surrounding that outlook, and at times
other factors, such as whether the rate is over- or under-biased. In the case of interest rates, central bank policymakers and market participants widely
agree that supporting the U.S. economic recovery while keeping inflation close to 2 percent will likely require real short-term rates, currently negative, to remain low
for some time. As shown in chart 2, the expected average of the short-term real rate over the next 18 years has gradually declined to near zero over the past few years,
in part reflecting downward revisions in expectations about the pace of the ongoing recovery and, hence, a pushing out of expectations regarding how long nominal short-
term rates will remain low.13 As the persistence of the effects of the crisis have become clearer, the Federal Reserve's communications have reinforced
the expectation that conditions are likely to worsen further. In fact, the FOMC indicated that it had, most recently, lowered its policy rate to a historically low
exceptionally low level of the federal funds rate at least as long as the unemployment rate is above 6.5 percent, projected inflation between one and two years ahead
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Figure 1: A sample of raw speech data.

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Figure 2: A sample of the same text after cleaning.

After combining the cleaned text with the corresponding meeting date and interest rate decision, I fit a Latent Dirichlet Allocation (LDA) model to the data. While the details are outside the scope of this paper, in essence, an LDA model finds groupings of words that tend to appear together across documents: these

2 Stopwords are words that appear so frequently that they don't carry much information. Examples of common stopwords include the words “a”, “the”, “and”, and so on. I used a standard list of stopwords available at <https://www.ranks.nl/stopwords>.

3 Porter stemming removes the suffix of words according to a well-defined process in order to allow words with the same root map to same object. For example, the words financial, financier, and financials would all get mapped into the same word: “financi”.

4 A bigram phrase is the concatenation of two neighboring words. So the phrase, “the dog sat still”, in bigrams, would be [“the dog”, “dog sat”, “sat still”]. This allows to capture some additional linguistic context, while still maintaining a relatively small overall vocabulary. This can be generalized further into ngrams.

are often interpreted as “latent topics” since they are not explicitly defined, but rather inferred from the statistical analysis. Figure 3 below shows the results of fitting an LDA model with 12 topics. There are several important things to note. First, the choice of topic numbers is exogenously chosen, and can certainly be somewhat arbitrary. The tradeoffs in topic modeling is to use a large number of topics with typically low interpretability, or to choose a smaller number of topics with more intuitive interpretations.⁵ Second, note the common appearance of the phrase “neutral rate”. This phrase is extremely common in the macroeconomic literature as it signifies, in essence, the long run equilibrium rate of interest. While it cannot be measured directly, much discussion and mathematical modeling goes into trying to make good estimates for this number. Given the prevalence of this phrase, in a follow up analysis, I would remove it and consider it a stop word. Finally, note the light grey highlighted rows. As I will show in the next section, these “topics” were selected as the most useful in predicting interest rate decisions.

Topic 0	neutral rate	bank independ	latin america	financi educ	macroprudenti polici	averag inflat	central clear	financi decis	leverag loan	protect consum
Topic 1	headlin inflat	oper risk	senior manag	neutral rate	basel framework	financi turmoil	price discoveri	labor cost	credit deriv	lender last
Topic 2	neutral rate	macroprudenti polici	headlin inflat	margin requir	asset bubbl	lender last	central clear	interest price	simpl rule	task forc
Topic 3	develop countri	longrun inflat	senior manag	neutral rate	oper risk	credit deriv	central clear	afford hous	world bank	ten year
Topic 4	neutral rate	central clear	margin requir	volcker rule	longterm debt	countercycl capit	incom wealth	macroprudenti polici	recent event	protect consum
Topic 5	neutral rate	price bubbl	credit product	central clear	oper risk	margin requir	labor cost	commun organ	frbu model	equilibrium real
Topic 6	neutral rate	central clear	mortgag servic	macroprudenti polici	longrun inflat	financi educ	financi disrupt	senior manag	capit assess	headlin inflat
Topic 7	credit deriv	mortgag servic	senior manag	financi educ	intern control	develop countri	forward rate	basel framework	oper risk	incent compens
Topic 8	neutral rate	macroprudenti polici	capit assess	develop countri	advers scenario	longterm unemploy	central clear	bank independ	macroprudenti tool	otc deriv
Topic 9	neutral rate	asset bubbl	treasuri market	equilibrium real	incent compens	financi educ	monei fund	student loan	financi turmoil	toobigtotall problem
Topic 10	neutral rate	oper risk	monei fund	margin requir	equilibrium real	corpor govern	central clear	securit market	basel framework	headlin inflat
Topic 11	neutral rate	task forc	incom wealth	treasuri market	central clear	rural area	new normal	sheet normal	fed balanc	neutral real

Figure 3: The results of a fitted LDA with 12 topics.

Finally, for each document in the corpus (i.e. each set of communication between FOMC interest rate decisions), I calculate the amount of time spent discussing each topic. Figure 4 below shows a time series of the interest rate decisions, along with the percent of communication devoted to each topic in the preceding weeks before the meeting.

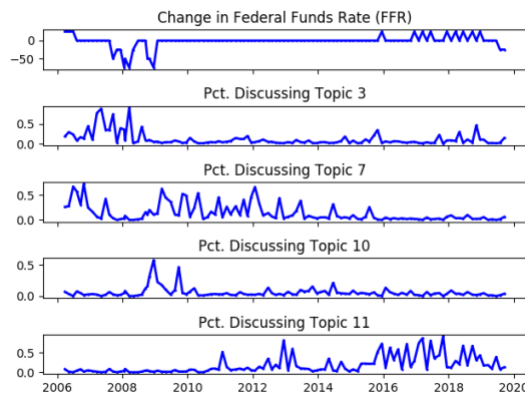


Figure 4: A time series of interest rate decisions and the time spent discussing relevant topics.

Finally, we can view the head of the dataset in Figure 5 below, noting that the final dataset has 111 observations.

```
>>> df.head()
  Topic0  Topic1  Topic2  Topic3  Topic4  Topic5  Topic6
0  0.255118  0.124658  0.043252  0.145469  0.046684  0.045981  0.041588
1  0.736499  0.016011  0.015795  0.022318  0.021972  0.026582  0.015738
2  0.510512  0.000000  0.010388  0.012247  0.000000  0.018453  0.000000
3  0.750645  0.015778  0.017898  0.019498  0.019051  0.017919  0.013994
4  0.645892  0.018795  0.016427  0.015077  0.016312  0.051070  0.000000
  Topic7  Topic8  Topic9  Topic10  Topic11  Change
0  0.060733  0.039576  0.030504  0.037390  0.128835  -25.0
1  0.014164  0.016824  0.022129  0.014010  0.077958  -25.0
2  0.000000  0.000000  0.000000  0.000000  0.394227  0.0
3  0.013389  0.017200  0.012581  0.013869  0.088178  0.0
4  0.000000  0.000000  0.012136  0.010300  0.185212  0.0
```

Figure 5: The first five (5) entries of the final dataset.

⁵ Additionally, there are more rigorous methods to determining the ideal number of topics, most notably using a so called “coherence” value. This was calculated for a range of topic numbers from 9 to 40, but the results are omitted for brevity since it ultimately wasn’t used to decide the number of topics to use. That said, the coherence score did also prefer models with a number of topics between 9 and 14.

ANALYSIS

My first step in analyzing the data was to reduce the dimensionality of the covariates since I only have 111 observations, but have 12 topics. Using a L1 penalized regression⁶ (also called LASSO), topics 3, 7, 10, and 11 were selected as the most relevant. These four (4) topics were then used in a standard OLS regression. The results from this exercise are shown in Figure 6 below.

Dep. Variable:	Change	R-squared:	0.311
Model:	OLS	Adj. R-squared:	0.285
Method:	Least Squares	F-statistic:	11.95
Date:	Mon, 02 Dec 2019	Prob (F-statistic):	4.73e-08
Time:	19:58:39	Log-Likelihood:	-459.16
No. Observations:	111	AIC:	928.3
Df Residuals:	106	BIC:	941.9
Df Model:	4		

	coef	std err	t	P > t	[0.025	0.975]
const	-0.8405	3.537	-0.238	0.813	-7.854	6.173
Topic3	-29.8516	9.124	-3.272	0.001	-47.941	-11.762
Topic7	20.5297	9.256	2.218	0.029	2.180	38.880
Topic10	-77.3146	19.405	-3.984	0.000	-115.786	-38.843
Topic11	20.9176	7.536	2.776	0.007	5.977	35.858

Omnibus:	26.904	Durbin-Watson:	1.035
Prob(Omnibus):	0.000	Jarque-Bera (JB):	53.707
Skew:	-0.978	Prob(JB):	2.18e-12
Kurtosis:	5.791	Cond. No.	13.9

Warnings:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Figure 6: Results from an OLS regression of the change in interest rate (in basis points) on the LASSO selected topics.

We see here that using the four (4) LASSO selected topics in a simple linear model explains approximately 31% of the total variation in interest rate changes, based on the R_2 score. Interestingly, we find that each of the coefficients on the included topics are statistically significant to 5% levels.

In order to test how well the OLS performs out of sample, I perform a leave-one-out cross validation. Here, I iteratively withhold a single observation, and fit a model on the remaining 110 observations. Then, I use the fitted model to make a prediction on the withheld observation. Figure 7 below shows the graphical results of these predictions.

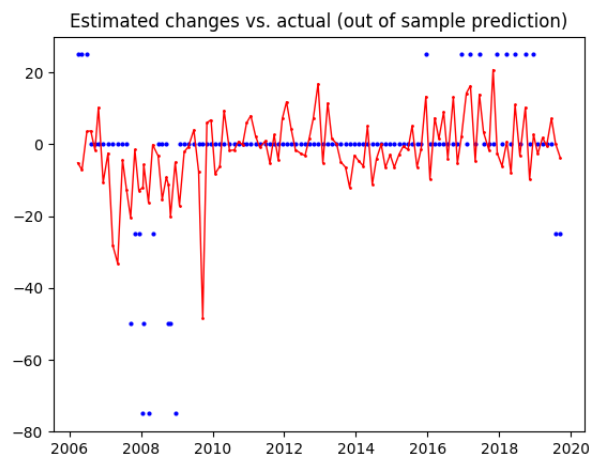


Figure 7: Leave-one-out predictions (red) compared to the actual interest rate changes (blue).

⁶ Note, the LASSO regression acts as a penalty on non-zero coefficients. Mathematically, it is the optimization problem $\min \left\{ \sum (y - \hat{\beta}x)^2 + \alpha \sum |\beta| \right\}$, where β 's are the coefficients, and α is the weight we give to non-zero coefficients. In this case, I chose $\alpha = 0.3$.

For robustness checks, I transformed the interest rate decision into a categorical problem⁷ and then trained a neural network with two (2) hidden layers to predict the ultimate decision based on the full topic distributions (i.e. without using LASSO to select variables). While the details of this are included in other work for brevity⁸, the trained neural network yielded an F1 score of 0.78 for the classification problem on the withheld test set. Similarly, this analysis is robust to other choices for the number of topics.

CONCLUSION

This work suggests that public speeches from the Federal Reserve Board of Governors do in fact seem to contain information that is useful in predicting future interest rate decisions. It is important to note, however, that this analysis does not show any causality. In any case, since the individuals that make the speeches are the same people that are involved in making the interest rate decisions, it is most likely the case that any information they embed in their speeches is reflective of their beliefs about what they will do in the future. This is to say that it's very unlikely that giving speeches would *cause* the FOMC to make any particular decision. Rather, we may prefer to consider that the FOMC first has some beliefs about what decision it will make in the future, and those beliefs then *cause* them to deliver a speech with a particular wording.

Despite this subtle clarification, the results are no less interesting. While more study is needed to rule out spurious correlations, these results are supportive of the idea that the FOMC, intentionally or not, is constantly broadcasting information about what its next move will be. Given the fact that these speeches have never been formally studied in the literature, and the fact that the interest rate decisions ultimately impact the lives of billions of people around the world, my tentative results indicate that there may be untapped information available to market participants about what the future holds.

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⁷ Specifically, I mapped a rate increase to the categorical vector [1,0,0], no change to [0,1,0], and a rate decrease to [0,0,1].

⁸ See Quiz 7.