

# Monetary Communication Rules\*

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\*The views expressed herein are our own and do not necessarily reflect those of the ECB or the Eurosystem.

# Motivation

- ▶ Monetary economics: interest rate determined by policy rule
  - Systematic mapping from macroeconomic variables to interest rate
  - "'Policy rule' was replaced by 'systematic policy,'... 'methodical, according to a plan, and not casually or at random.'" (Taylor, 1993)
- ▶ We propose thinking about *communication* with a systematic rule
  - FOMC post-meeting announcements, decided by FOMC vote
    - Text covers Fed's policy decisions and expectations of economy
  - Systematic language corresponding to other policy and macro forecasts

[Taylor \(1993\)](#)[Statement Ex.](#)[FedSpeak in News](#)[Text vs. Rates](#)

# This Paper

1. Estimates time-varying regression (ridge) on text and Fed policy/forecasts
  - Separate text regression for each forecast/policy variable
    - ↪ estimated mappings called *monetary communication rules*
2. Measures when the rules shift and private expectation responses
  - Change in communication rules correlated with increased uncertainty
    - ▶ Larger high-frequency monetary surprises
    - ▶ Greater professional forecaster dispersion
3. General framework to model, estimate, and track communication rules
  - Detection procedure for breaks in communication rules

# Related Literature

## ► Text Analysis of Communication

- Baker, Bloom, Davis and Renault (2021); Calomiris, Harris, Mamaysky and Tessari (2022); Campbell, Evans, Fisher and Justiniano (2012); Cieslak, Hansen, McMahon and Xiao (2021); Doh, Song and Yang (2022b); Ehrmann and Fratzscher (2005, 2007); Ericsson (2017, 2016); Gardner, Scotti and Vega (2021); Handlan (2020); Hansen, McMahon and Prat (2018); Hassan, Hollander, van Lent and Tahoun (2019); Husted, Rogers and Sun (2020); Liang, Meursault, Routledge and Scanlon (2022); Shapiro and Wilson (2021); and others...
- **This paper:** focuses on systematic aspects of central bank communication

## ► Theory of Public Communication

- Angeletos and La’O (2013); Angeletos and Lian (2018); Angeletos and Pavan (2007); Bassetto (2019); Caballero and Simsek (2022); Crawford and Sobel (1982); Doh, Gruber and Song (2022a); Farmer, Nakamura and Steinsson (2023); Gáti (2023); Herbert (2022); Kydland and Prescott (1977); Morris and Shin (2002); Moscarini (2007); Ou, Zhang and Zhang (2022); and others...
- **This paper:** framework for systematic communication rule for data

# Presentation Outline

① Intro

② Data and Text

③ Regression

④ Fixed Rule

⑤ Rule Shifts

⑥ Private Sector Beliefs

⑦ Conclusion

# Data

► **Communication Text:** FOMC statements (FRB, 1999-2022)

Example

► **Realized policy variables** (FRB, 1999-2022)

- Target fed funds rate, change in FFR, target FFR next year
- Total assets, shadow rate, 10Y Treasury - FFR

► **Internal Forecasts:** Greenbook/Tealbook (FRB, 1999-2017)

- Real GDP growth, unemployment, headline and core inflation
- Next quarter and next year

► **Private sector expectations** (2007-2022)

- Dispersion from Survey of Professional Forecasters (SPF)
- |Monetary surprises| from Acosta (2023); Bauer and Swanson (2023); Gürkaynak, Sack and Swanson (2005); Nakamura and Steinsson (2018)

# Text Representation: Introduction

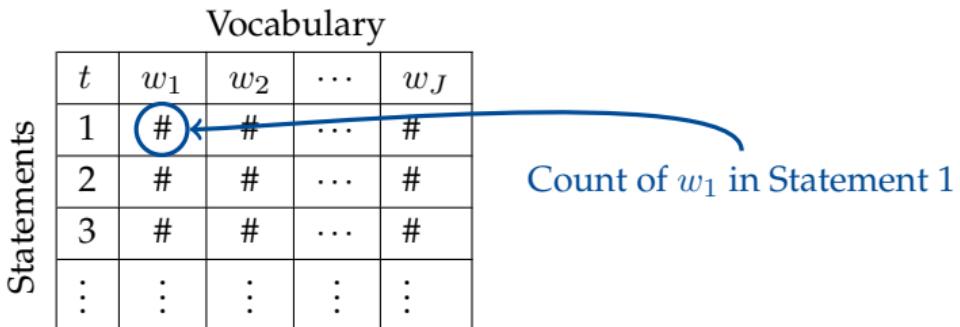
- ▶ Need to numerically represent FOMC post-meeting statement text
- ▶ First, consider a simplified representation:
  - Vocabulary = set of all words used in FOMC Statements,  $\{w_1, \dots, w_J\}$
  - Each statement = a vector of counts of words

Vocabulary

$t$	$w_1$	$w_2$	$\dots$	$w_J$
1	#	#	$\dots$	#
2	#	#	$\dots$	#
3	#	#	$\dots$	#
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

Statements

Count of  $w_1$  in Statement 1



# Text Representation: Baseline

- ▶ Each statement = vector of weighted counts of 4-grams (sequences of 4 words)

Set of 4-grams

$t$	$w_1$	$w_2$	...	$w_J$
1	#	#	...	#
2	#	#	...	#
3	#	#	...	#
:	:	:	:	:

Statements

Weighted count of 4-gram  $w_1$  in Statement 1

- ▶ Build 4-grams vocabulary from FOMC statements ( $\approx 750$ )
- ▶ Weighting adjusts for text length and common 4-grams (TFIDF)

# Text Processing and Vocab Construction

- ▶ Each statement = vector of **weighted counts** of **4-grams** (sequences of 4 words)
- ▶ Build vocabulary from all **4-grams** used in FOMC Statements
  - Pre-processing: Drop numbers/stopwords (*the/a/of/to/...*)  
Lemmatization (*decided/deciding* → **decide**)  
Entity-encoding (*Federal Open Market Committee* → fomc)
  - Example of pre-processing:

<i>The Federal Open Market Committee decided today to keep its target for the federal funds rate at 5-1/4 percent...</i>	[ "fomc <b>decide</b> today keep", " <b>decide</b> today keep target", "today keep target <u>fundsrate</u> ", ... ]
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  - Drop **4-grams** in < 5% statements → **4-grams** vocabulary ~ 750

# TFIDF Weighting

- ▶ Each statement = vector of **weighted counts** of **4-grams** (sequences of 4 words)
- ▶ **TFIDF** = Term-frequency inverse-document-frequency

$$\text{TFIDF} = \frac{TF}{DF}$$

where

$$TF = \frac{\# \text{ token t occurs in document d}}{\text{total } \# \text{ of tokens in document d}}$$

and

$$DF = \frac{\# \text{ of documents in which token t occurs}}{\text{total } \# \text{ of documents}}$$

- ▶ **TFIDF weighting** adjusts for text length and common/uninformative words

# Robustness: Alternative Text Representations

1. Vary the sequence length of N-gram and occurrence threshold

[More](#)

2. Cluster similar 4-grams → 100 clusters

[More](#)

- Embed 4-grams with large-language model (BERT)
- Cosine similarity to group similar 4-grams (agglomerative clustering)

3. Large-language model (BERT) → 40 dim. vector representation

[More](#)

- Embed entire statement with BERT model
- Dense space that encodes "context" of statement as vector
- Dimension reduction (PCA): 700+ dimension BERT vector → 40 dimensions

# Assumptions

1. FOMC statement is union of messages  $m^y$  about variables  $y \in Y$  Sub-messages
  2.  $y$ -message ( $m^y$ )  $\approx$  linear combo of 4-grams ( $w_j$ ) Linear Combo
  3. Fed chooses text aligned with expectations, on average Mean Truth
  4. Stable mapping between expectations and text over time window  $h$  Fixed Coef.
- *Communication rule on variable  $y$ :*

$$m_t^y = \mathcal{F}_t^y(y_t)$$

5.  $\mathcal{F}^y$  invertible, so can write *inverse communication rule*:

$$y_t = (\mathcal{F}_t^y)^{-1}(m_t^y)$$

Set Y

# Communication Rule Specification

- ▶ Estimate inverse communication rule for each policy/forecast ( $y$ ):

$$y_t = \sum_j \beta_j^{h,y} w_{j,t} + \varepsilon_t^{h,y}$$

$$\hat{\beta}_{ridge}^{h,y} = \underset{\beta}{\operatorname{argmin}} \sum_t \left( y_t - \sum_j \beta_j^{h,y} w_{j,t} \right)^2 + \alpha^{h,y} \sum_j \left( \beta_j^{h,y} \right)^2$$

- $\alpha^{h,y}$  = optimal ridge penalty parameter estimated

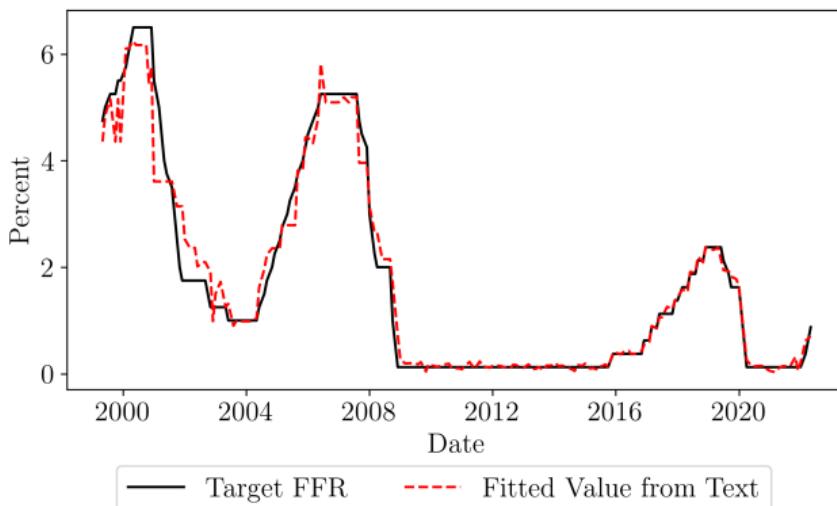
CV

# Fixed Communication Rules

- ▶ Suppose that the communication rule is stable over whole sample or “fixed”

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- ▶ Suppose that the communication rule is stable over whole sample or “fixed”



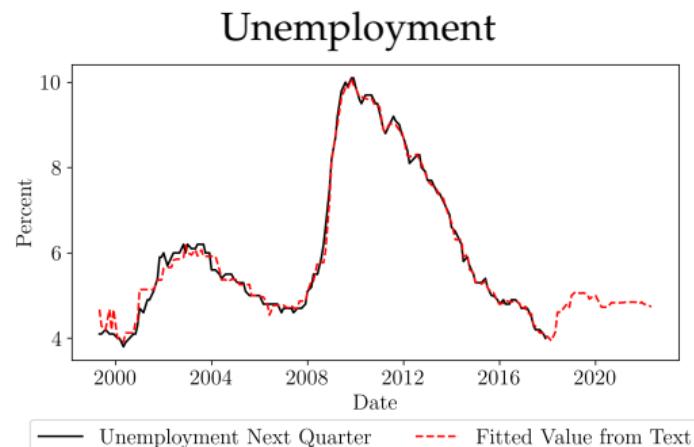
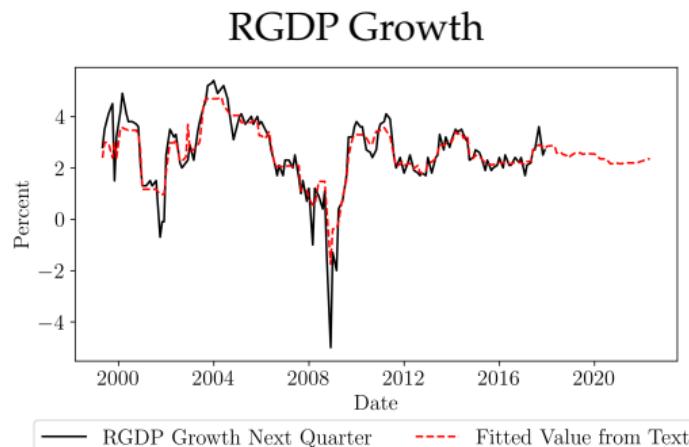
- ▶ Evidence of systematic communication:

- Fitted-values from estimated communication rules ( $\hat{y}$ ) close to actual values ( $y$ )
- True for all variables, except next-quarter headline inflation forecast

$R^2$  More Top Words

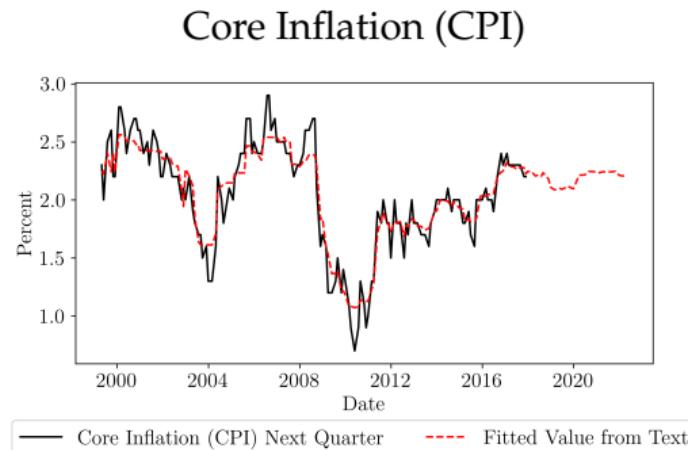
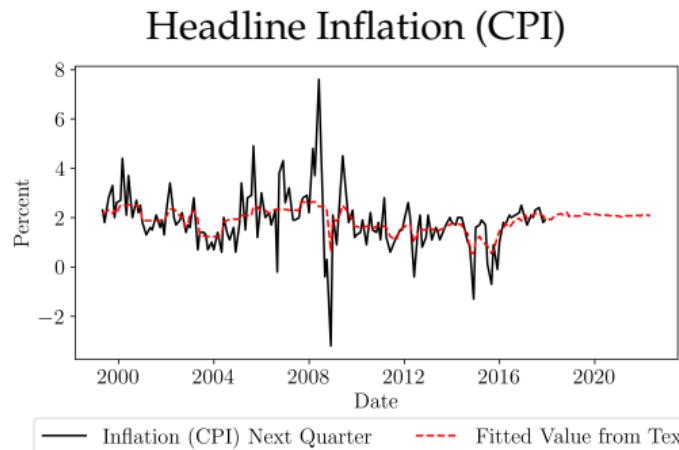
# Fixed Communication Rule - Real Forecasts

- ▶ Greenbook forecast of next quarter
- ▶ Language systematically varies with real forecast

[More](#)

# Fixed Communication Rule - Inflation Forecasts

- ▶ Greenbook forecast of next quarter
- ▶ Headline inflation not communicated systematically



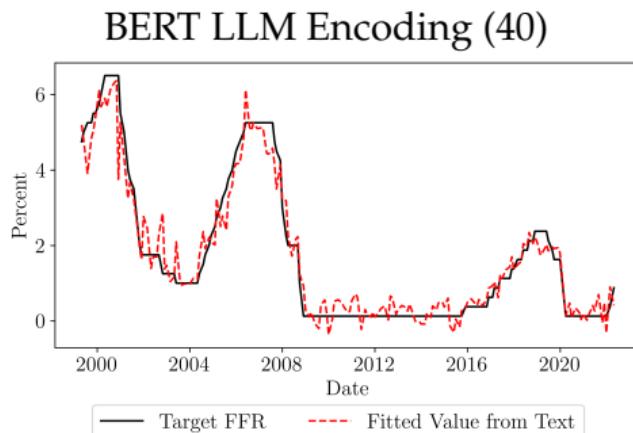
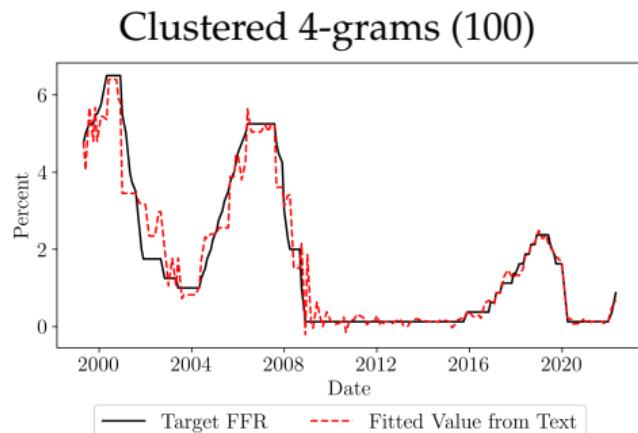
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# Robustness: Alternative Text Representation

- ▶ Estimate fixed rule with lower-dimension text representations

# Robustness: Alternative Text Representation

- ▶ Estimate fixed rule with lower-dimension text representations
- ▶ Still find evidence of systematic communication



Alt. Text Rep

Alt. Real

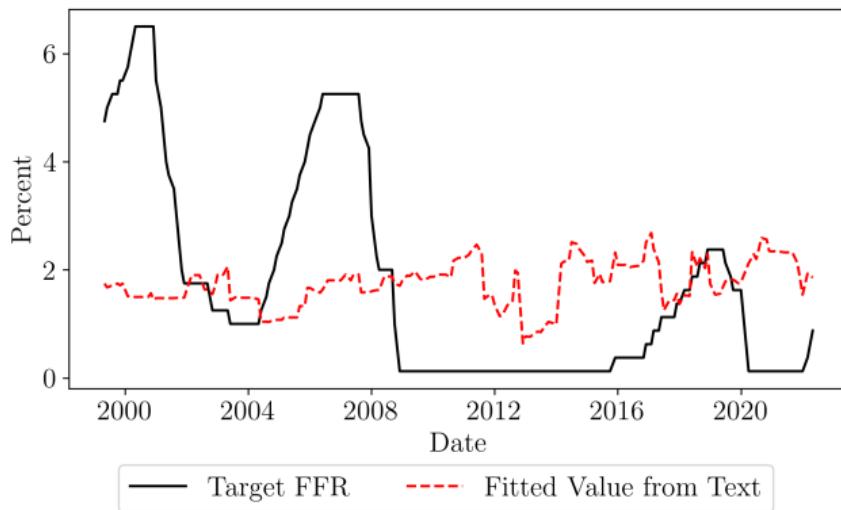
Alt. Inflation

# Robustness: Shuffled Communication Rules

- ▶ Exercise: Shuffle timing of FOMC statements, so no longer match with  $y_t$ 
  - Estimate ridge regressions with mismatched observations

# Robustness: Shuffled Communication Rules

- ▶ Exercise: Shuffle timing of FOMC statements, so no longer match with  $y_t$ 
  - Estimate ridge regressions with mismatched observations



↪ Fitted-values from "shuffled" communication rule do **not** match  $y$

[More](#)[Alt Text Rep](#)

# Monetary Communication in News

[Back](#)

## What to Watch at the Fed's First Meeting of 2023

The central bank is expected to lift interest rates and offer signals about what might come next.



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By Ann Saphir

REVIEW & OUTLOOK

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The central bank signals negative real interest rates throughout 2022.



Markets

### What to Expect From the Fed This Week

Bloomberg reporter, K...

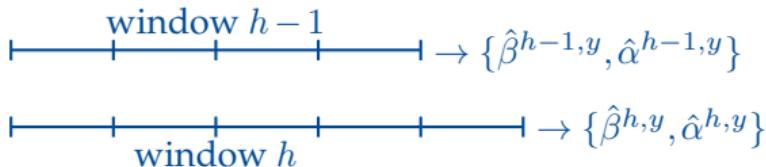
**The Fed Chair's Challenge: Be Clear, but Not Too Certain**

Talking to the former chair Ben Bernanke and others about the task ahead



# Shifts in Communication Rules Over Time

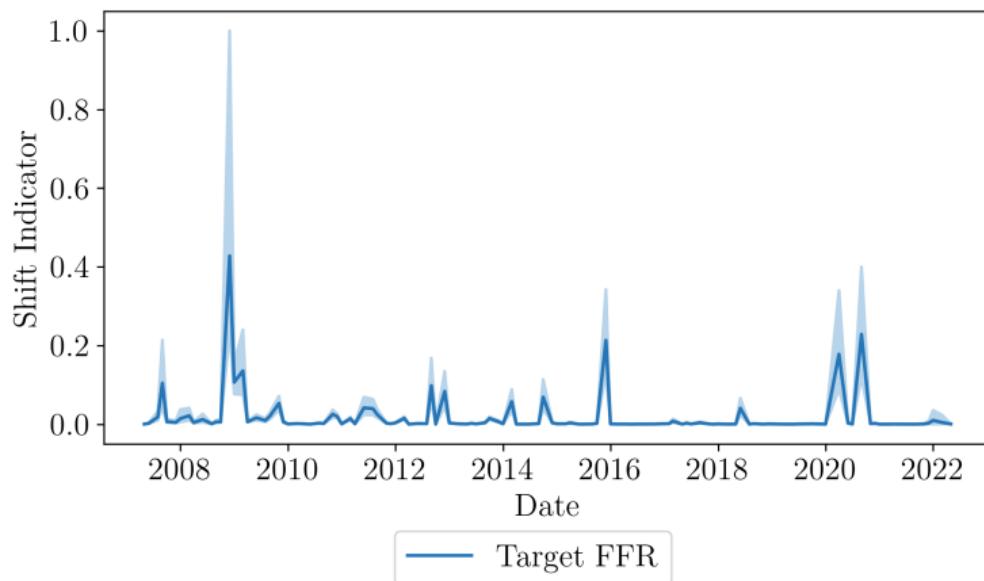
- ▶ Estimate communication rules with an expanding window  $h$ 
  - Different  $\{\beta^{h,y}, \alpha^{h,y}\}$  for each variable  $y$  and each window  $h$
  - First, smallest window = 8 years (64 FOMC meetings)
  
- ▶ Shift in communication rule from window  $h - 1$  to  $h$ 
  - Estimate rules for different windows:



- Produce fitted-values with each rule for same sample  $\rightarrow \hat{y}^{h-1}, \hat{y}^h$

$$\text{Shift Indicator}_h = 1 - \text{Corr}(\hat{y}^{h-1}, \hat{y}^h)$$

# Shift Indicator for Target FFR Communication Rule



- ▶ Spike in indicator → shift in parameters of rule

[Pairwise corr.](#)[Other Shift Indicators](#)[Around ZLB](#)[Alt Text Rep](#)

# Private Sector Beliefs and Communication Rule Changes

- ▶ How do shifts in communication rule relate to private sector beliefs?
  1. Surprise: Abs. value of asset-based monetary surprises (meeting-level)
  2. Disagreement: Forecast dispersion (SPF) on macro variables (quarterly)
- ▶ Shifts in communication rule
  - slightly larger monetary surprises Surprises
  - greater dispersion in professional forecasts Dispersion

# Monetary Surprises and Shifts in Comm. Rules (2007-2022)

- ▶ Monetary surprises: Acosta (2023); Bauer and Swanson (2023); Gürkaynak et al. (2005); Nakamura and Steinsson (2018)

$$|\text{Surprise}|_t = \gamma_0 + \gamma_1 \text{Shift}_t + \gamma_2 |\text{Change Target FFR}|_t + \tau_t + \varepsilon_t$$

	NS Shock	GSS Target	GSS Path	BS Shock
<b>Shift Indicator</b>	0.133** (0.053)	0.046 (0.063)	0.109** (0.046)	0.114** (0.054)
<b>  Change Target FFR  </b>	1.982 (1.195)	4.423*** (1.423)	0.622 (1.037)	1.127 (1.129)
Year FE	Yes	Yes	Yes	Yes
N	118	118	118	100
R <sup>2</sup>	0.392	0.296	0.368	0.318

- ▶ Log transformation, drop 12-2008/1-2009/3-2020

# Forecast Dispersion and Shifts in Comm. Rules (2007-2022)

- Forecast dispersion: IQR of forecasts (quarterly) from SPF

$$\begin{aligned} \text{Dispersion}_q = & \gamma_0 + \gamma_1 \text{Shift}_q + \gamma_2 |\text{Change Target FFR}|_q \\ & + \gamma_3 (\text{Shift}_q \times |\text{Change Target FFR}|_q) + \gamma_4 \text{Dispersion}_{q-1} + \tau_q + \varepsilon_q \end{aligned}$$

Shift Coef ( $\gamma_1$ )	Forecast Horizon				
	(0)	(1)	(2)	(3)	(4)
CPI	0.387**	0.124	0.221***	0.161**	0.131*
Core CPI	0.312***	0.139	0.157*	0.129	0.029
RGDP growth	0.561***	0.51***	0.29***	0.368***	0.317***
Employment	0.737***	0.62***	0.515***	0.559***	0.471***
Housing	0.095	0.439***	0.259*	0.304**	0.277**

- Log transformation, drop Q4-2008/Q1-2009/3-2020

BERT    CPI    Core    RGDP    Emp    Housing

# Conclusion

- ▶ Evidence of systematic Fed communication, *monetary communication rules*
- ▶ First step in measuring systematic communication policy
- ▶ Private sector beliefs are correlated with changes in the communication rule
- ▶ Flexible method to study systematic communication

Other text methods

# Thank You!

# References I

- Acosta, M., 2023. The perceived causes of monetary policy surprises. Working Paper .
- Angeletos, G.M., La’O, J., 2013. Sentiments. *Econometrica* 81, 739–779.
- Angeletos, G.M., Lian, C., 2018. Forward Guidance without Common Knowledge. *American Economic Review* 108, 2477–2512. URL: <https://pubs.aeaweb.org/doi/10.1257/aer.20161996>, doi:10.1257/aer.20161996.
- Angeletos, G.M., Pavan, A., 2007. Efficient use of information and social value of information. *Econometrica* 75, 1103–1142.
- Baker, S.R., Bloom, N., Davis, S., Renault, T., 2021. Twitter-derived measures of economic uncertainty. Technical Report. Stanford University.
- Bassetto, M., 2019. Forward guidance: Communication, commitment, or both? *Journal of Monetary Economics* 108, 69–86. doi:10.1016/j.jmoneco.2019.08.015.
- Bauer, M., Swanson, E., 2023. An Alternative Explanation for the “Fed Information Effect”. *American Economic Review* 113, 664–700.
- Caballero, R.J., Simsek, A., 2022. Monetary policy with opinionated markets. *American Economic Review* 112, 2353–92. URL: <https://www.aeaweb.org/articles?id=10.1257/aer.20210271>, doi:10.1257/aer.20210271.
- Calomiris, C., Harris, J., Mamaysky, H., Tessari, C., 2022. Fed implied market prices and risk premia. NBER Working Paper .
- Campbell, J., Evans, C., Fisher, J., Justiniano, A., 2012. Macroeconomic Effects of Federal Reserve Forward Guidance. *Brookings Papers on Economic Activity* 43, 1–80.
- Cieslak, A., Hansen, S., McMahon, M., Xiao, S., 2021. Policymakers’ uncertainty. Working Paper .
- Crawford, V.P., Sobel, J., 1982. Strategic Information Transmission. *Econometrica* 50, 1431–1451. URL: <http://www.jstor.org.ezp2.lib.umn.edu/stable/1913390>, doi:10.2307/1913390.
- Doh, T., Gruber, J., Song, D., 2022a. Does the state-based forward guidance change the way policymakers talk about the outlook? Technical Report. Federal Reserve Bank of Kansas City.
- Doh, T., Song, D., Yang, S.K., 2022b. Deciphering Federal Reserve Communication via Text Analysis of Alternative FOMC Statements. FRB Kansas City Working Paper .
- Ehrmann, M., Fratzscher, M., 2005. How should central banks communicate? ECB Working Paper .

## References II

- Ehrmann, M., Fratzscher, M., 2007. Communication by central bank committee members: Different strategies, same effectiveness? *Journal of Money, Credit and Banking* 39, 509–541.
- Ericsson, N., 2017. Predicting Fed forecasts. *Journal of Reviews on Global Economics* .
- Ericsson, N.R., 2016. Eliciting GDP forecasts from the FOMC's minutes around the financial crisis. *International Journal of Forecasting* 32, 571–583.
- Farmer, L., Nakamura, E., Steinsson, J., 2023. Learning about the long run. Working Paper .
- Gardner, B., Scotti, C., Vega, C., 2021. Words speak as loudly as actions: Central bank communication and the response of equity prices to macroeconomic announcements. *Journal of Econometrics* 231, 387–409.
- Gáti, L., 2023. Talking over time – dynamic central bank communication. *Journal of Money, Credit and Banking* 55, 1147–1176.
- Gürkaynak, R., Sack, B., Swanson, E., 2005. Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking* 1, 55–93.
- Handlan, A., 2020. Text shock and monetary surprises: Text analysis of fomc statements with machine learning. Working Paper .
- Hansen, S., McMahon, M., Prat, A., 2018. Transparency and deliberation within the fomc: a computational linguistics approach. *The Quarterly Journal of Economics* 133, 801–870.
- Hassan, T., Hollander, S., van Lent, L., Tahoun, A., 2019. Firm-level political risk: Measurement and effects. *The Quarterly Journal of Economics* 134, 2135–2202.
- Herbert, S., 2022. State-dependent Central Bank Communication with Heterogeneous Beliefs. Technical Report. Banque de France.
- Husted, L., Rogers, J., Sun, B., 2020. Monetary Policy Uncertainty. *Journal of Monetary Economics* 115, 20–36.
- Kydland, F.E., Prescott, E.C., 1977. Rules Rather than Discretion: The Inconsistency of Optimal Plans. *Journal of Political Economy* 85, 473–491. URL: <https://www.jstor.org/stable/1830193>.
- Liang, P., Meursault, V., Routledge, B., Scanlon, M., 2022. Pead.txt: Post-earnings announcement drift using text. Working Paper .
- Morris, S., Shin, H.S., 2002. Social value of public information. *American Economic Review* 92, 1521–1534.
- Moscarini, G., 2007. Competence Implies Credibility. *American Economic Review* 97, 37–63. URL: <https://www.aeaweb.org/articles?id=10.1257/aer.97.1.37>, doi:10.1257/aer.97.1.37.

# References III

- Nakamura, E., Steinsson, J., 2018. High-Frequency Identification of Monetary Non-Neutrality: The Information Effect. *Quarterly Journal of Economics* 133, 1283–1330.
- Ou, S., Zhang, D., Zhang, R., 2022. The return of Greenspan: Mumbling with great incoherence. Working Paper .
- Shapiro, A., Wilson, D., 2021. Taking the Fed at its Word: A New Approach to Estimating Central Bank Objectives Using Text Analysis. *Review of Economic Studies* 89, 2768–2805.
- Taylor, J., 1993. Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy* 39, 195–214.

# Taylor (1993)

- ▶ "A policy rule can be implemented and operated more informally by policymakers who recognize the general instrument responses that underlie the policy rule, but who also recognize that operating the rule requires judgment"

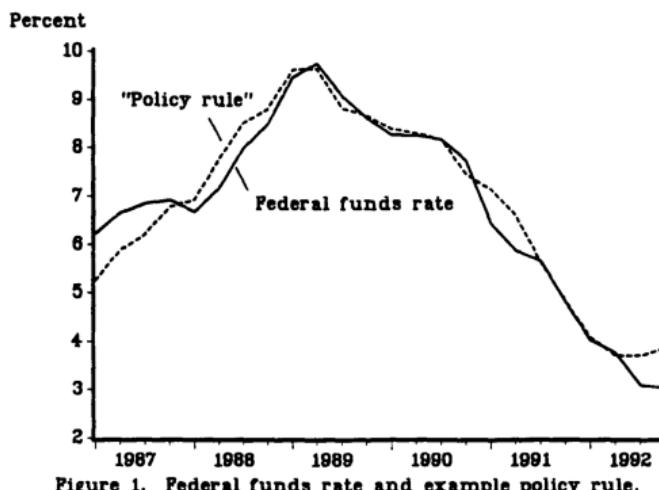
[Back](#)

Figure 1. Federal funds rate and example policy rule.

# Example FOMC Statement (Sept 2006) by Sentence

1. The Federal Open Market Committee decided today to keep its target for the federal funds rate at 5-1/4 percent.
2. The moderation in economic growth appears to be continuing, partly reflecting a cooling of the housing market.
3. Readings on core inflation have been elevated, and the high levels of resource utilization and of the prices of energy and other commodities have the potential to sustain inflation pressures.
4. However, inflation pressures seem likely to moderate over time, reflecting reduced impetus from energy prices, contained inflation expectations, and the cumulative effects of monetary policy actions and other factors restraining aggregate demand.
5. Nonetheless, the Committee judges that some inflation risks remain.
6. The extent and timing of any additional firming that may be needed to address these risks will depend on the evolution of the outlook for both inflation and economic growth, as implied by incoming information.

[Back-Intro](#)[Back-Data](#)

# FOMC Statement (June 2022) - Part 1

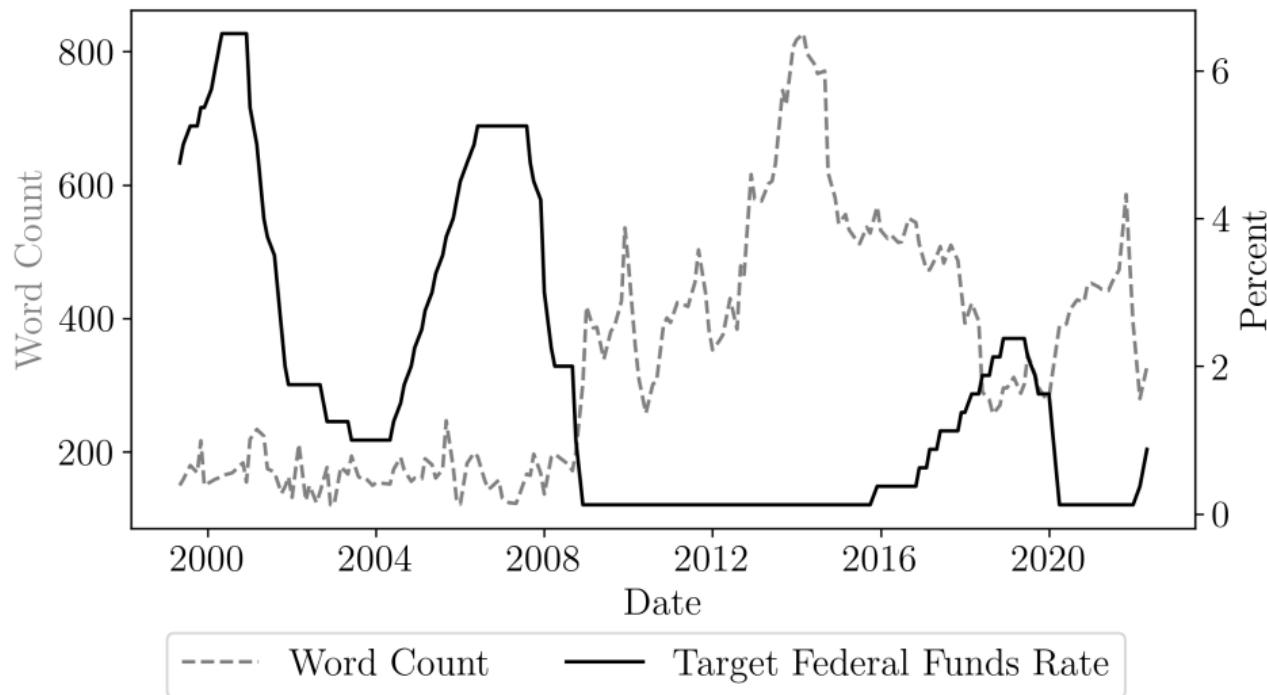
- ▶ Overall economic activity appears to have picked up after edging down in the first quarter. Job gains have been robust in recent months, and the unemployment rate has remained low. Inflation remains elevated, reflecting supply and demand imbalances related to the pandemic, higher energy prices, and broader price pressures.
  
- ▶ The invasion of Ukraine by Russia is causing tremendous human and economic hardship. The invasion and related events are creating additional upward pressure on inflation and are weighing on global economic activity. In addition, COVID-related lockdowns in China are likely to exacerbate supply chain disruptions. The Committee is highly attentive to inflation risks.

## FOMC Statement (June 2022) - Part 2

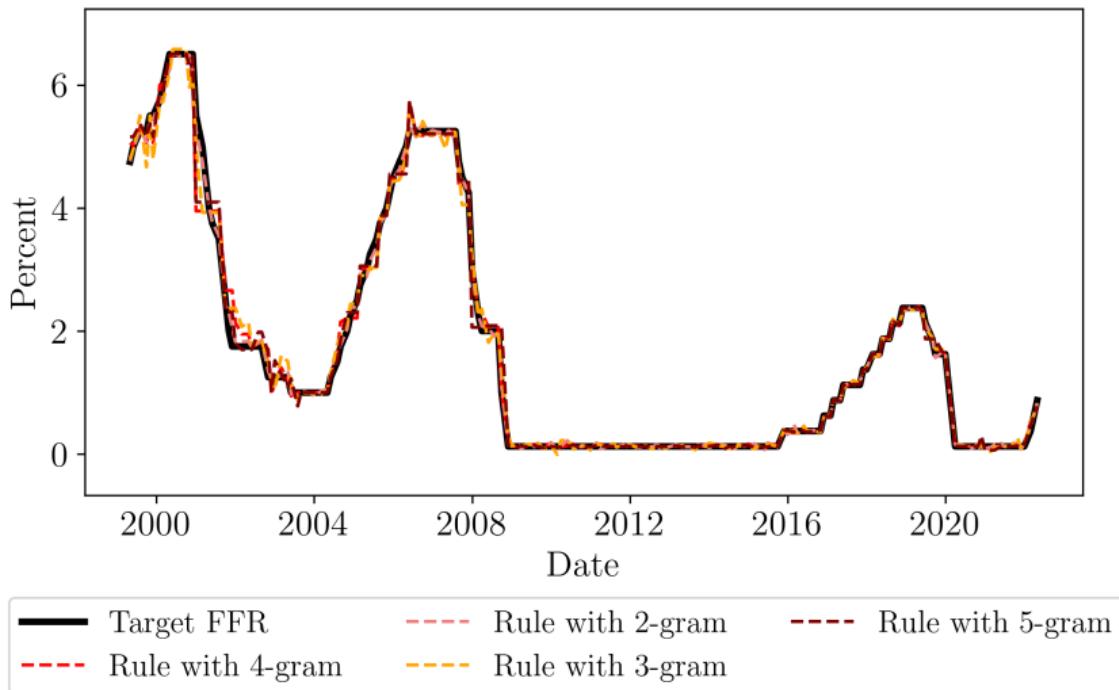
- ▶ The Committee seeks to achieve maximum employment and inflation at the rate of 2 percent over the longer run. In support of these goals, the Committee decided to raise the target range for the federal funds rate to 1-1/2 to 1-3/4 percent and anticipates that ongoing increases in the target range will be appropriate. In addition, the Committee will continue reducing its holdings of Treasury securities and agency debt and agency mortgage-backed securities, as described in the Plans for Reducing the Size of the Federal Reserve's Balance Sheet that were issued in May. The Committee is strongly committed to returning inflation to its 2 percent objective.
  
- ▶ In assessing the appropriate stance of monetary policy, the Committee will continue to monitor the implications of incoming information for the economic outlook. The Committee would be prepared to adjust the stance of monetary policy as appropriate if risks emerge that could impede the attainment of the Committee's goals. The Committee's assessments will take into account a wide range of information, including readings on public health, labor market conditions, inflation pressures and inflation expectations, and financial and international developments.

[Back-Intro](#)[Back-Data](#)

# Text and Rates have Different Variation

[Back](#)

# N-gram Comparison

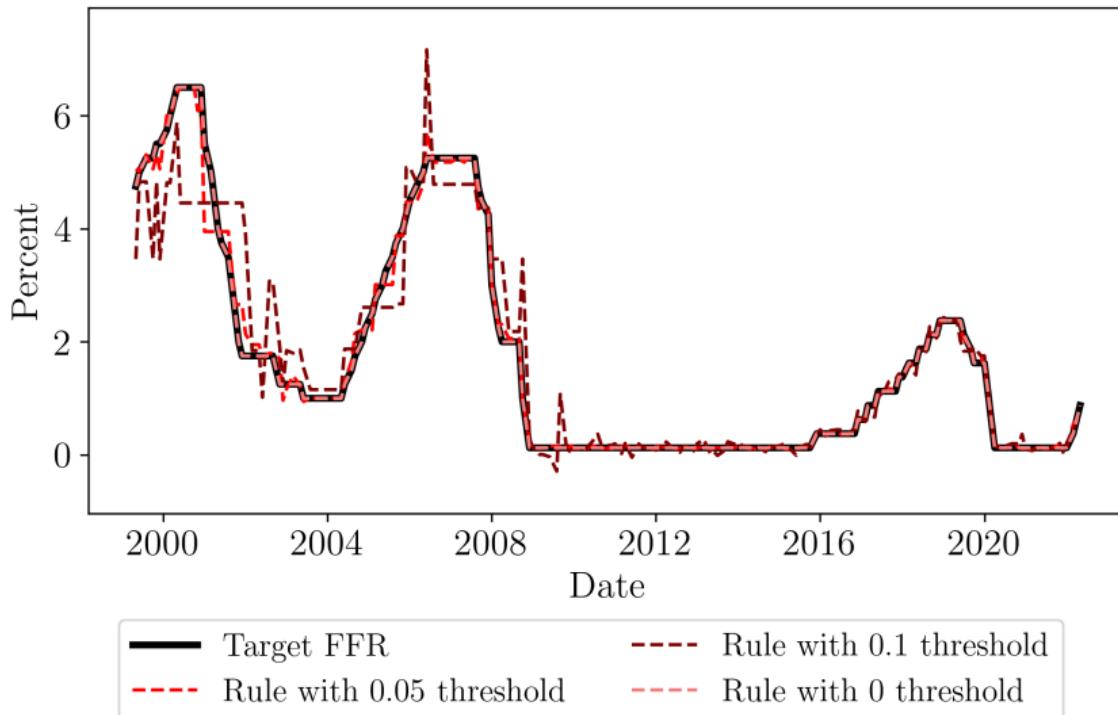
[Back](#)

# N-grams and Text Distribution

N-gram	(Baseline)			
	4	2	3	5
Threshold	0.05	0.05	0.05	0.05
Number of N-grams	748	817	795	695
Mimimum Appearance of N-gram	10	10	10	10
Number of Empty Documents	3	0	2	4

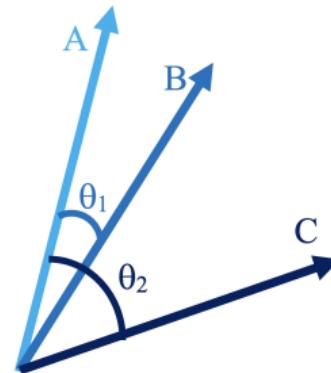
[Back](#)

# Threshold Comparison



# Clustering 4-grams

- ▶ Encode 4-grams with LLM Bert (embedding vector)
  - Allows for means to compare 4-grams
  - More similar 4-grams; more similar vectors
- ▶ Measure pairwise cosine similarity between all 4-gram embeddings

[Back](#)

# Clustering 4-grams

4-gram	Cluster ID
important ongoing support economic	0
measure support economy flow	0
ongoing support economic activity	0
policy measure support economy	0
provide important ongoing support	0
provide ongoing support economic	0
tool support us economy	0
decline toward level judge	1
level help maintain accommodative	1
level judge consistent dual	1
move toward level judge	1
sizable level help maintain	1
toward level judge consistent	1

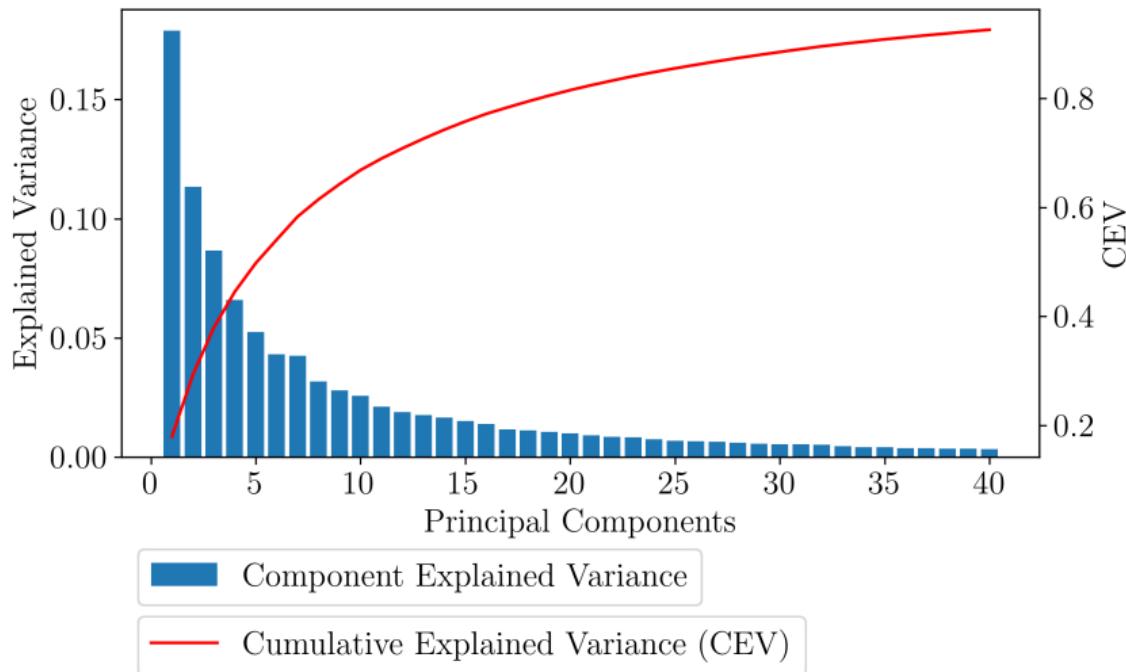
[Back](#)

# BERT Application

- ▶ BERT is a general, LLM to encode English text numerically
- ▶ Encoded vectors capture “context” with 768 dimensions
- ▶ Specific domain → some unnecessary dimensions
  - General model differentiates extremely varied texts
  - Comparing only FOMC statements, need fewer dimensions
- ▶ Apply PCA to the embeddings → 40 components  $\approx 93\%$  variation

[Back](#)

# BERT Embeddings and PCA

[Back](#)

## Assumption 1. Sub-messages

Messages are made of sub-messages for each variable  $y \in Y$ .

$$m_t = \bigcup_{y \in Y} m_t^y$$

Back

## Assumption 2. Linear Combo

Sub-message on  $y$  is a linear combination of 4-grams.

$$m_t^y = \sum_j \beta_j^y w_{j,t}.$$

Back

## Assumption 3. Mean truthtelling

We assume that the Fed chooses  $m_t^y$  such that on average

$$m_t^y = y.$$

for each variable  $y \in Y$ .

Back

## Assumption 4. Fixed coefficients

$$\hat{\beta}_{ridge}^{h,y} = \underset{\beta}{\operatorname{argmin}} \sum_t (y_t - \sum_j \beta_j^{h,y} w_{j,t})^2 + \alpha^{h,y} \sum_j (\beta_j^{h,y})^2$$

For each window,  $h$ , assume communication rule coefficients  $\hat{\beta}_{ridge}^{h,y}$  are stable.

[Back](#)

# The Set of Macro Variables

A macro variable  $y \in Y$  denotes  $y_{t+k}$ , where

- ▶  $k = 0 \rightarrow$  realized contemporaneous variable:
  - Target Fed funds rate, change in FFR, target FFR next year
  - Total assets, shadow rate, 10Y Treasury - FFR
- ▶  $k > 0 \rightarrow k$ -quarter-ahead forecasts:
  - Fed expectation of real GDP growth, unemployment, headline and core inflation  $k$  quarters ahead
  - Next quarter ( $k = 1$ ) and next year ( $k = 4$ )

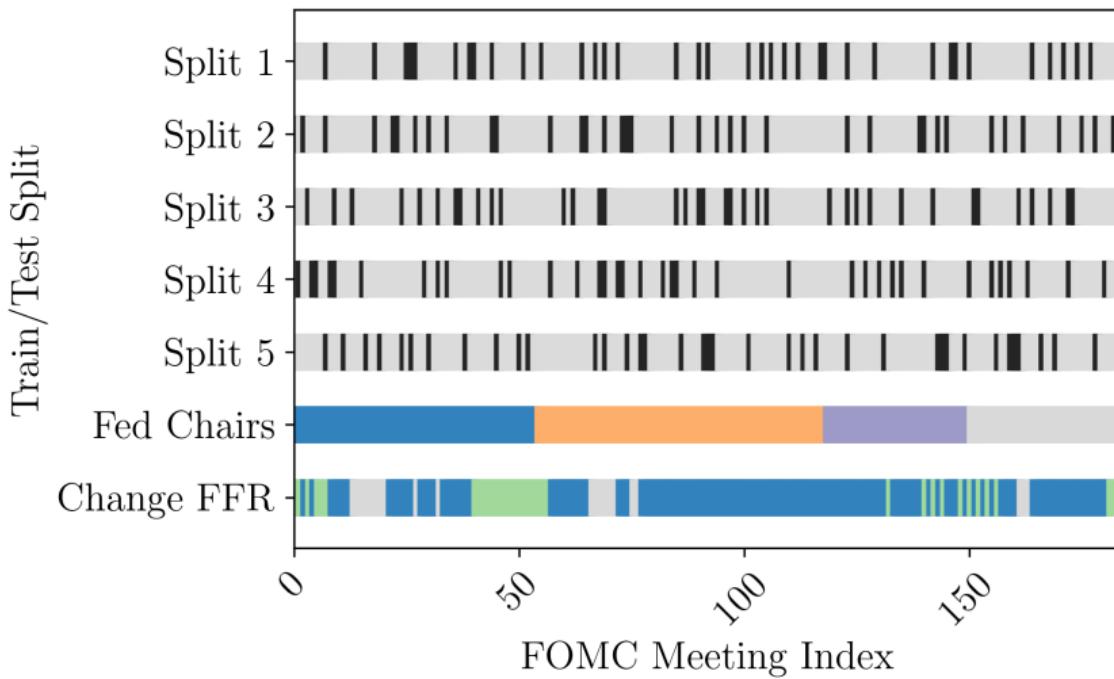
Back

# Stratified K-Fold Cross-Validation

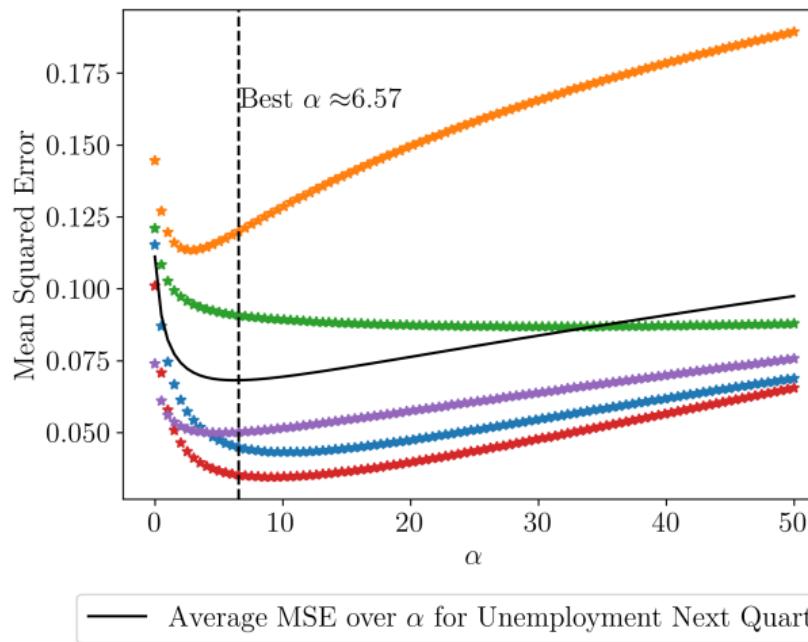
1. 5 subsamples (folds)
  - Stratified → Fed chair and rate change
  - Five iterations where use 4 folds training (in-sample), 1 for validation (out-of-sample)
2. Create a grid for  $\alpha$ , and for each  $\alpha_i$  on the grid, estimate  $\beta$  and choose the  $\alpha$  that minimizes some measure of out-of-sample error (MSE).
3. Do this for each configuration of training and validation samples.
4. Take average across the configurations.
5. "One-standard-error" rule:  $\alpha$  that generates MSE one-SE above min.  $\rightarrow \alpha^*$
6. Estimate  $\beta^{ridge}$  for that  $\alpha^*$ .

[Back](#)

# Stratified K-Folds

[Back](#)

# Select Optimal Penalty Parameter $\alpha$

[Back](#)

# Out-of-sample Accuracy

- ▶ Split data into 5 subsamples → Stratified splits by Fed chair and rate change
- ▶ Produces 5 opportunities for evaluation:
  - Estimate regression on 4 subsamples as the “in-sample”
  - Remaining subsample not used in estimation, used as “out-of-sample”
  - Rotate the fold used as out-of-sample
- ▶ Below is average accuracy for target FFR communication rule

Averages	In-sample	Out-of-sample
$R^2$	0.99	0.96
$MSE$	0.05	0.12

[Back](#)

# Other Fixed Rules

## ► Policy variables

- Change in contemporaneous target FFR
- Target FFR one year ahead
- Shadow rate
- Total assets
- 10Y Treasury - FFR

Change FFR

FFR Next Year

Shadow Rate

Total Assets

10Y Treasury - FFR

## ► Macro variables

- Real GDP growth next quarter
- Real GDP growth next year
- Unemployment next quarter
- Unemployment next year
- CPI inflation (headline) next quarter
- CPI inflation (headline) next year

Real GDP Next Quarter

Real GDP Next Year

Unemployment Next Quarter

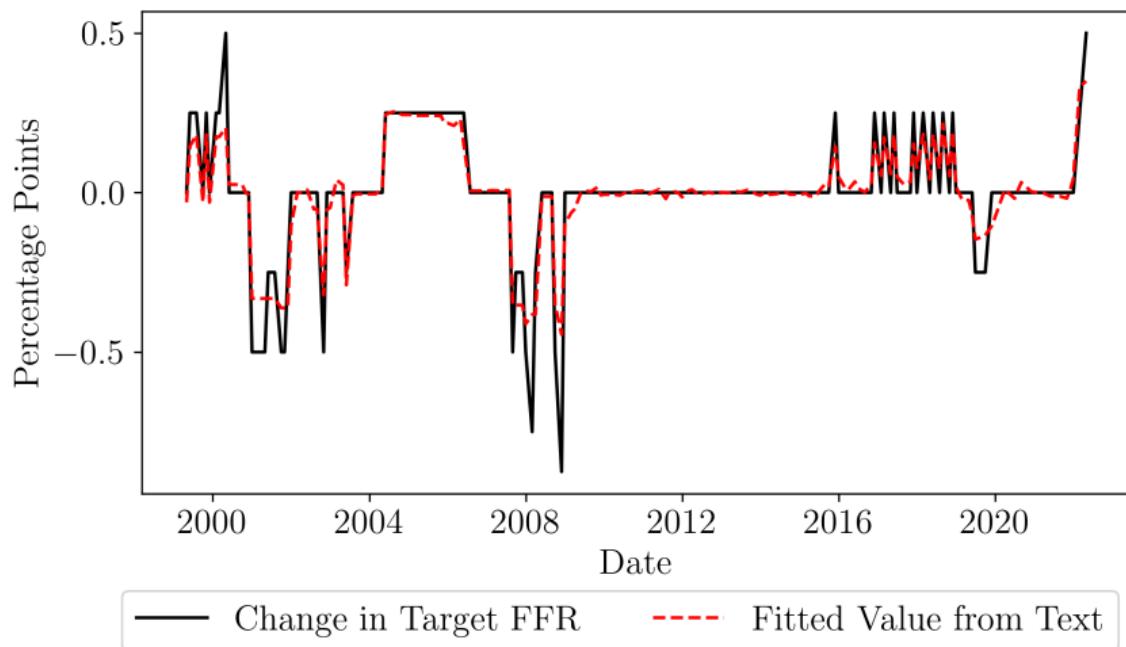
Unemployment Next Year

Inflation (Headline) Next Quarter

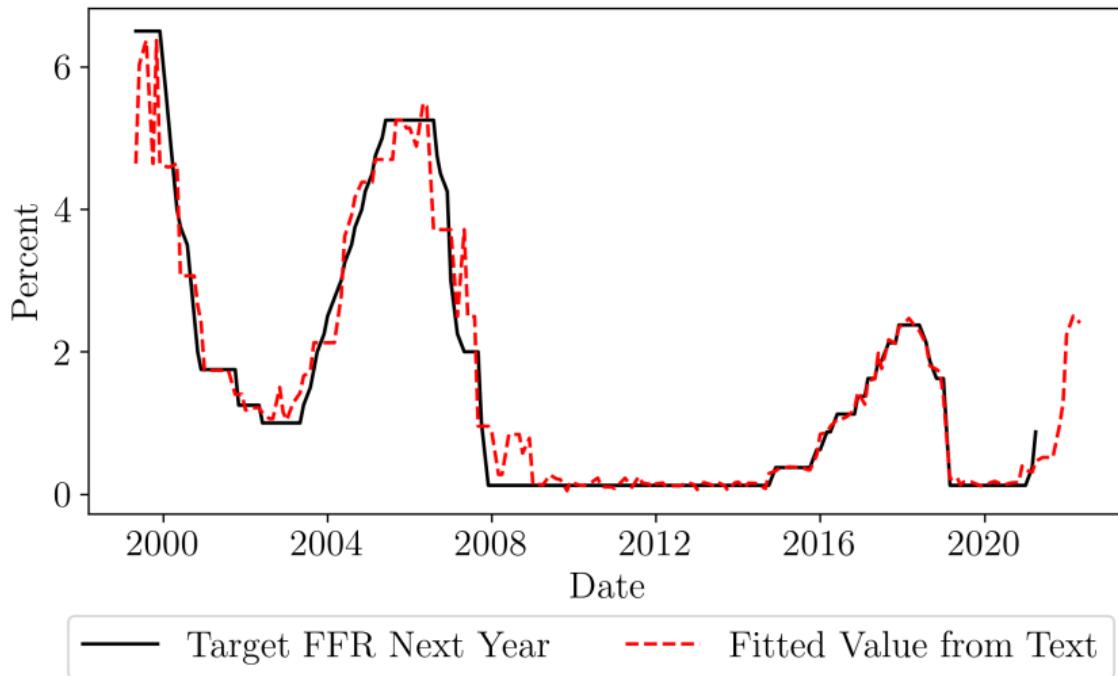
Inflation (Headline) Next Year

Back

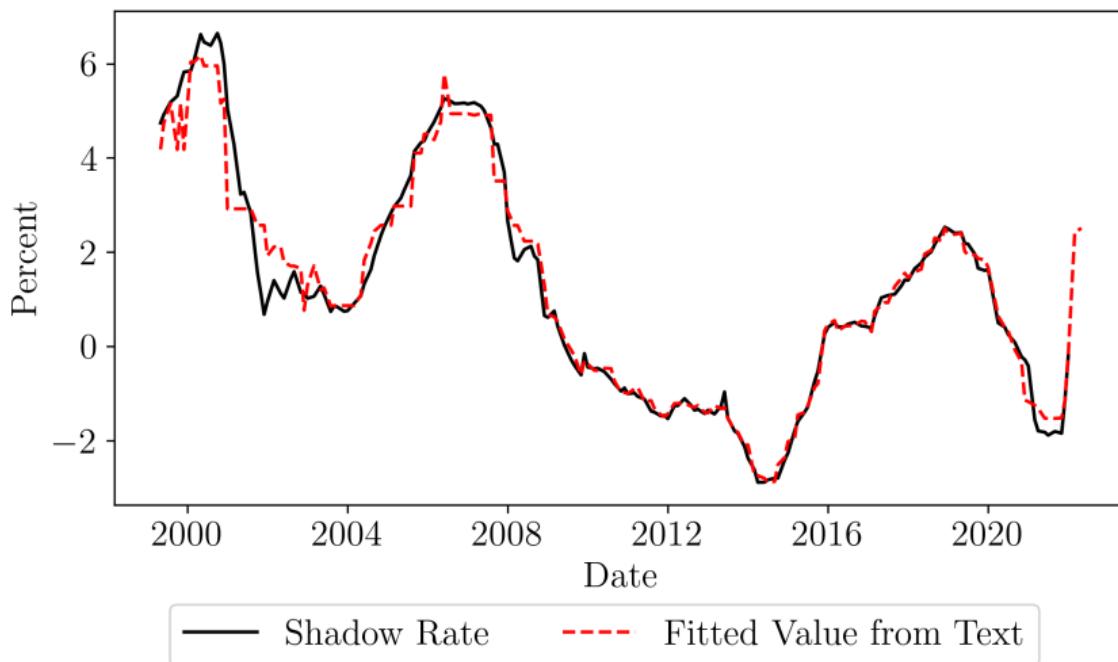
# Change in FFR

[Back](#)

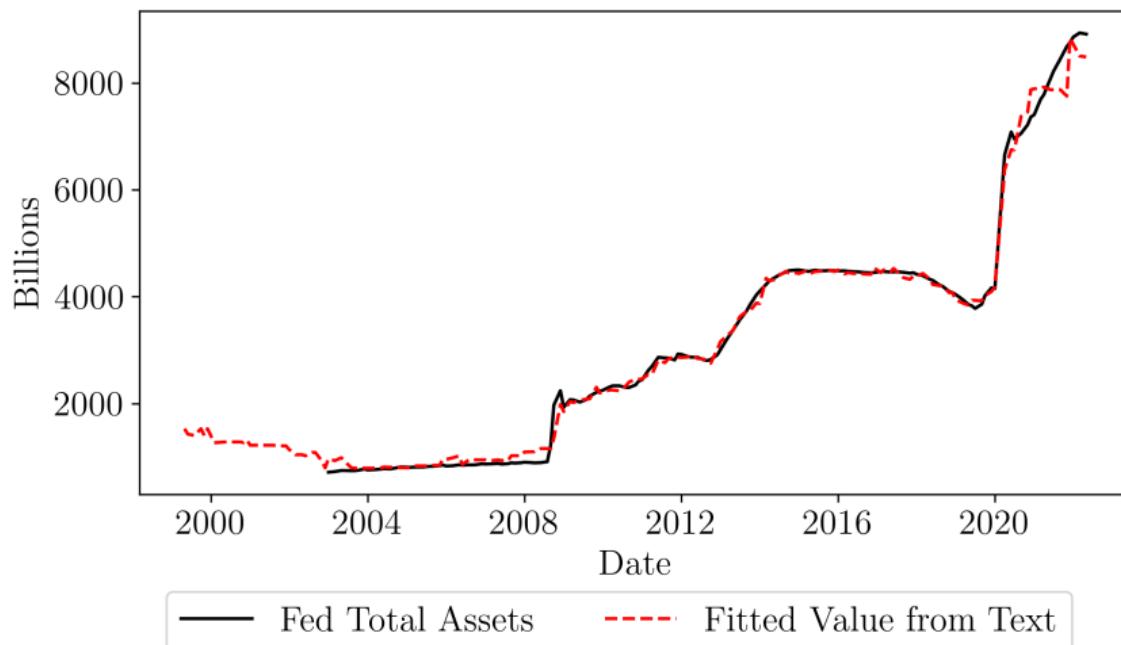
# Target FFR Next Year

[Back](#)

# Shadow Rate

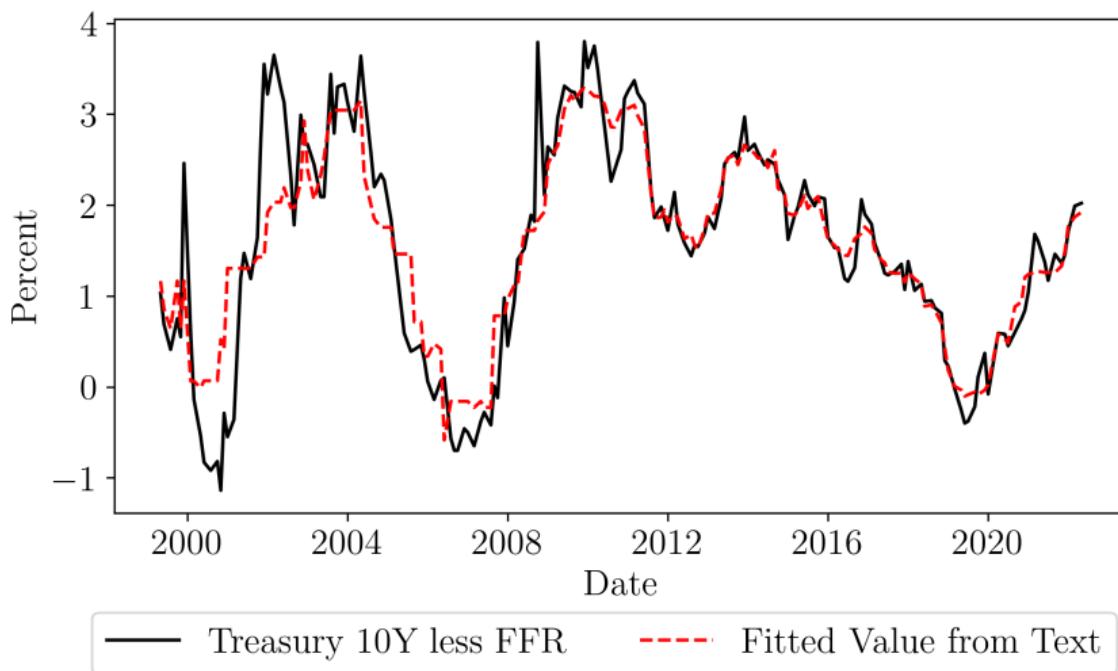
[Back](#)

# Total Assets

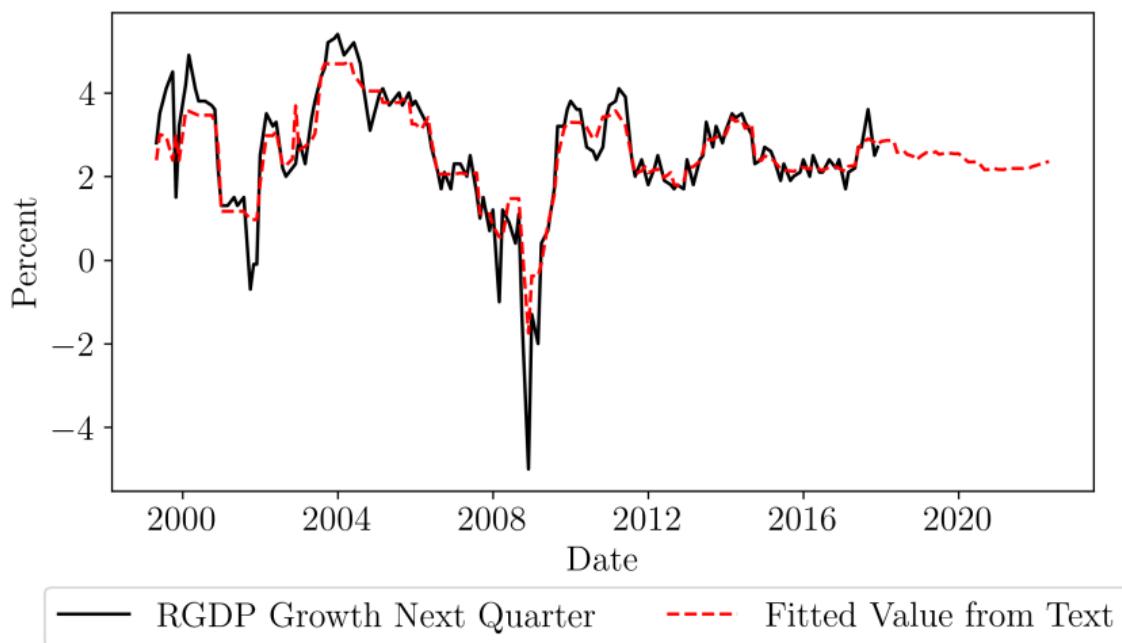


Back

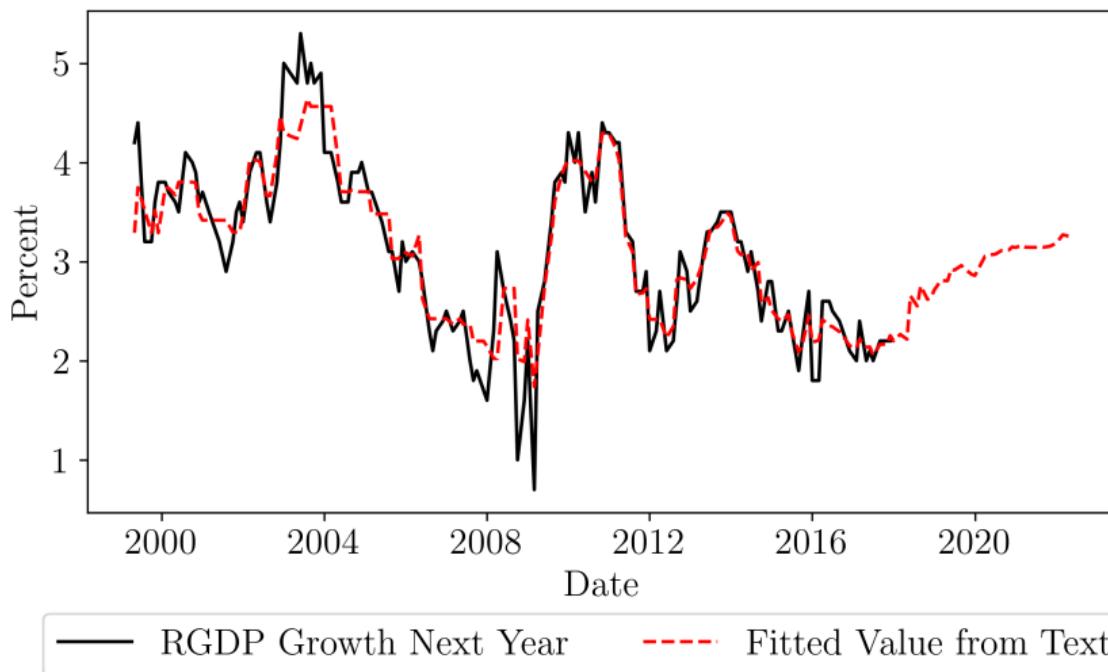
# 10Y Treasury - FFR

[Back](#)

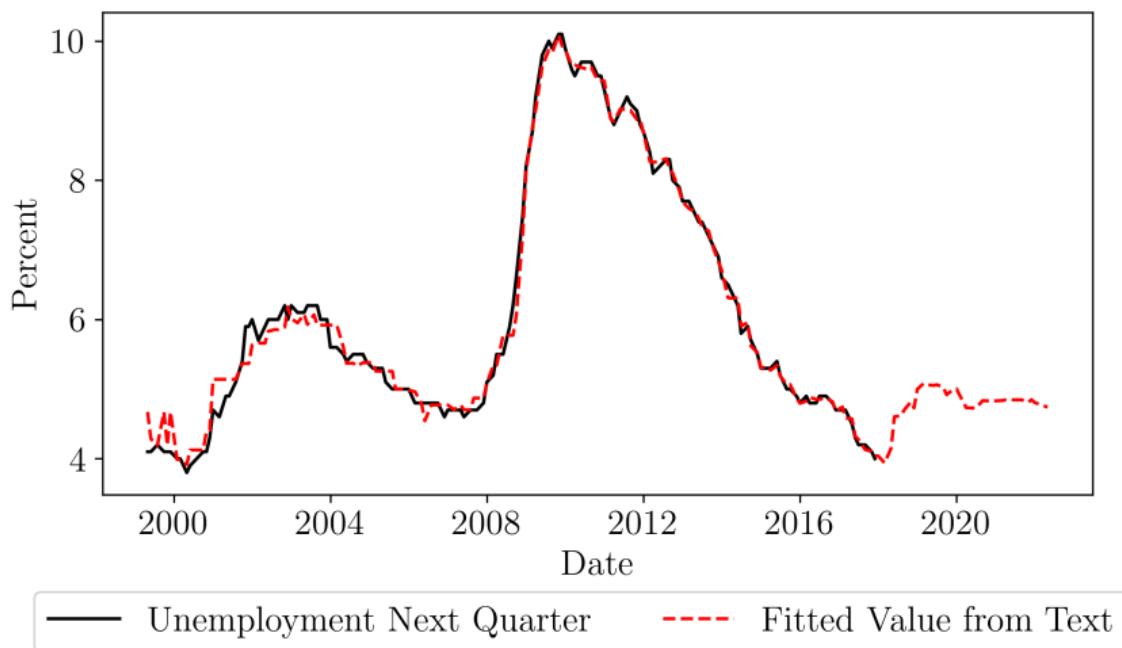
# Real GDP Growth Next Quarter

[Back](#)

# Real GDP Growth Next Year

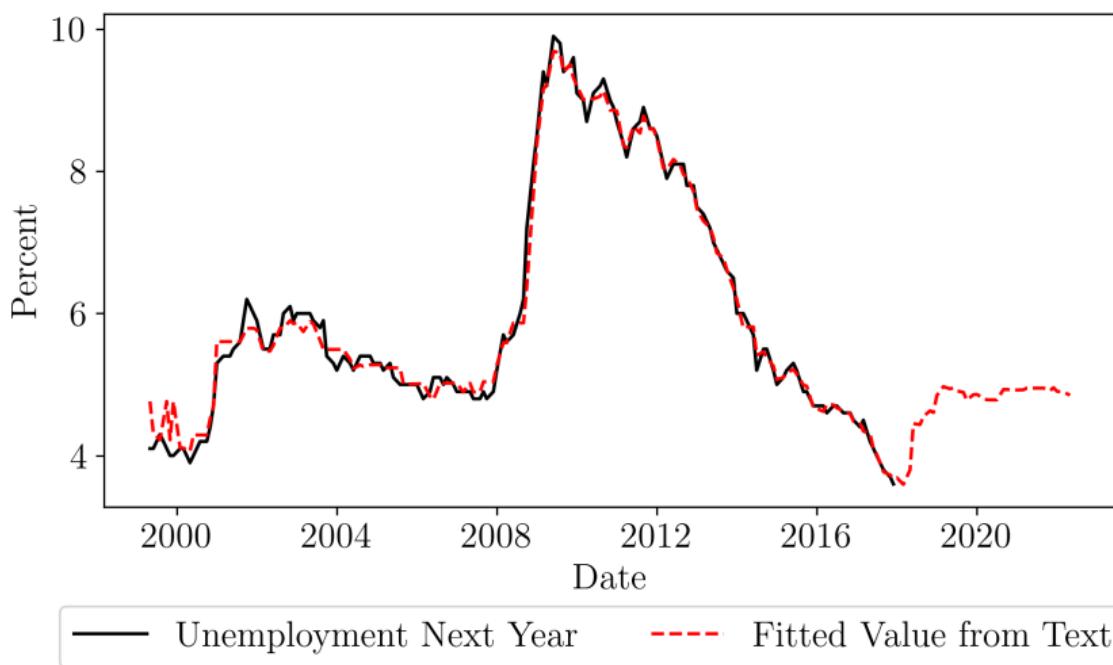
[Back](#)

# Unemployment Next Quarter

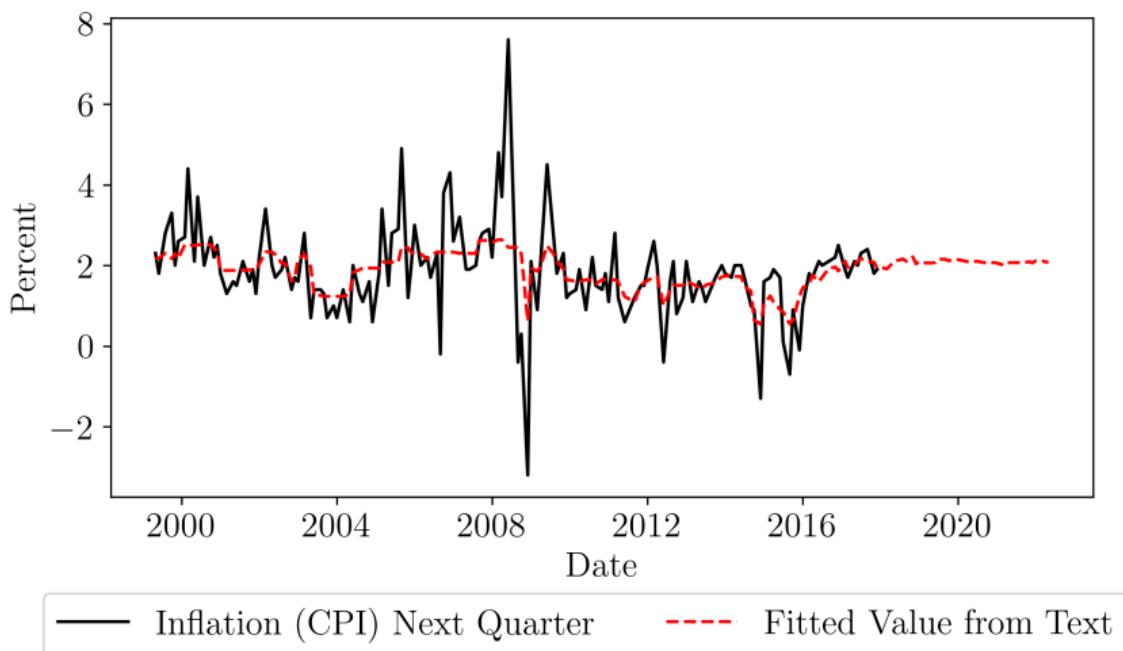


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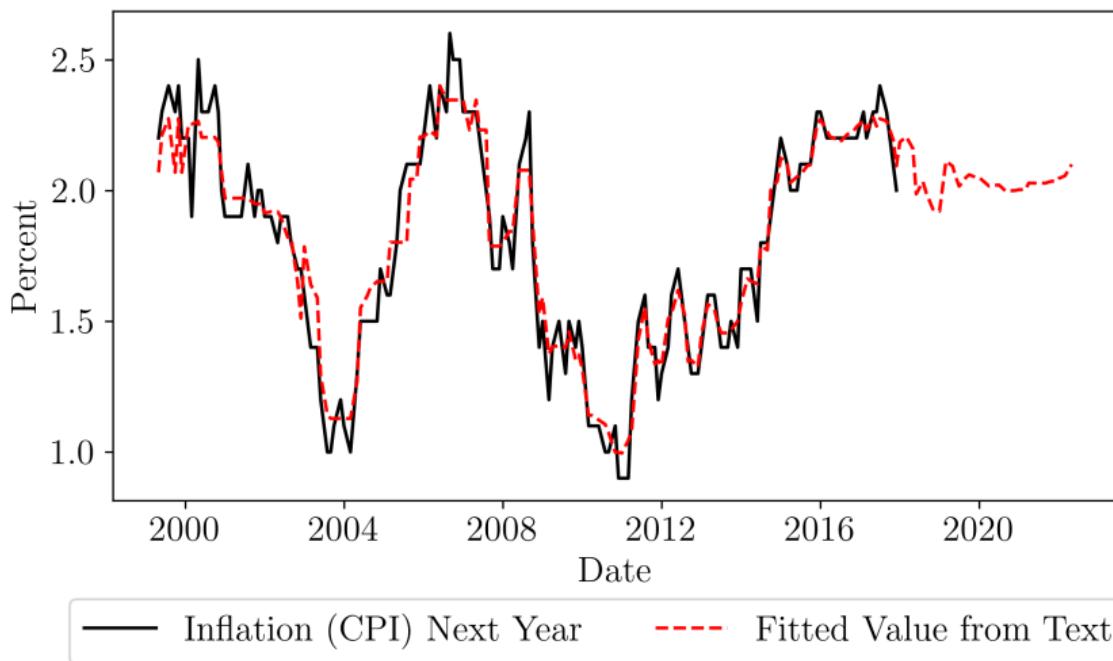
# Unemployment Next Year

[Back](#)

# CPI Inflation (Headline) Next Quarter

[Back](#)

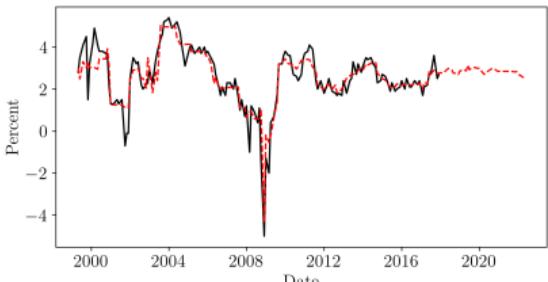
# CPI Inflation (Headline) Next Year

[Back](#)

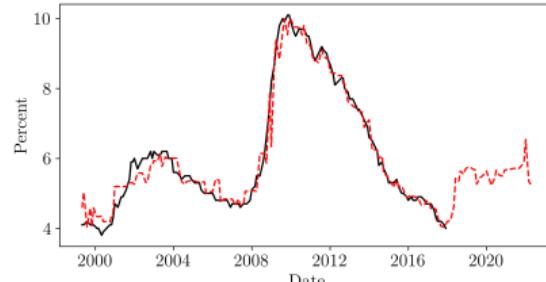
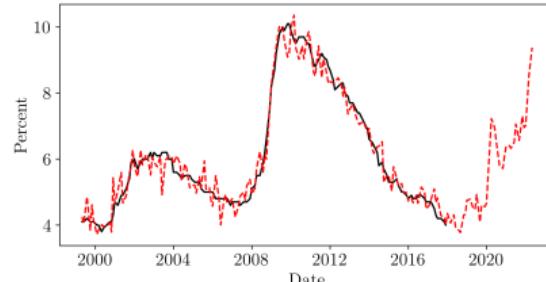
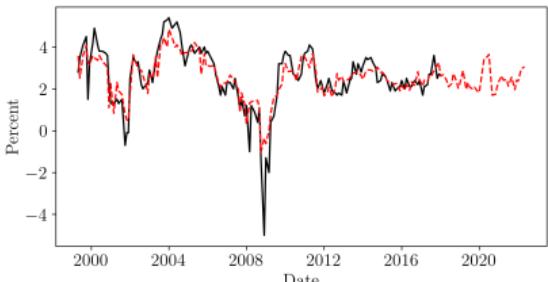
# Real Forecasts - Alternative Text Rep.

[Back](#)

## RGDP Growth



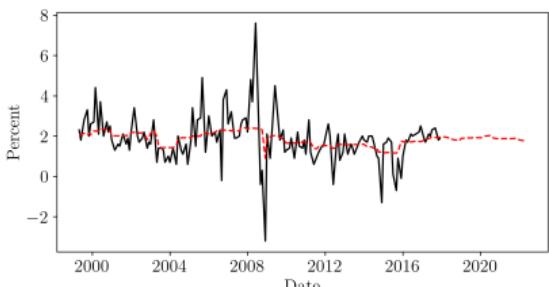
## Unemployment

**Cluster****BERT**

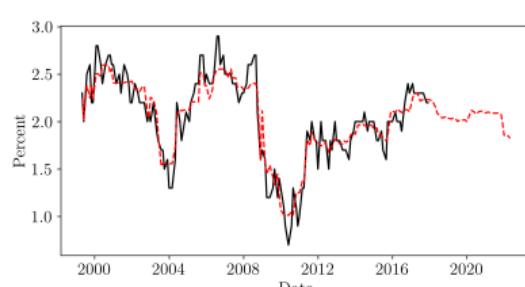
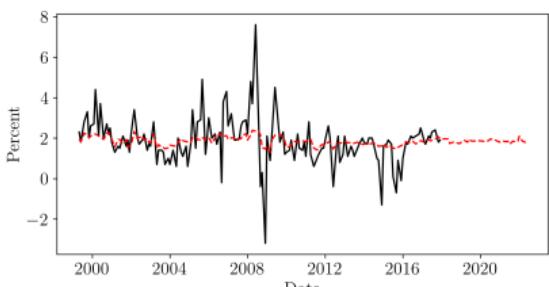
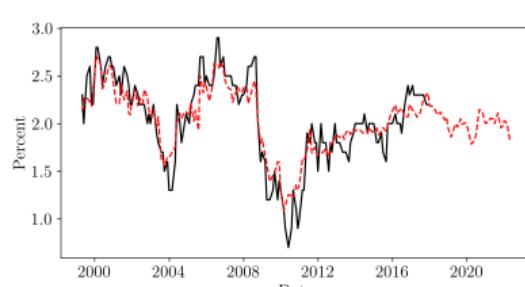
# Inflation Forecasts - Alternative Text Rep.

[Back](#)

## Headline Inflation (CPI)



## Core Inflation (CPI)

**Cluster****BERT**

# Top Words for Target Rate and Fixed Rule

	Higher Target FFR	$\beta_j$	Lower Target FFR	$\beta_j$
1	provide ongoing support economic	0.20	achieve decide keep target	-0.59
2	condition generate economic weakness	0.20	long_run goal maximum employment	-0.38
3	continue monitor economic outlook	0.15	after action stance monetary_policy	-0.26
4	only gradual increase fundsrate	0.15	achieve inflation moderately above	-0.19
5	risk weight mainly toward	0.11	progress toward maximum employment	-0.19
6	long-run inflation expectation continue	0.08	fundsrate bp related action	-0.19
7	stance monetary_policy economic activity	0.05	near mandate consistent level	-0.16
8	include low rate resource	0.05	economic outlook inform incoming	-0.16
9	stance monetary_policy remain appropriate	0.04	fundsrate likely remain time	-0.16
10	likely measure nonetheless respond	0.04	fundsrate bp believe even	-0.16
11	lower target fundsrate bp	0.04	expect toward objective maximum	-0.16
12	decide keep target range	0.04	target fundsrate bp related	-0.16
13	inflation carefully monitor actual	0.04	employment inflation assessment take	-0.15
14	moderate pace labor indicator	0.04	energy import price dissipate	-0.11
15	carefully monitor actual expect	0.04	financial condition remain accommodative	-0.11

[Back](#)

# Other Shuffled Rules

## ► Policy variables

- Change in contemporaneous target FFR
- Target FFR one year ahead
- Shadow rate
- Total assets
- 10Y Treasury - FFR

Change FFR

FFR Next Year

Shadow Rate

Total Assets

10Y Treasury - FFR

## ► Macro variables

- Real GDP growth next quarter
- Real GDP growth next year
- Unemployment next quarter
- Unemployment next year
- CPI inflation (headline) next quarter
- CPI inflation (headline) next year

Real GDP Next Quarter

Real GDP Next Year

Unemployment Next Quarter

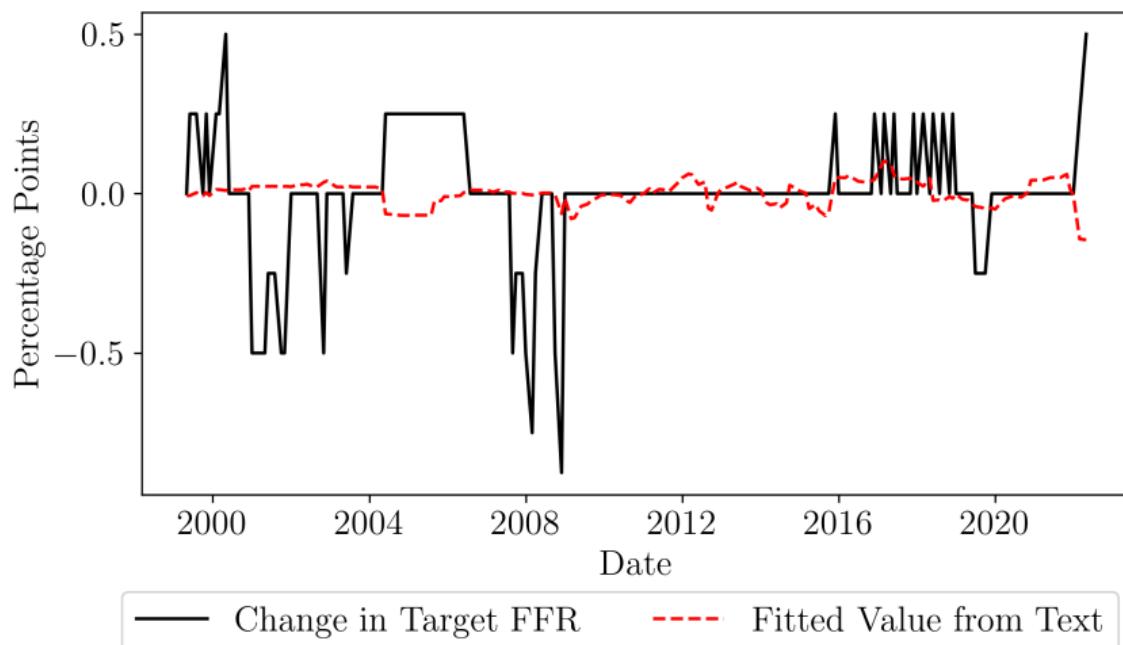
Unemployment Next Year

Inflation (Headline) Next Quarter

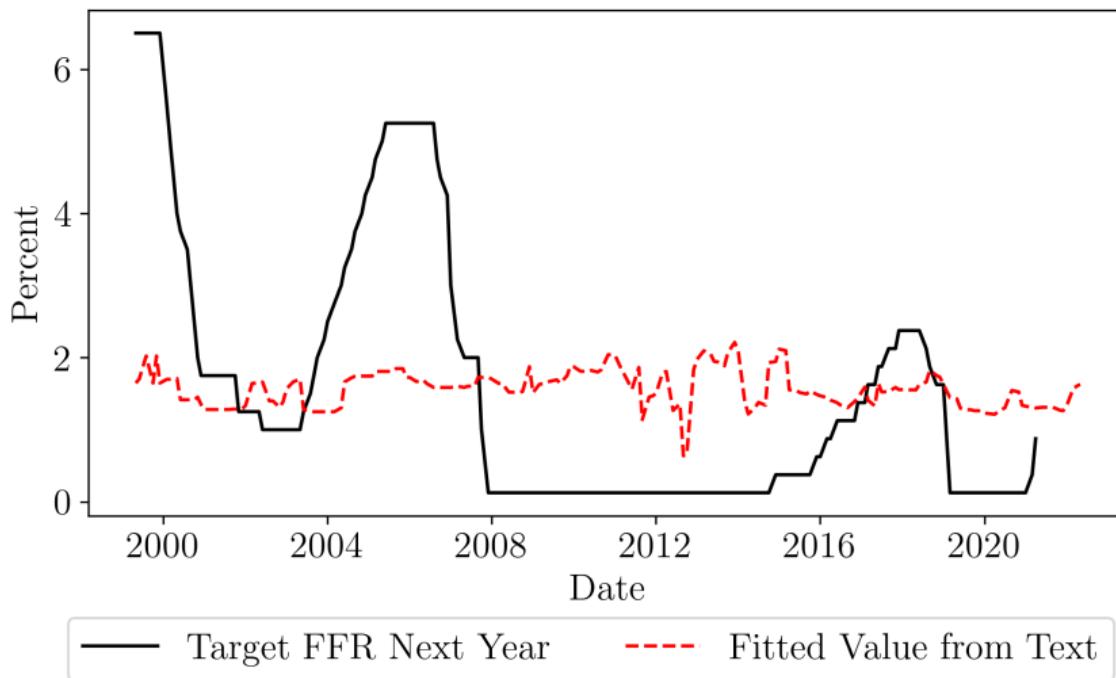
Inflation (Headline) Next Year

Back

# Shuffle: Change in FFR

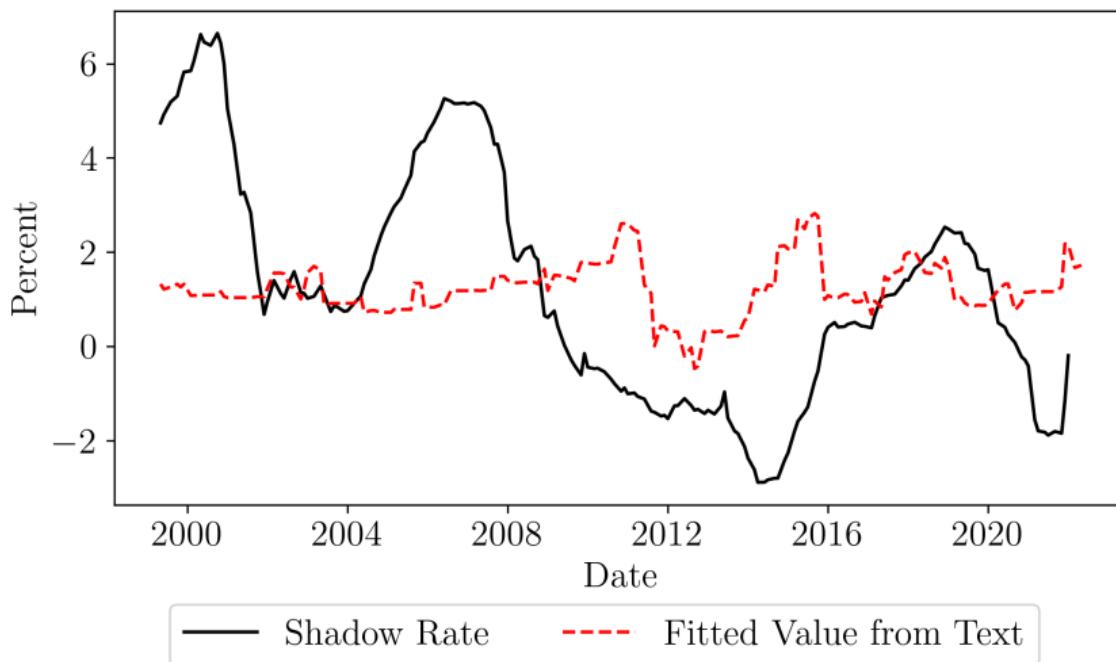
[Back](#)

# Shuffle: Target FFR Next Year

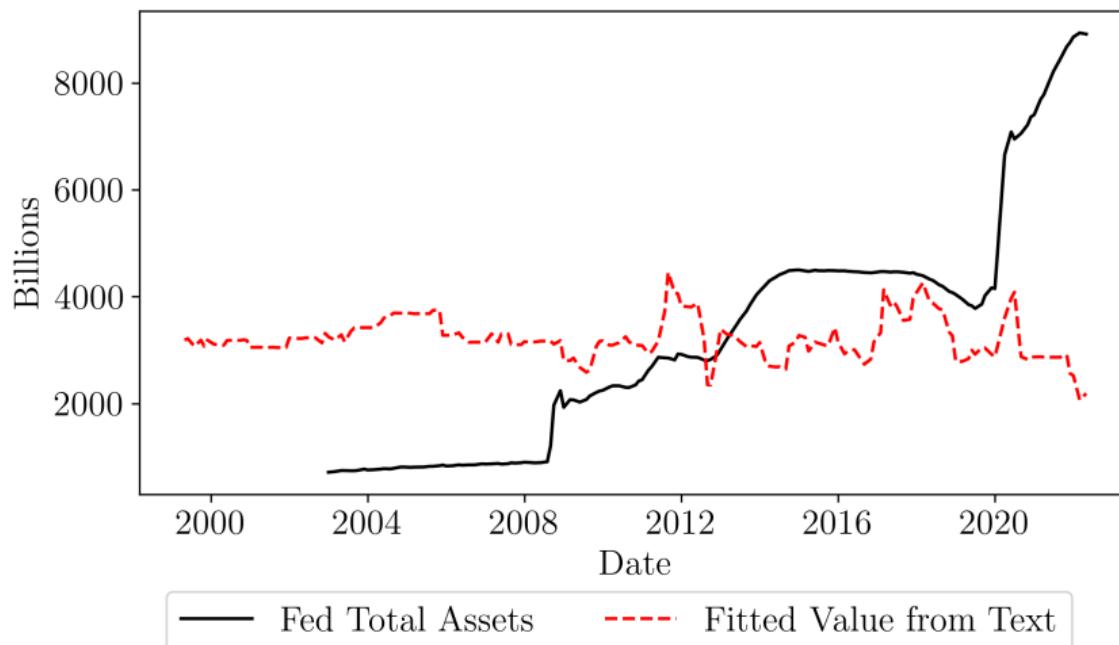


Back

# Shuffle: Shadow Rate

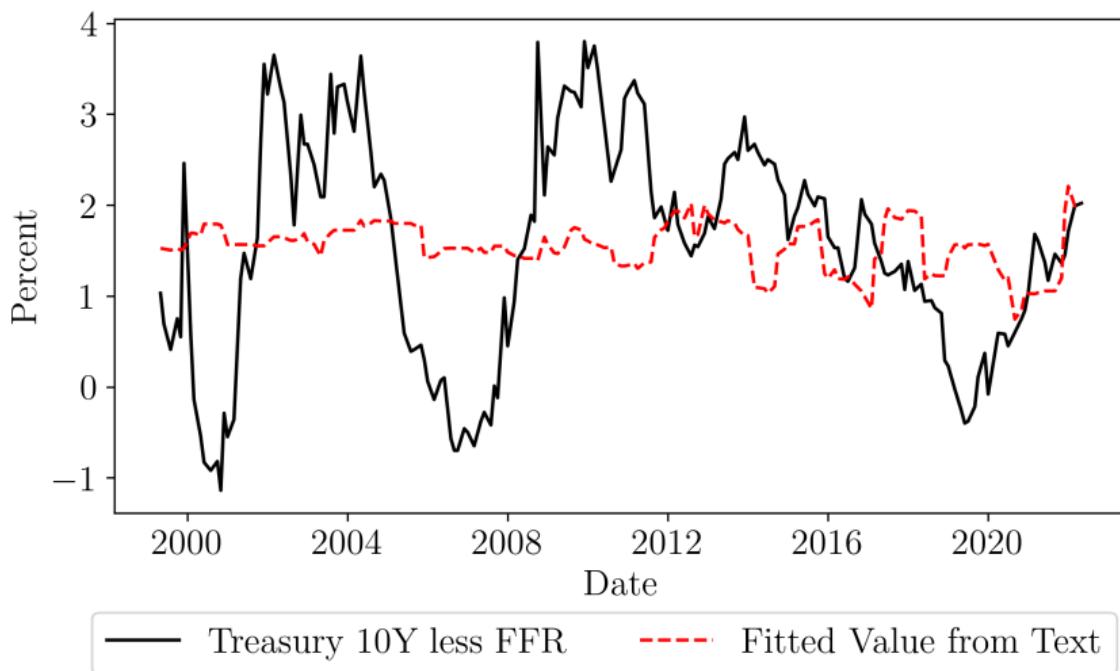
[Back](#)

# Shuffle: Total Assets

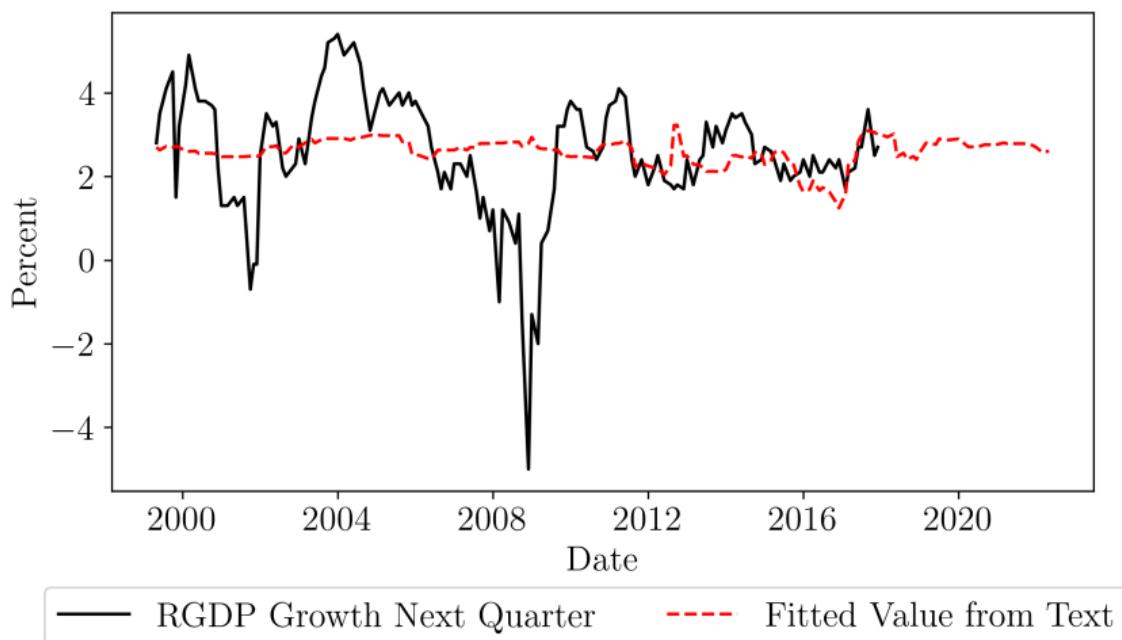


Back

# Shuffle: 10Y Treasury - FFR

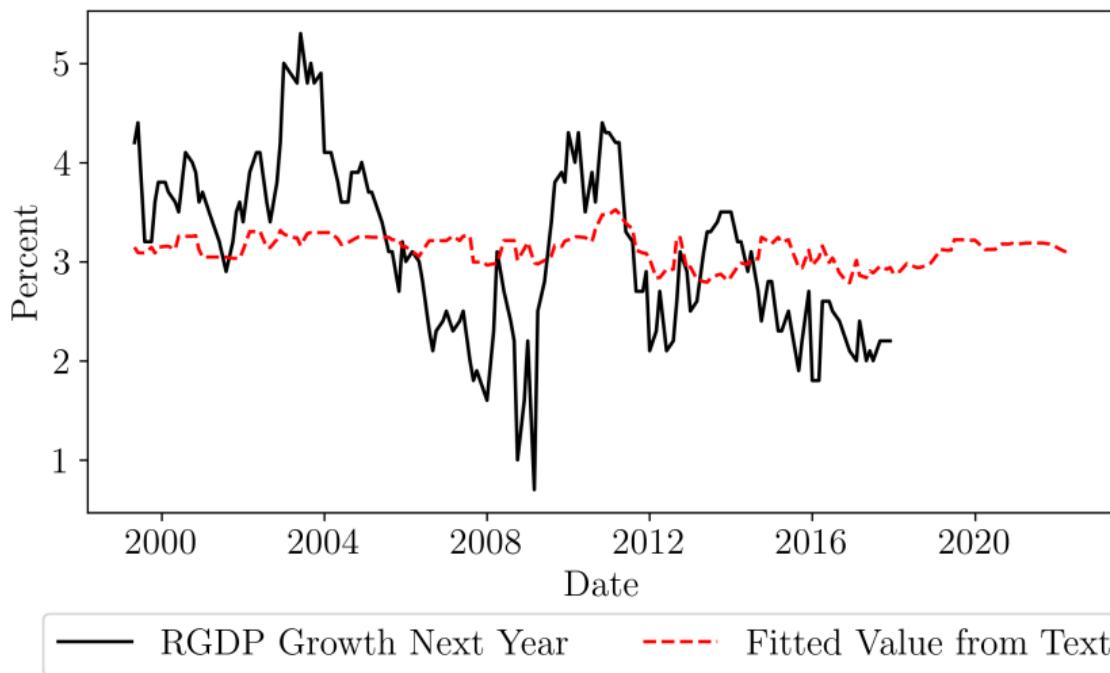
[Back](#)

# Shuffle: Real GDP Growth Next Quarter

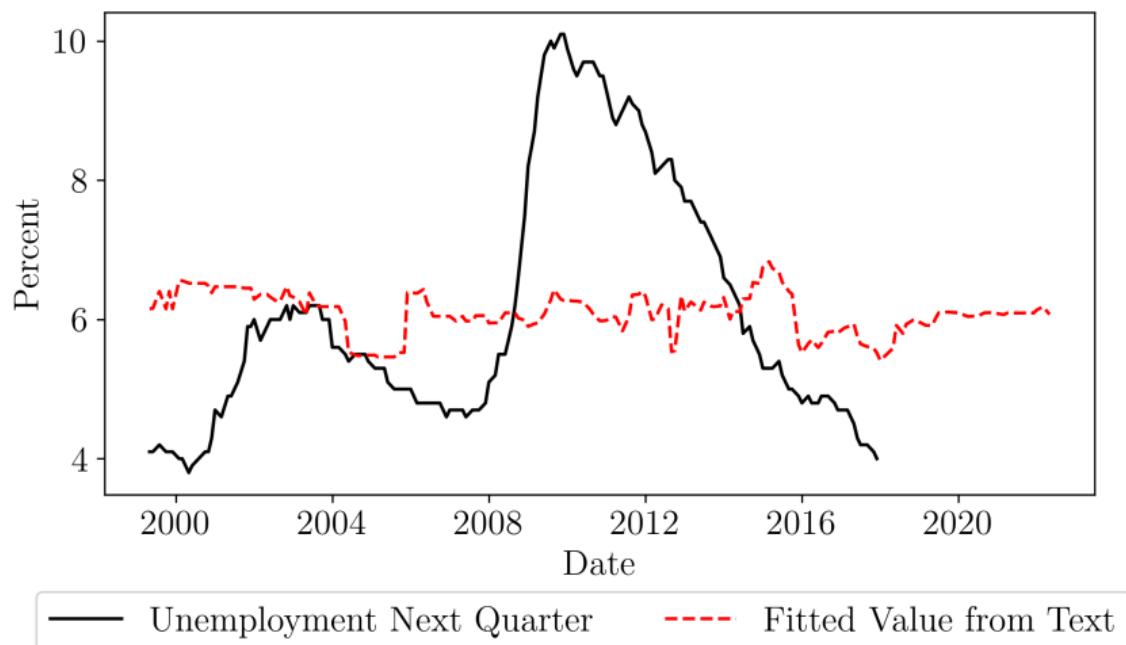


Back

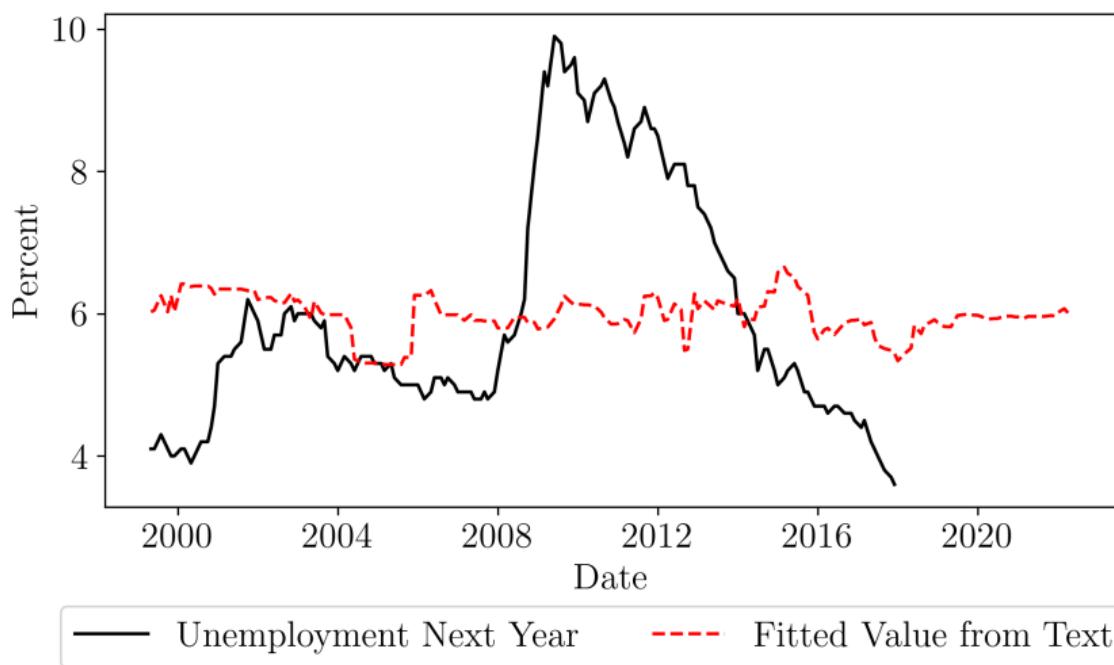
# Shuffle: Real GDP Growth Next Year

[Back](#)

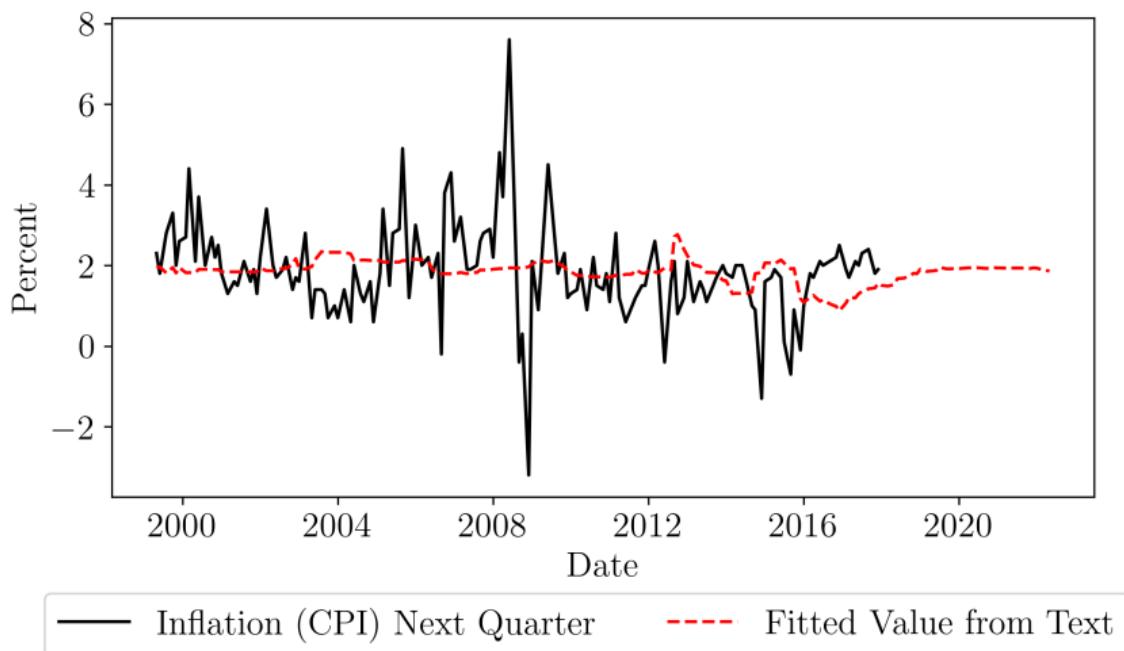
# Shuffle: Unemployment Next Quarter

[Back](#)

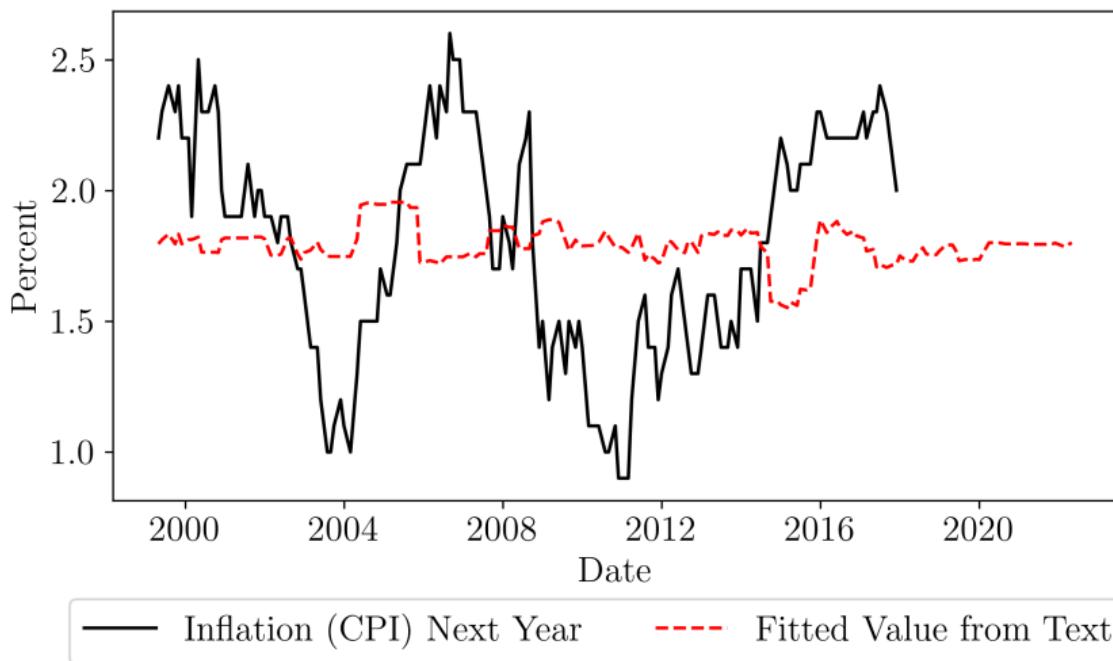
# Shuffle: Unemployment Next Year

[Back](#)

# Shuffle: CPI Inflation (Headline) Next Quarter

[Back](#)

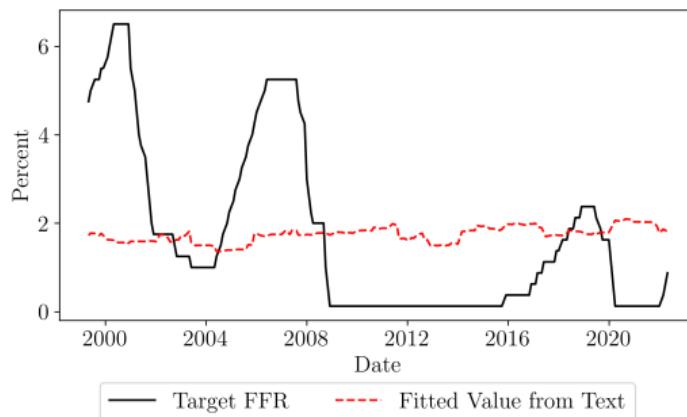
# Shuffle: CPI Inflation (Headline) Next Year

[Back](#)

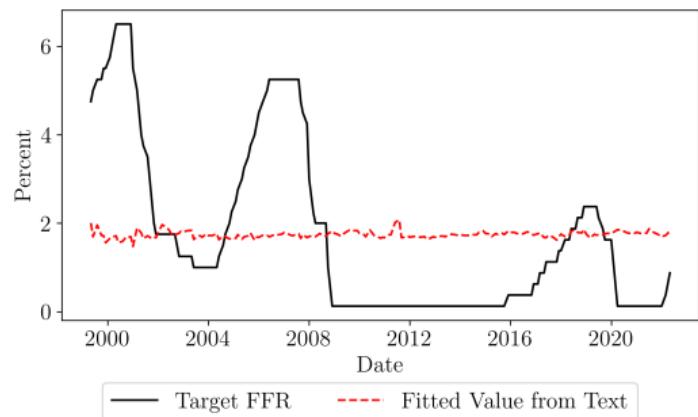
# Shuffle: Alternative Text Rep.

[Back](#)

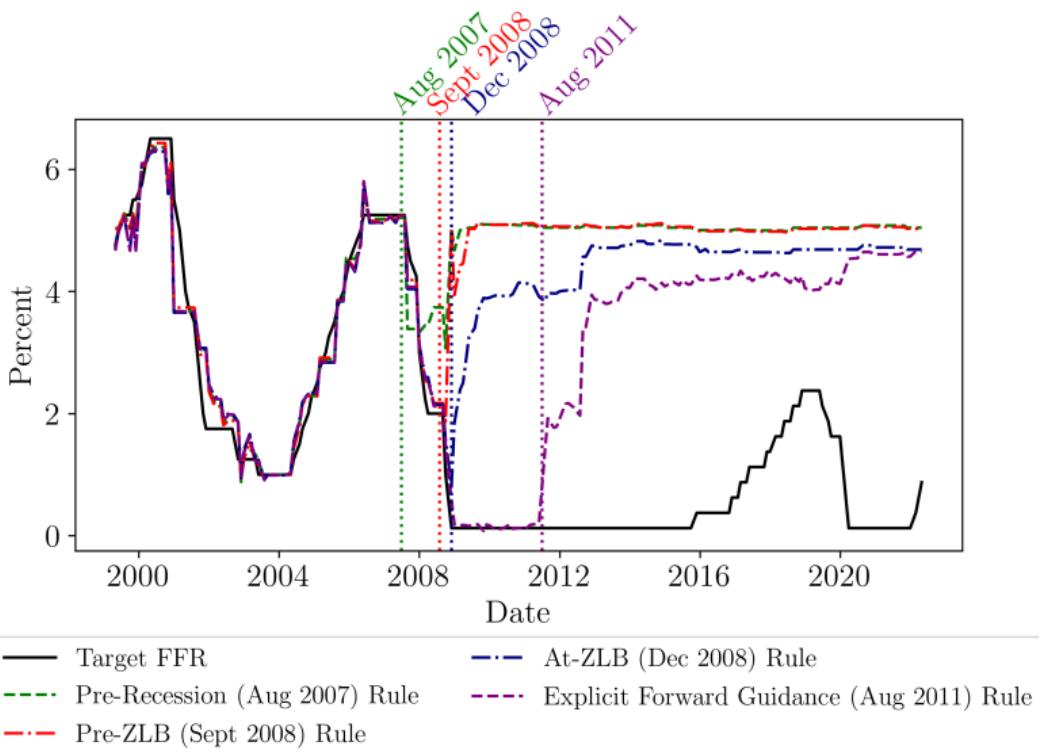
## Clustered 4-grams



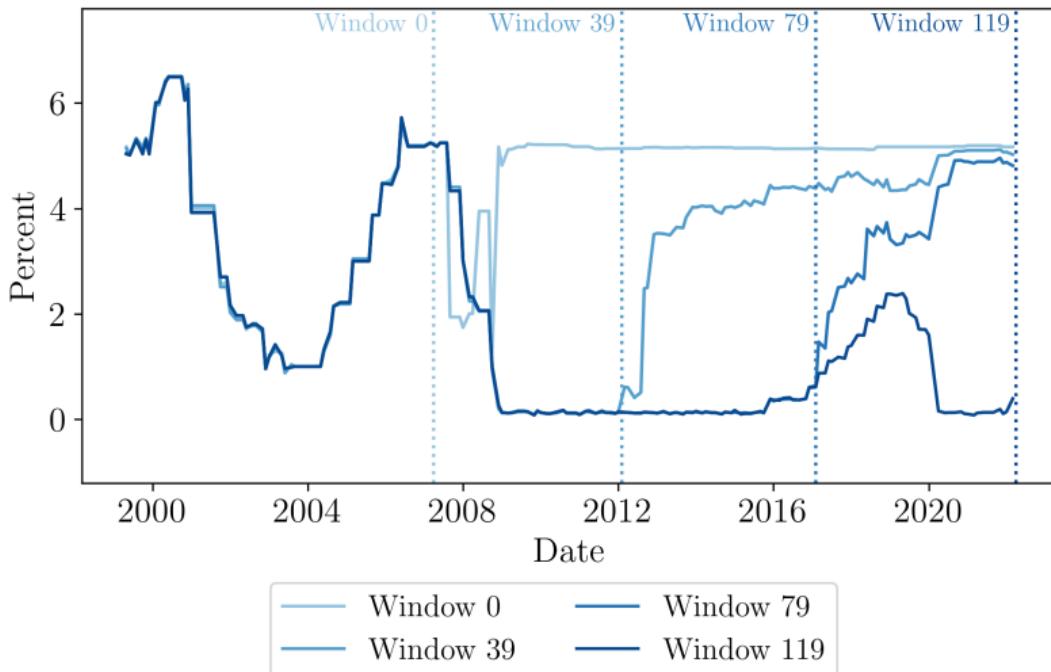
## BERT LLM Encoding



# Communication Rules around ZLB 2008

[Back](#)

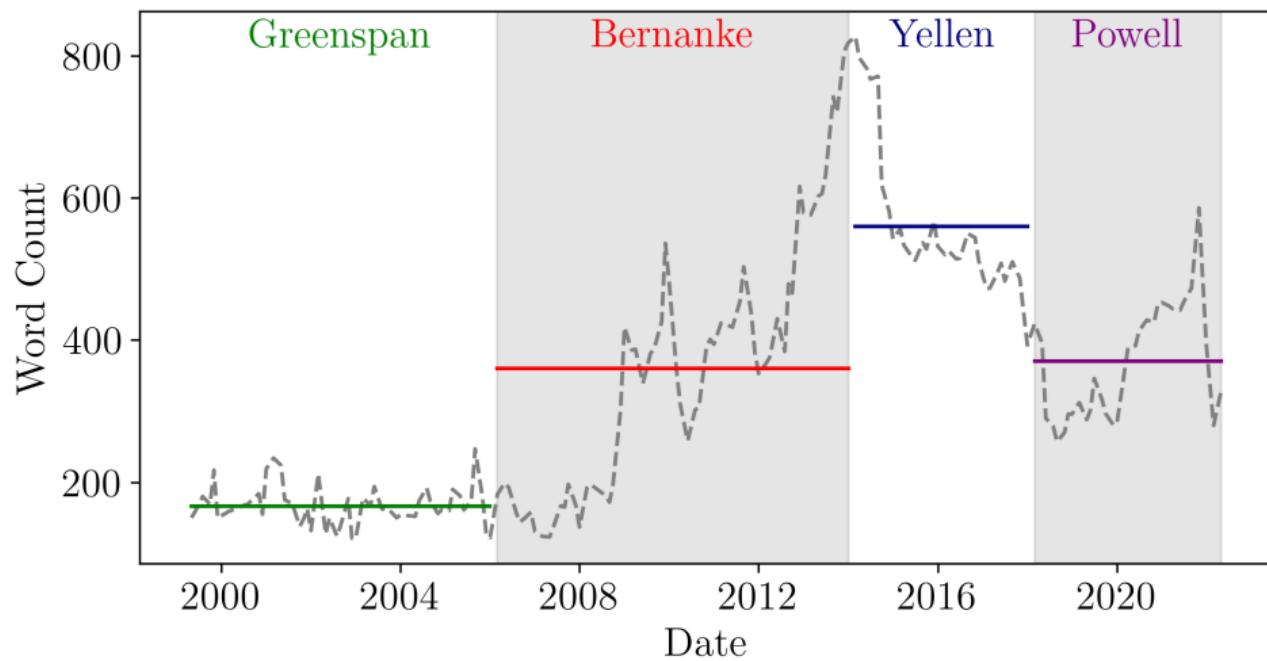
# Expanding Communication Rule for Target FFR

[Back](#)

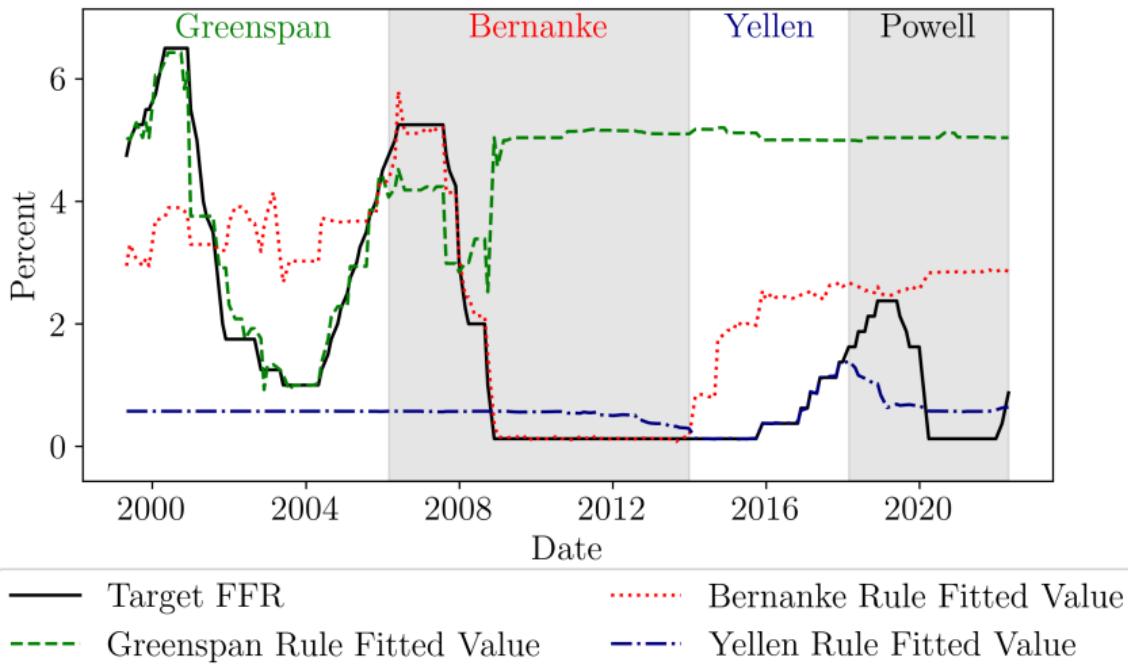
# Rolling Window Communication Rules



# FOMC Statement Length by Chair

[Back](#)

# Fed Chair Communication Rules

[Back](#)

# Other Shift Indicators

## ► Policy variables

- Change in contemporaneous target FFR
- Target FFR one year ahead
- Shadow rate
- Total assets
- 10Y Treasury - FFR

Change FFR

FFR Next Year

Shadow Rate

Total Assets

10Y Treasury - FFR

## ► Macro variables

- Real GDP growth next quarter
- Real GDP growth next year
- Unemployment next quarter
- Unemployment next year
- CPI inflation (headline) next quarter
- CPI inflation (headline) next year

Real GDP Next Quarter

Real GDP Next Year

Unemployment Next Quarter

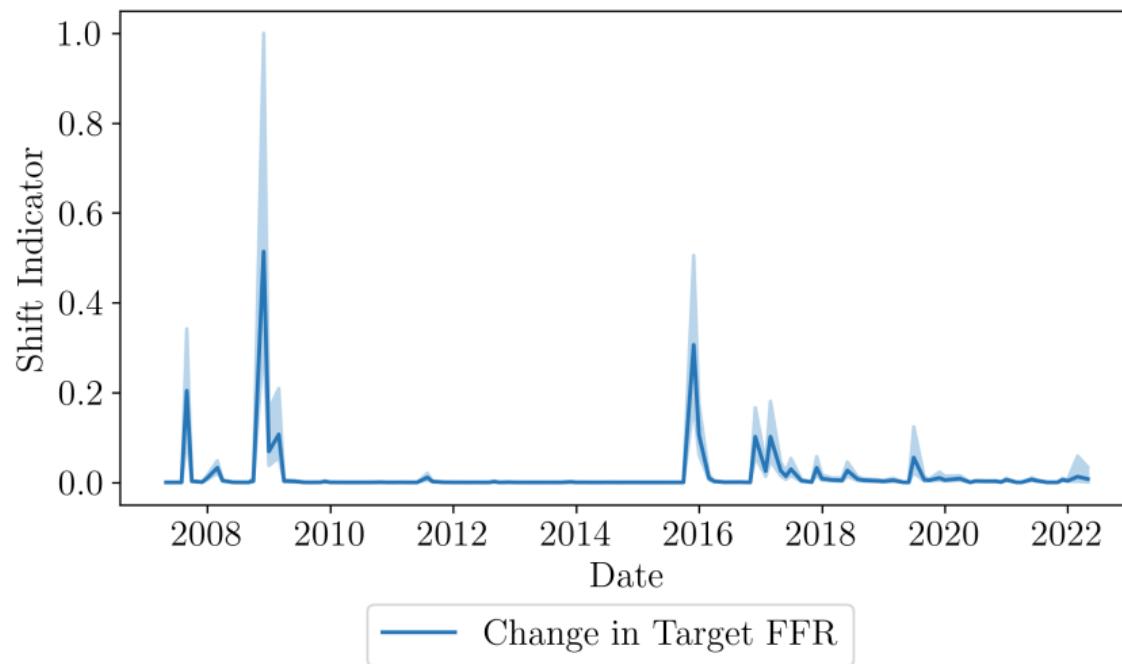
Unemployment Next Year

Inflation (Headline) Next Quarter

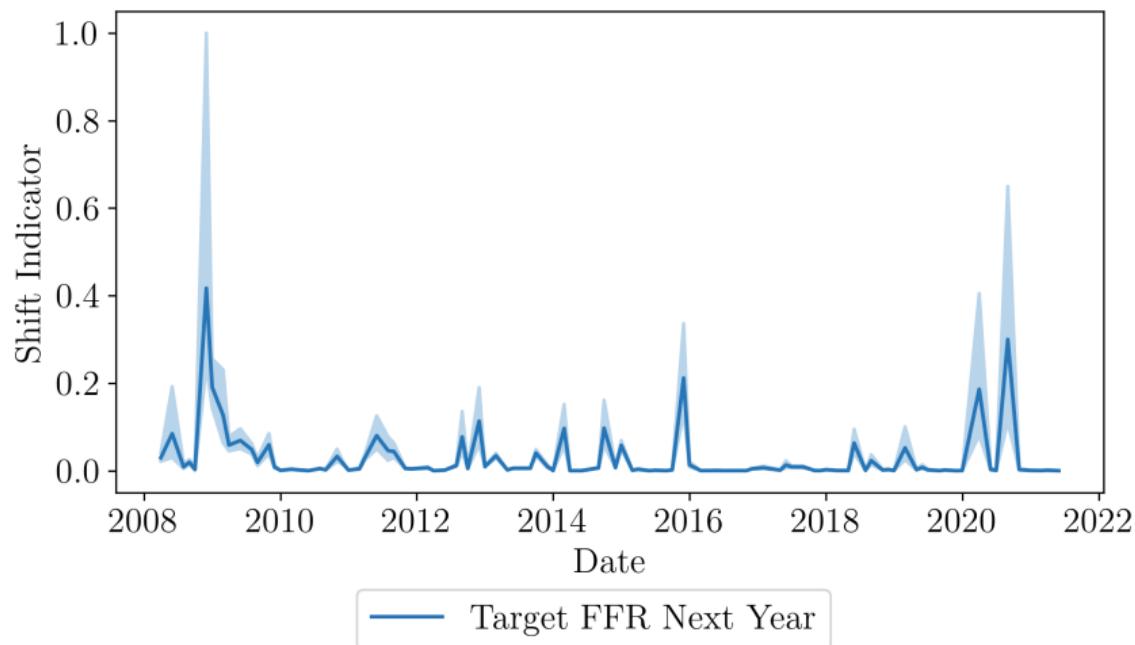
Inflation (Headline) Next Year

Back

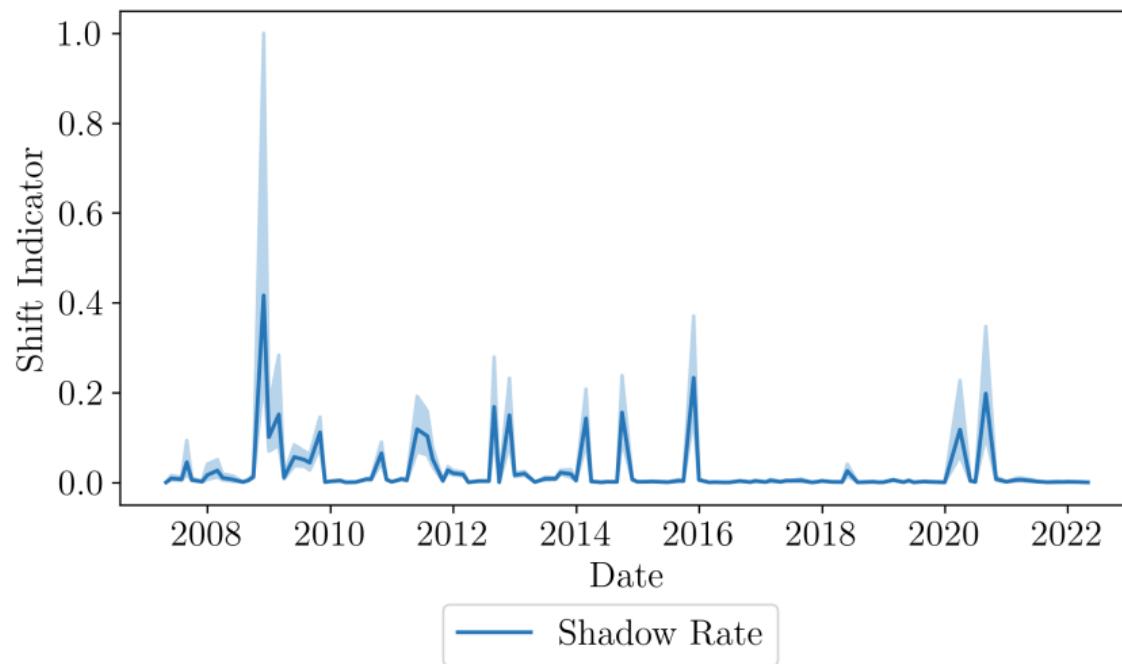
## Shift Indicator: Change in FFR

[Back](#)

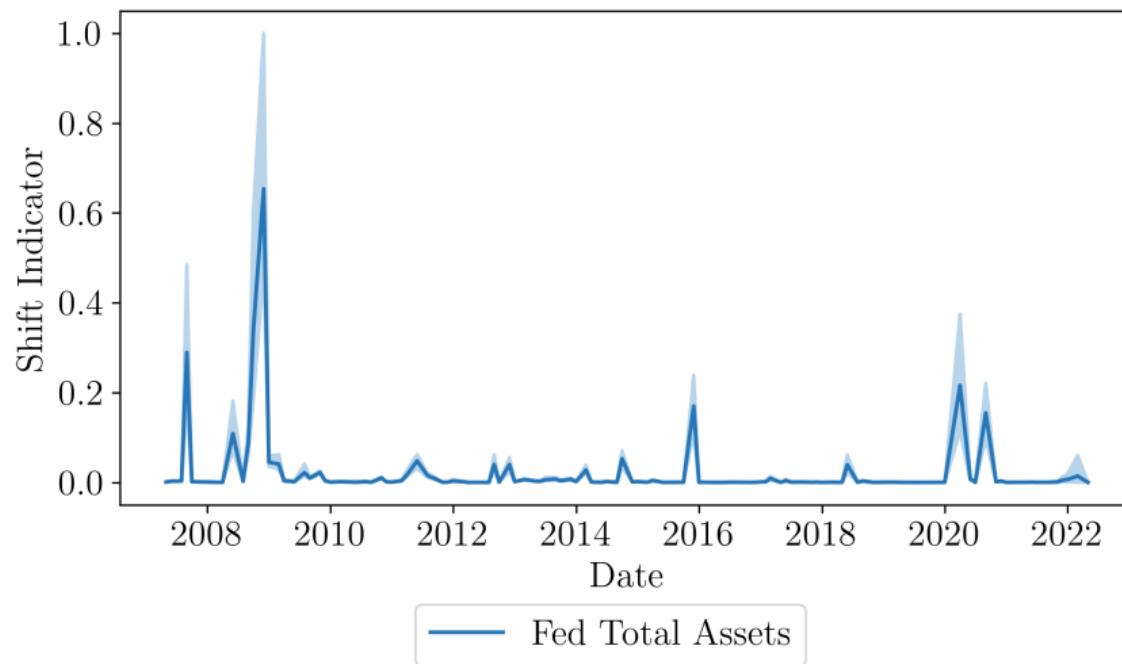
# Shift Indicator: Target FFR Next Year

[Back](#)

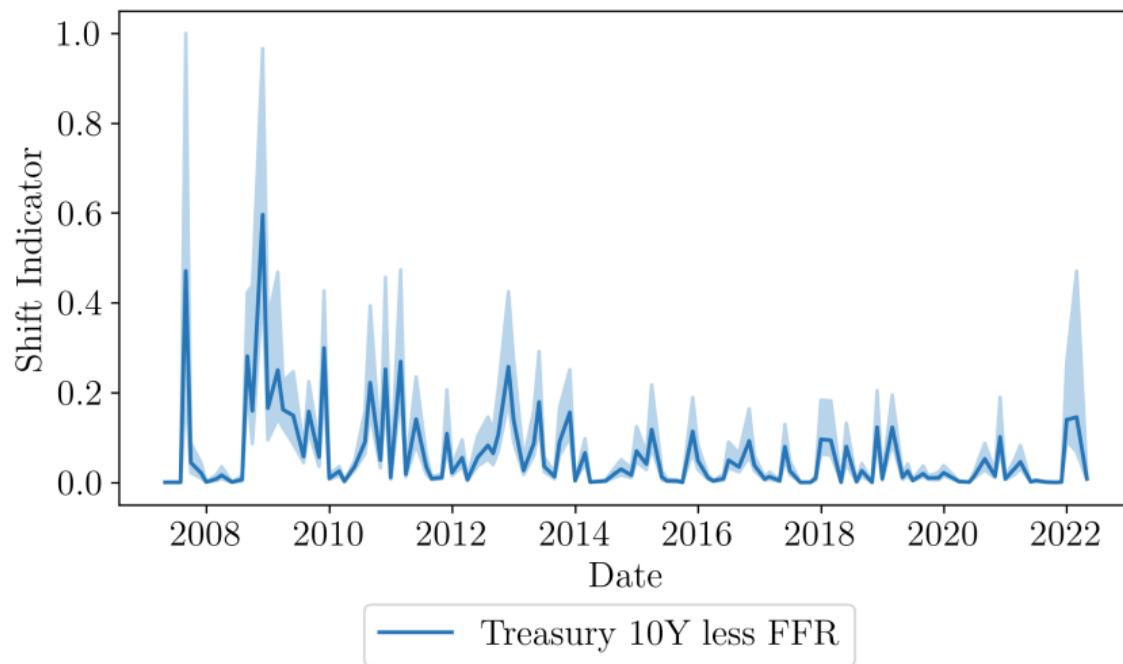
# Shift Indicator: Shadow Rate

[Back](#)

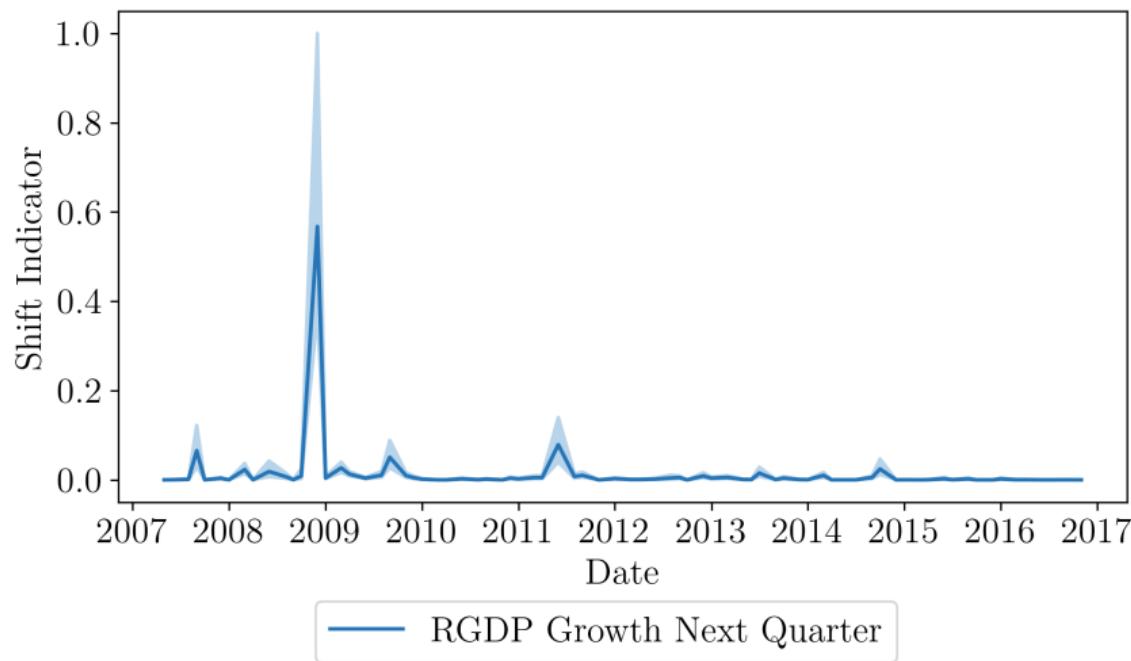
# Shift Indicator: Total Assets

[Back](#)

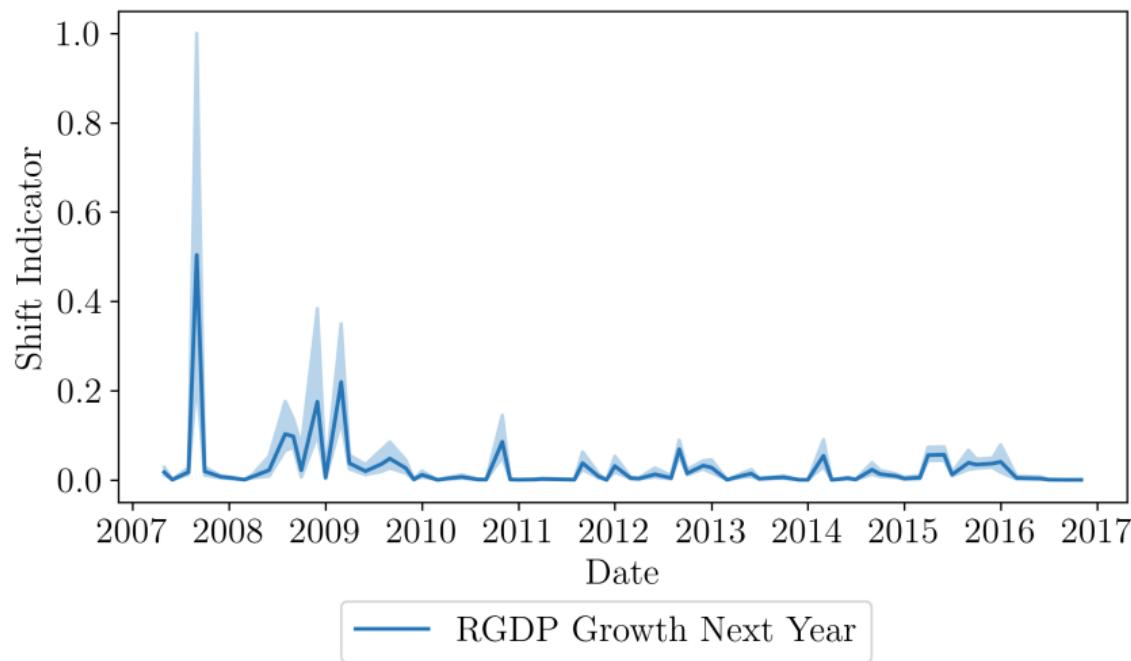
# Shift Indicator: 10Y Treasury - FFR

[Back](#)

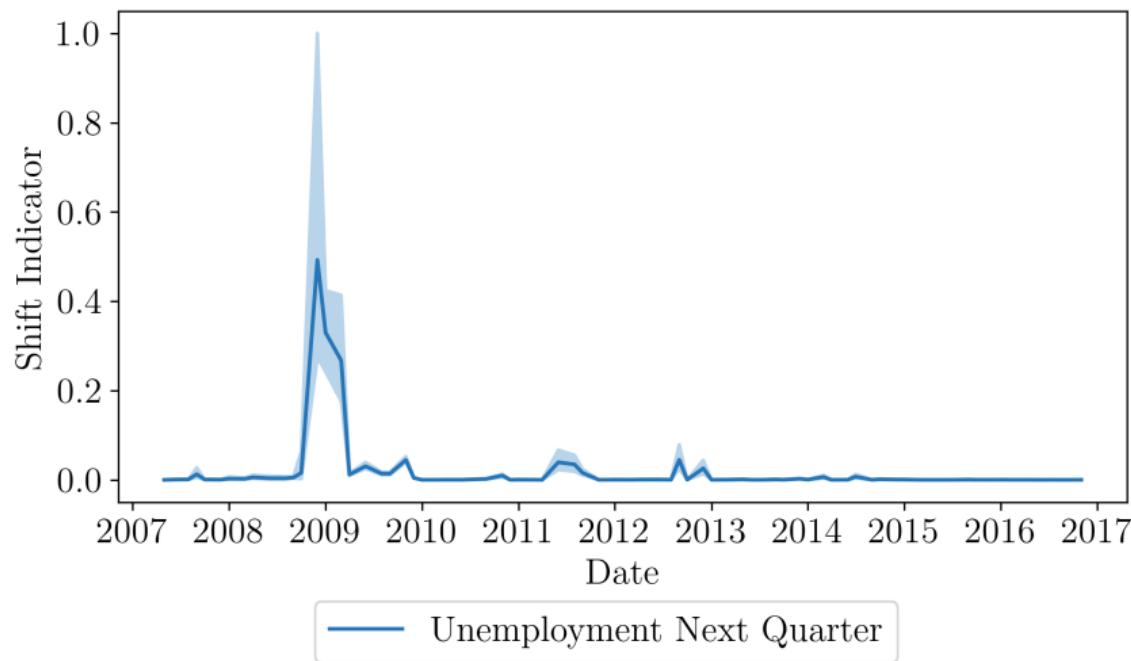
# Shift Indicator: Real GDP Growth Next Quarter

[Back](#)

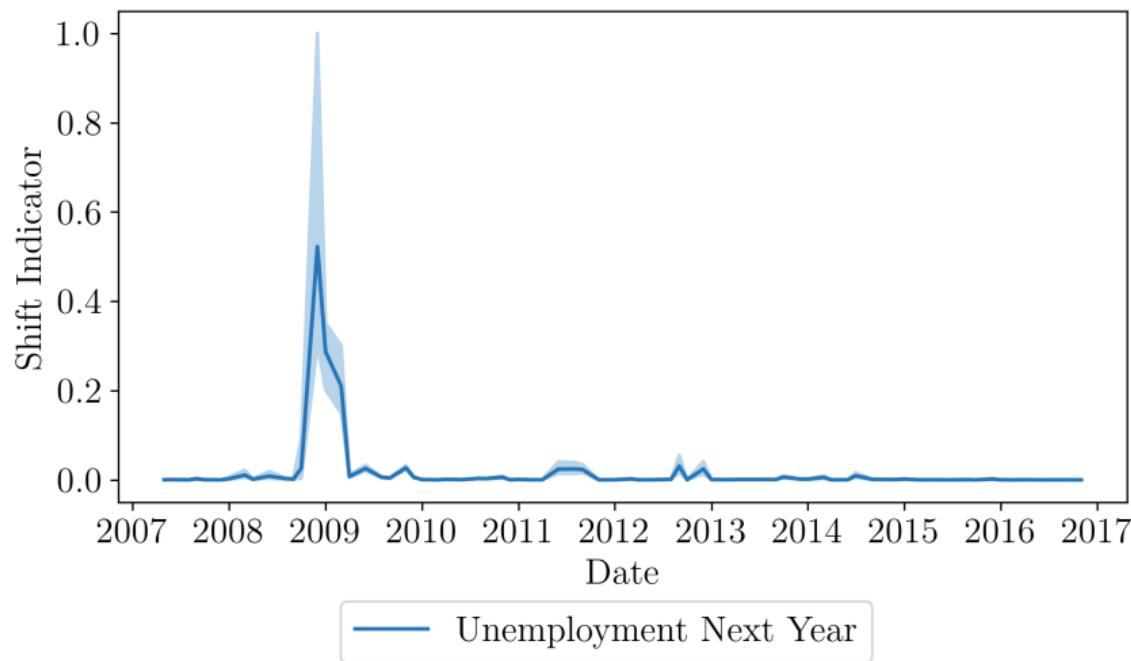
# Shift Indicator: Real GDP Growth Next Year

[Back](#)

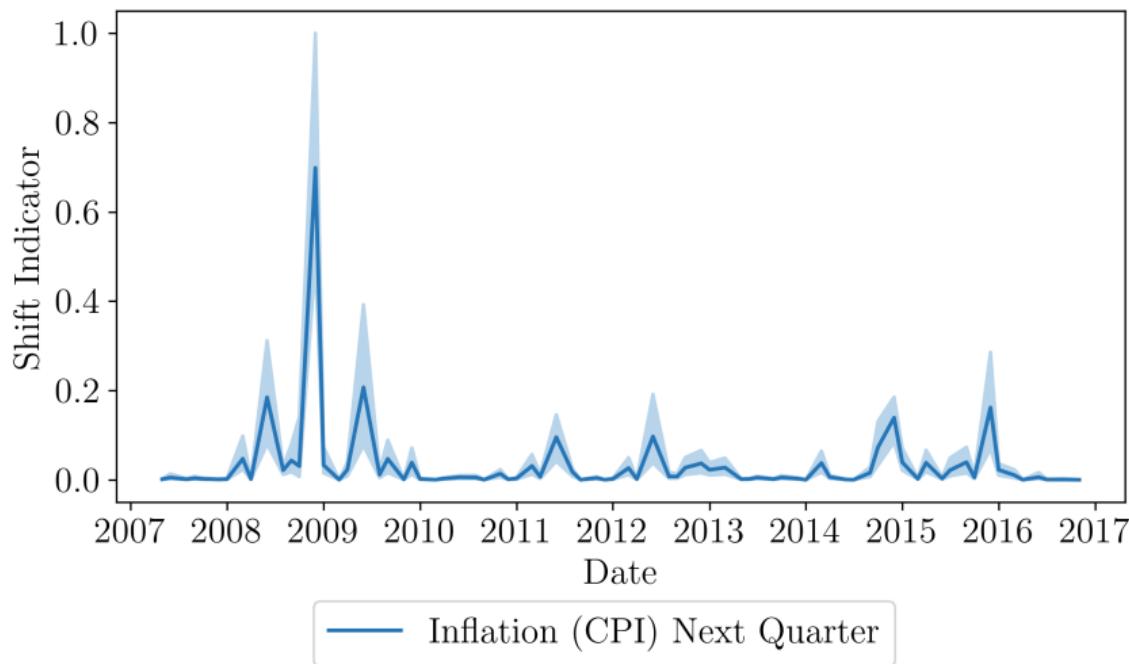
# Shift Indicator: Unemployment Next Quarter

[Back](#)

# Shift Indicator: Unemployment Next Year

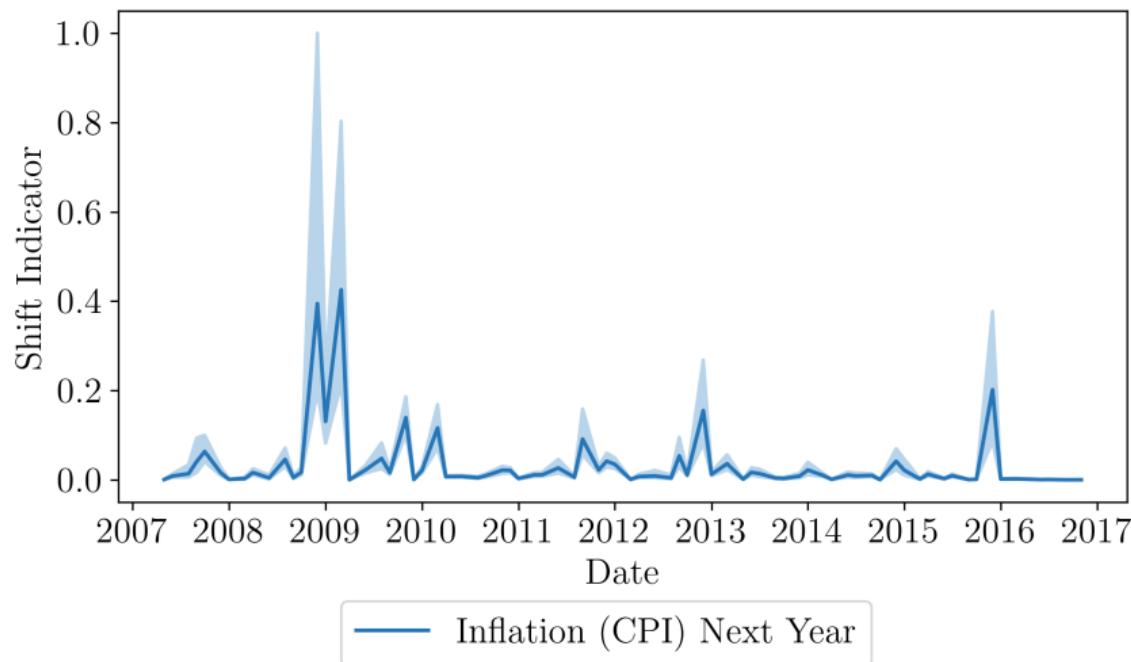
[Back](#)

# Shift Indicator: CPI Inflation (Headline) Next Quarter



Back

## Shift Indicator: CPI Inflation (Headline) Next Year



Back

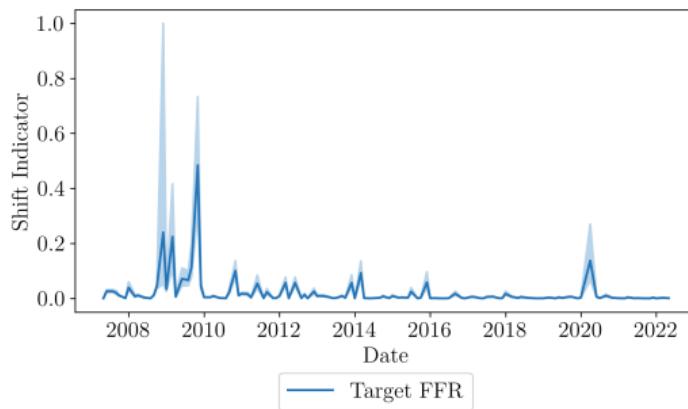
# Pairwise correlation of Shift Indicators

	Target FFR	$\Delta$ Target FFR	TFFR Next Year	Shadow Rate	Fed Assets	10Y Tre.-FFR	Unemp. $q+1$	Unemp. $q+4$	RGDP $q+1$	RGDP $q+4$	Infl. $q+1$	Infl. $q+4$
Target FFR	<b>1.00</b>	0.75	0.96	0.94	0.84	0.51	0.71	0.69	0.73	0.64	0.59	0.72
$\Delta$ TFFR	0.75	<b>1.00</b>	0.63	0.71	0.73	0.34	0.76	0.77	0.83	0.42	0.69	0.74
TFFR Next Year	0.96	0.63	<b>1.00</b>	0.92	0.75	0.27	0.75	0.76	0.77	0.46	0.76	0.80
Shadow Rate	0.94	0.71	0.92	<b>1.00</b>	0.77	0.39	0.68	0.65	0.68	0.48	0.58	0.72
Fed Assets	0.84	0.73	0.75	0.77	<b>1.00</b>	0.41	0.66	0.66	0.79	0.52	0.68	0.60
10Y Tre.-FFR	0.51	0.34	0.27	0.39	0.41	<b>1.00</b>	0.13	0.07	0.12	0.87	0.01	0.07
Unemp. $q+1$	0.71	0.76	0.75	0.68	0.66	0.13	<b>1.00</b>	0.99	0.83	0.29	0.62	0.85
Unemp. $q+4$	0.69	0.77	0.76	0.65	0.66	0.07	0.99	<b>1.00</b>	0.86	0.22	0.66	0.83
RGDP $q+1$	0.73	0.83	0.77	0.68	0.79	0.12	0.83	0.86	<b>1.00</b>	0.25	0.81	0.69
RGDP $q+4$	0.64	0.42	0.46	0.48	0.52	0.87	0.29	0.22	0.25	<b>1.00</b>	0.23	0.25
Infl. $q+1$	0.59	0.69	0.76	0.58	0.68	0.01	0.62	0.66	0.81	0.23	<b>1.00</b>	0.58
Infl. $q+4$	0.72	0.74	0.80	0.72	0.60	0.07	0.85	0.83	0.69	0.25	0.58	<b>1.00</b>
Average	0.76	0.70	0.74	0.71	0.70	0.35	0.69	0.68	0.70	0.47	0.60	0.65

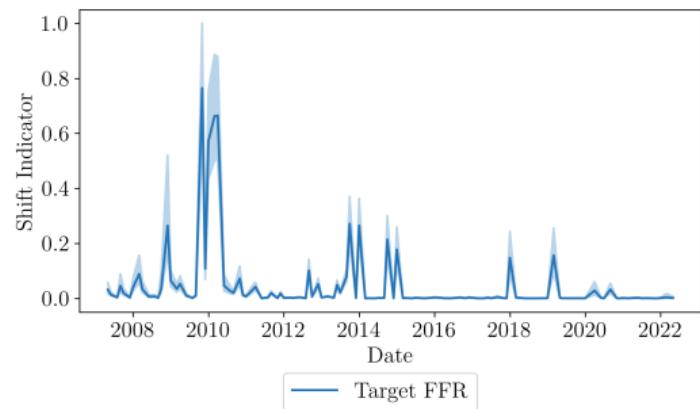
Back

# Shift Indicator: Alternative Text Representation

Clustered 4-grams



BERT LLM Encoding



Back

# Monetary Surprises and Shifts in Comm. Rules (2007-2022)

- BERT embedding measure of text → shift indicator

BERT Shift

$$|\text{Surprise}|_t = \gamma_0 + \gamma_1 (\text{BERT Shift})_t + \gamma_2 |\text{Change Target FFR}|_t + \tau_t + \varepsilon_t$$

	NS Shock	GSS Target	GSS Path	BS Shock
<b>Shift Indicator (<math>\gamma_1</math>)</b>	-0.012 (0.05)	0.081 (0.057)	-0.022 (0.043)	-0.059 (0.051)
<b> \text{Change Target FFR}  (<math>\gamma_2</math>)</b>	2.538** (1.211)	4.55*** (1.389)	1.088 (1.046)	1.771 (1.113)
Year FE	Yes	Yes	Yes	Yes
N	118	118	118	100
$R^2$	0.354	0.306	0.335	0.293

- Log transformation, drop 12-2008/1-2009/3-2020

Back-Main

Back-MS

# Forecast Dispersion and Shifts in Comm. Rules (2007-2022)

- BERT embedding measure of text → shift indicator

BERT Shift

$$\begin{aligned} \text{Dispersion}_q = & \gamma_0 + \gamma_1 (\text{BERT Shift})_q + \gamma_2 |\text{Change Target FFR}|_q \\ & + \gamma_3 ((\text{BERT Shift})_q \times |\text{Change Target FFR}|_q) + \gamma_4 \text{Dispersion}_{q-1} + \tau_q + \varepsilon_q \end{aligned}$$

Shift Coef. ( $\gamma_1$ )	Forecast Horizon				
	(0)	(1)	(2)	(3)	(4)
CPI	0.382**	0.076	0.189**	0.163*	0.076
Core CPI	0.285**	0.096	0.108	0.072	-0.003
RGDP growth	0.487***	0.524***	0.327***	0.406***	0.301***
Employment	0.652***	0.669***	0.558***	0.581***	0.452***
Housing	0.045	0.486***	0.175	0.27*	0.285**

- Log transformation, drop Q4-2008/Q1-2009/3-2020

Back-Main

Back-Disp

# Dispersion CPI

[Back](#)

	q	q+1	q+2	q+3	q+4
Shift Indicator	0.387** (0.144)	0.124 (0.092)	0.221*** (0.079)	0.161** (0.073)	0.131* (0.075)
Target FFR Change	1.901** (0.796)	0.255 (0.508)	0.833* (0.425)	0.93** (0.403)	0.584 (0.414)
Interaction	-0.507** (0.198)	-0.122 (0.127)	-0.26** (0.108)	-0.173* (0.1)	-0.169 (0.104)
Lagged Dispersion	-0.129 (0.149)	0.079 (0.171)	-0.151 (0.137)	-0.258** (0.127)	-0.216 (0.166)
Year FE	Yes	Yes	Yes	Yes	Yes
N	58	58	58	58	58
R2	0.521	0.737	0.753	0.781	0.684
Adj. R2	0.281	0.605	0.63	0.672	0.526

# Dispersion Core CPI

[Back](#)

	q	q+1	q+2	q+3	q+4
Shift Indicator	0.312*** (0.1)	0.139 (0.094)	0.157* (0.078)	0.129 (0.081)	0.029 (0.084)
Target FFR Change	1.537*** (0.548)	1.416** (0.543)	1.048** (0.455)	0.816* (0.463)	-0.046 (0.497)
Interaction	-0.4*** (0.137)	-0.188 (0.13)	-0.189* (0.108)	-0.147 (0.114)	0.005 (0.116)
Lagged Dispersion	-0.066 (0.143)	-0.121 (0.164)	0.044 (0.167)	-0.005 (0.17)	0.163 (0.163)
Year FE	Yes	Yes	Yes	Yes	Yes
N	58	58	58	58	58
R2	0.775	0.837	0.855	0.823	0.77
Adj. R2	0.663	0.755	0.782	0.735	0.655

# Dispersion RGDP Growth

[Back](#)

	q	q+1	q+2	q+3	q+4
Shift Indicator	0.561*** (0.111)	0.51*** (0.122)	0.29*** (0.083)	0.368*** (0.079)	0.317*** (0.076)
Target FFR Change	3.217*** (0.632)	3.788*** (0.711)	2.616*** (0.475)	2.186*** (0.425)	2.572*** (0.435)
Interaction	-0.742*** (0.153)	-0.694*** (0.169)	-0.402*** (0.116)	-0.519*** (0.11)	-0.471*** (0.106)
Lagged Dispersion	-0.25** (0.115)	-0.323** (0.12)	-0.231** (0.111)	-0.353*** (0.119)	-0.395*** (0.114)
Year FE	Yes	Yes	Yes	Yes	Yes
N	58	58	58	58	58
R2	0.859	0.845	0.87	0.84	0.801
Adj. R2	0.789	0.768	0.805	0.761	0.701

# Dispersion Employment

[Back](#)

	q	q+1	q+2	q+3	q+4
Shift Indicator	0.737*** (0.143)	0.62*** (0.134)	0.515*** (0.129)	0.559*** (0.133)	0.471*** (0.11)
Target FFR Change	5.831*** (0.859)	5.069*** (0.81)	3.592*** (0.779)	3.392*** (0.744)	3.077*** (0.616)
Interaction	-1.015*** (0.201)	-0.867*** (0.186)	-0.719*** (0.18)	-0.747*** (0.187)	-0.618*** (0.152)
Lagged Dispersion	-0.161 (0.098)	-0.257** (0.105)	-0.271* (0.135)	-0.286** (0.137)	-0.272** (0.12)
Year FE	Yes	Yes	Yes	Yes	Yes
N	58	58	58	58	58
R2	0.897	0.909	0.891	0.847	0.844
Adj. R2	0.846	0.863	0.837	0.771	0.765

# Dispersion Housing Starts

[Back](#)

	q	q+1	q+2	q+3	q+4
Shift Indicator	0.095 (0.112)	0.439*** (0.161)	0.259* (0.146)	0.304** (0.129)	0.277** (0.127)
Target FFR Change	1.03 (0.697)	2.746*** (0.926)	1.986** (0.884)	1.532** (0.725)	2.196*** (0.714)
Interaction	-0.194 (0.158)	-0.651*** (0.222)	-0.41* (0.204)	-0.405** (0.177)	-0.378** (0.176)
Lagged Dispersion	-0.319* (0.172)	-0.092 (0.16)	-0.249 (0.198)	-0.372** (0.179)	-0.267 (0.16)
Year FE	Yes	Yes	Yes	Yes	Yes
N	58	58	58	58	58
R2	0.615	0.697	0.768	0.805	0.837
Adj. R2	0.422	0.546	0.652	0.708	0.756

# Benchmarking to Other Text Approaches

► To benchmark our 4-gram/ridge regression approach, we implement:

- Dictionary approach
- ChatGPT approach

Dictionary

ChatGPT

► This comparison is for the fixed communication rules

Back-Shuffle

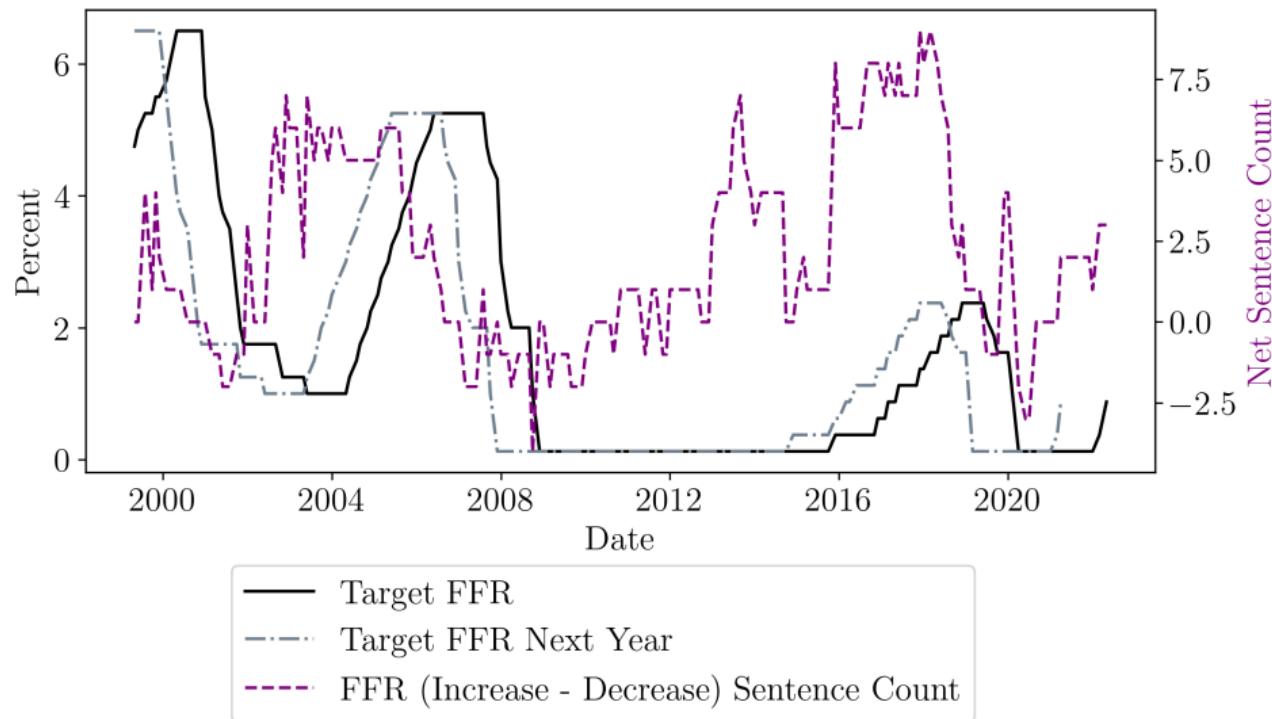
Back-Conclusion

# Dictionary Approach

- ▶ Create a dictionary of
  - Topic words (macro forecasts and policy terms)
  - Direction words (increasing/high vs decreasing/low)
- ▶ Identify (topic × direction) at the sentence level
  - Negation handling, subsentence phrases, and scaling
  - Sentences may have multiple topics
  - Then aggregate up to FOMC statement level
- ▶ Implicitly, dictionary method is a “fixed” communication rule

[Back](#)

# Dictionary Rule



Back

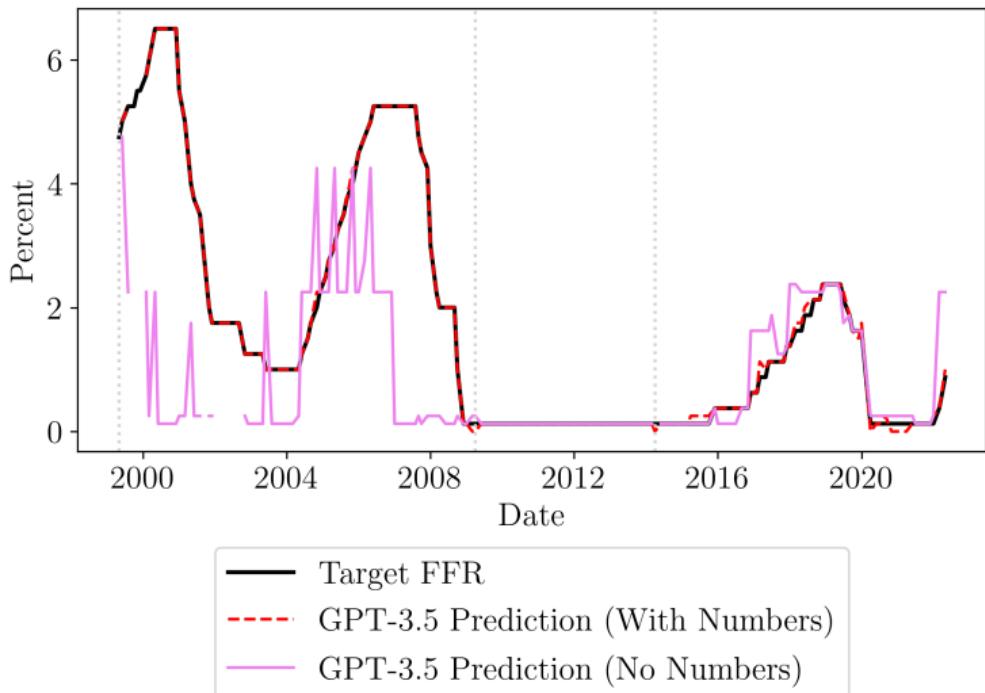
# ChatGPT Prompt

- ▶ GPT-3.5 Turbo frontier LLM that captures context in text
- ▶ Ask it to predict Tealbook forecast and policy variables
  - Few-shot learning with three examples
- ▶ Prompt:

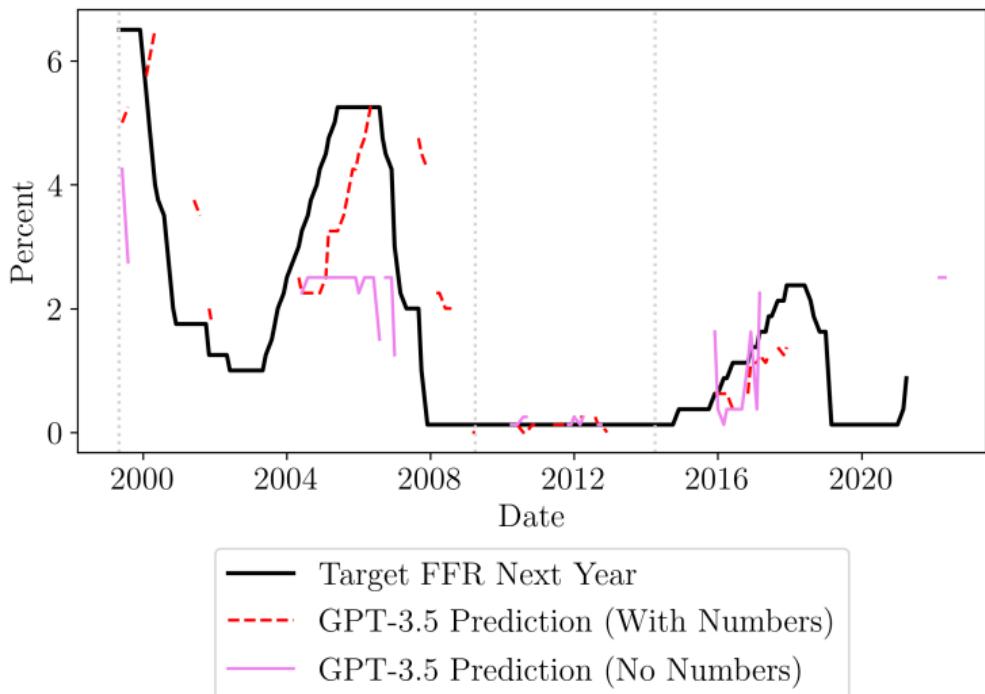
*"Based on the following FOMC statement, what is your best guess of the <measure> the Federal Reserve thinks the <variable> will be <horizon>? FOMC statement: <statement>"*
- ▶ Overall, it is a powerful tool.
  - Able to extract numbers well, but not specialized concepts
  - Training data unknown, fine-tuning data too small

[Back](#)

# ChatGPT Rule: Target FFR

[Back](#)

# ChatGPT Rule: Target FFR Next Year

[Back](#)

