Identifying Monetary Policy Shocks: A Natural Language Approach

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MOTIVATION

- Goal: study the effects of monetary policy i_t on macro variables $\boldsymbol{Y_t}$
- Problem: i_t endogenously reacts to $\boldsymbol{Y_t}$
- Formalize problem:

$$i_t = f(\Omega_t) + \varepsilon_t$$

  - Ω_t: information set of central bank, contains $\boldsymbol{Y_t}$
  - $f(\cdot)$: systematic conduct of monetary policy
  - ε_t: monetary policy shock

MOTIVATION

- Idea of Romer and Romer (2004)
  - Run linear regression
    $$\Delta i_t = \alpha + \beta i_{t-1} + \boldsymbol{\gamma} \boldsymbol{X_t} + \varepsilon_t^{RR}$$
    $\boldsymbol{X_t}$ contains forecasts from documents prepared for FOMC ("Greenbooks")
  - With residuals $\hat{\varepsilon}_t^{RR}$, construct IRFs of $\boldsymbol{Y_t}$

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- Key assumptions:
  1. Forecasts of Fed economists are good approximation of information set Ω_t
  2. Linear specification is good approximation of systematic policy $f(\cdot)$

MAIN IDEA OF THIS PAPER

- Revive the idea of Romer and Romer (2004) using ...
- Natural language processing:
  - Process language in thousands of pages of text prepared for FOMC meetings
  - Show that sentiment around economic concepts is informative beyond forecasts
- Machine learning:
  - Include forecasts and sentiment indicators in a regression, also nonlinearly
  - Hundreds of regressors $\rightarrow$ apply ridge regression as dense ML technique

PREVIEW OF FIVE FINDINGS

1. Contribution of systematic vs. exogenous changes in monetary policy
   - Original Romer-Romer regression: $R^2 = 0.5$; implies 50% of ΔFFR are shocks
   - Our approach $R^2 = 0.94$; implies much of original RR shock variation is endogenous

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   - Mostly real activity sentiments and forecasts, limited role for price variables

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2. Inspecting the drivers of systematic changes in monetary policy
   - Mostly real activity sentiments and forecasts, limited role for price variables

3. What are monetary policy shocks?
   - FOMC reaches decisions not directly related to staff's analysis
   - E.g. based on long-run credibility concerns

PREVIEW OF FIVE FINDINGS (CONT'D)

4. Effects of monetary policy shocks
   - Estimated shocks give theoretically consistent IRFs of standard variables
   - Not the case for shocks estimated with original Romer-Romer specification

$$i \uparrow \Rightarrow \; Y \downarrow \;\; P \downarrow \;\; EBP \uparrow \;\; SP500 \downarrow$$

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5. Real-time application to recent Fed meetings using Beigebooks only
   - Not feasible with original Romer-Romer approach because of forecast publication lag
   - Rate hikes in 2022/23 almost entirely systematic (17bp out of 450 bp are shock)

METHODOLOGY

STEP 1. PROCESS RAW TEXT

- Download documents associated with scheduled FOMC meetings
  - Main focus: Beigebook & Tealbook A (for earlier dates: Red- & Greenbooks)
  - Real-time version: Beigebook only
- Start with the meeting on October 5, 1982, which is when the Fed started targeting the Fed Funds Rate as their policy tool, see Thornton (2006)
- End with latest available meeting in December 2016 $\Rightarrow$ 276 FOMC meetings
- Some of subsequent analysis runs until the ZLB (2008:10)

STEP 2. IDENTIFY ECONOMIC CONCEPTS

- After cleaning steps, we store all singles, doubles, and triples
  - "... consumer price inflation ..." gives a triple, two doubles and three singles
  - "... inflation and economic activity ..." gives us three singles and one double
  - "... for inflation. Activity on the other hand..." gives us three singles
- Select most frequently discussed economic concepts
- Combine/exclude overlapping concepts Details
- Final list amounts to 296 economic concepts

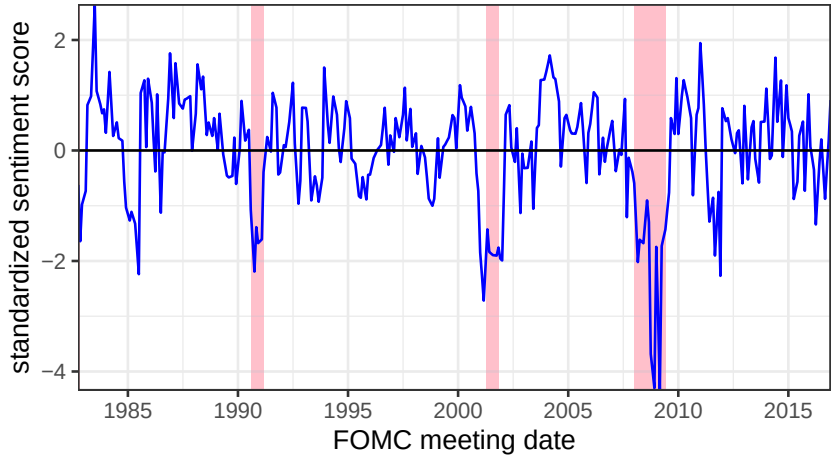
MOST FREQUENT ECONOMIC CONCEPTS

STEP 3. CONSTRUCT SENTIMENT

- Apply a method inspired by Hassan, Hollander, van Lent, and Tahoun (2020)
- Consider the 10 words mentioned before and after each concept's appearance
- Check whether these are words associated with positive or negative sentiment
  - Use classification based on enhanced version of Loughran and McDonald (2011)
- Each positive word gives a score of +1 and each negative word of -1
- Sum up the scores within a meeting, and scale by the total number of words
- Using sentences instead of +/- 10-word windows gives very similar indicators

Dictionary example

EXAMPLE: SENTIMENT AROUND "ECONOMIC ACTIVITY"



More

STEP 4. RUN RIDGE REGRESSION

$$\Delta i_t = \alpha + \beta i_{t-1} + \Gamma(\widetilde{\boldsymbol{X}}_t, \boldsymbol{Z}_t) + \varepsilon_t^*$$

- $\widetilde{\boldsymbol{X}}_t$: numerical forecasts: with all variables, lags, differencing $\rightarrow$ 132 time series
- $\boldsymbol{Z_t}$: sentiment indicators $\rightarrow$ 296 time series, also include 4 lags
- $\Gamma(\cdot)$ captures non-linearity $\rightarrow$ implement as linear-quadratic specification
- Problem is "curse of dimentionality"
  - In above setting, $3,226$ variables on the right hand side
  - Before ZLB, 210 observations
- Solution: ridge regression with 10-fold cross-validation

INTERMEDIATE VALIDATION EXERCISE: DO SENTIMENT INDICATORS PROVIDE USEFUL INFORMATION?

DO SENTIMENT INDICATORS PROVIDE USEFUL INFORMATION?

- Discussion of Romer and Romer (2004) by Cochrane (2004):
  - Enough to orthogonalize FFR changes with respect to the staff's forecasts alone ...
  - ... IF forecast for variable of interest incorporates available information efficiently
  - Argument relies on Greenbook forecast of $X = E[X|\Omega]$
- We provide evidence that Greenbook forecast best interpreted as **modal**

  "I would characterize our forecasts over the years as an effort to present a meaningful, modal forecast of the most likely outcome. When we felt that there was some skewness to the probability distribution, we tried to identify it. In this instance, as we looked at the recent data, we felt that there was a greater thickness in the area of our probability distribution a little above our modal forecast."
  (Michael Prell, director of RS in FOMC meeting on July 2-3, 1996)
- We show econometrically that sentiments predict forecast errors, so $X \neq E[X|\Omega]$

DO SENTIMENT INDICATORS PROVIDE USEFUL INFORMATION?

	Left hand side: Greenbook unemployment rate forecast errors							
	(1) current quarter	(2) 1-quarter ahead	(3) 1-year ahead	(4) 2-years ahead	(5) current quarter	(6) 1-quarter ahead	(7) 1-year ahead	(8) 2-years ahead
First PC of all sentiments	-0.029*	-0.114**	-0.445**	-0.622**				
	[0.016]	[0.049]	[0.190]	[0.238]				
Economic activity sentiment					-0.026	-0.098**	-0.285*	-0.363**
					[0.016]	[0.048]	[0.165]	[0.171]
Constant	-0.019	-0.070**	-0.082	0.059	-0.019	-0.069**	-0.077	0.160
	[0.014]	[0.033]	[0.121]	[0.201]	[0.014]	[0.035]	[0.145]	[0.258]
R-squared	0.045	0.149	0.248	0.208	0.033	0.097	0.090	0.055
Obs	210	210	210	62	210	210	210	62

- Unemployment rate forecast errors predictable with sentiments
- Interpretation: negative activity sentiment $\Rightarrow$ positive error
  is consistent with negative sentiment capturing thicker upper tail

other variables

RESULTS OF THE IDENTIFICATION PROCEDURE

R^2 ACROSS DIFFERENT REGRESSION MODELS

	Number of regressors	(1) R^2 with 10-word sentiment (main specification)	(2) R^2 with 5-word sentiment (robustness)
Romer-Romer original OLS with subset of forecasts	19	0.50	
Ridge with extended set of forecasts	133	0.55	
Ridge with all forecasts & sentiments (linear)	429	0.65	0.66
Ridge with all forecasts & sentiments (nonlinear)	858	0.75	0.77
Ridge with all forecasts & sentiments (linear with lags)	1,613	0.87	0.88
Ridge with all forecasts & sentiments (nonlinear with lags)	3,226	0.94	0.95

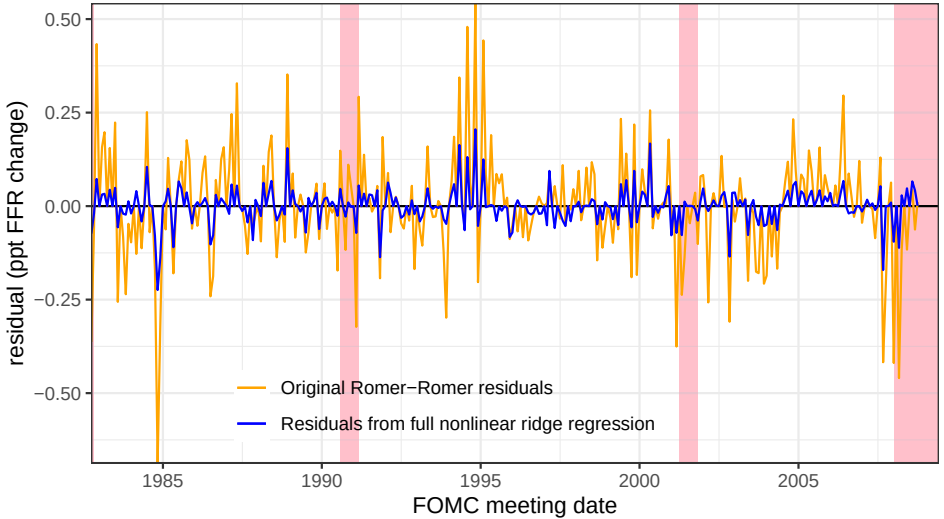
- R^2 tells us how much of the variation in Δi is explained by systematic policy
- Wider side of forecasts, human language, lags and nonlinearities all rise R^2

WHAT EXPLAINS THE SYSTEMATIC COMPONENT?

Sentiment PC1		**Sentiment PC2**		**Numerical forecast PC1**	
economy	0.141	advanced foreign economies	-0.141	output growth (+1)	0.187
firms	0.139	merchandise	0.140	output growth (0)	0.175
economic activity	0.136	foreign economies	0.135	bus. fixed inv. growth (+2)	0.160
manufacturing activity	0.133	credit standards	-0.131	ind. prod. growth (+1)	0.160
commercial real estate	0.131	farm	0.127	output growth (+2)	0.158
manufacturing firms	0.130	cash	0.125	nominal output growth (+1)	0.153
labor market	0.125	core inflation	-0.124	housing starts (+1)	0.151
services	0.123	industrial production	0.123	housing starts (+2)	0.150
consumer confidence	0.118	trade deficit	0.121	housing starts (+3)	0.150
industries	0.117	developing countries	0.119	housing starts (0)	0.149

- Real activity variables important for sentiment and forecast PCs
- Limited role for sentiment around price and financial variables

ESTIMATED MONETARY POLICY SHOCKS



What are monetary policy shocks?

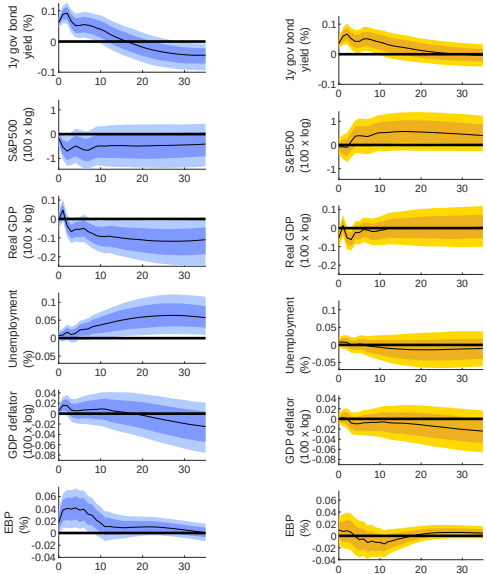
- In the paper we provide case studies for meetings with largest estimated shocks
- It turns out that these are situations in which the FOMC made decisions based on considerations not directly related to the economic outlook
  - In particular long-run credibility concerns
- Key example is November 1994 meeting, largest tighetning shock in our sample
  - Staff material suggests market had already built in a rate hike
  - Greenspan advocated a larger hike: "a mild surprise would be of significant value."

THE EFFECTS OF MONETARY POLICY SHOCKS

SETTING TO ESTIMATE IRFS

- Directly follow monthly BVAR framework Jarocinski and Karadi (2020)
- Shock series is 1982:10 to 2008:10, but can estimate BVAR through to 2016
- System includes 1-year Treasury yield, the log of the S&P500, log real GDP, the unemployment rate, the log GDP deflator, and the excess bond premium (EBP)
- Report bands based on 16th and 84th percentiles
- Results similar with local projections approach (Jordà, 2005)

FULL NONLINEAR RIDGE VS. RR OLS

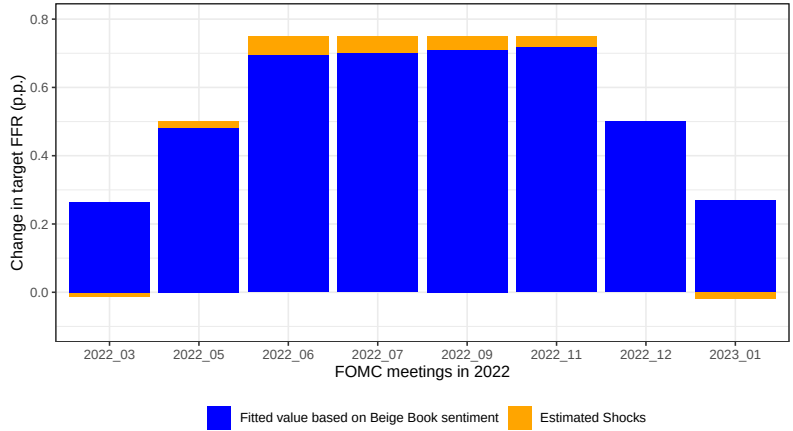


REAL-TIME APPLICATION

IDEA OF REAL-TIME APPLICATION

- Beigebooks are publicly available prior to every FOMC meeting
- Constructing sentiments from Beigebook $\rightarrow$ limited proxy for FOMC's information
  - We verify this in the period where we can use both Tealbooks and Beigebooks
- Not possible to apply original Romer-Romer method: no forecasts in Beigebook!
- Run regression over the 2015-2022 period and zoom in on 2022 and early 2023

INTEPRETING THE 2022-23 RATE HIKES



- Contractionary shock component (orange area) cumulates to 17 basis points

CONCLUSION

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- Classic question in macroeconomics: what are the effects of monetary policy?
- This paper estimates monetary policy shocks by:
  - Accurately capturing the information available to the FOMC
  - Allowing for nonlinearities in the decision process
- NLP and ML techniques enable us to retrieve shocks with desirable proprieties
- Monetary policy has sizeable effects on activity, inflation, asset prices, risk premia
- **We make our estimated shocks and sentiment indicators available online!**

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APPENDIX SLIDES

COMBINING AND EXCLUDING CONCEPTS

- Using the raw list of economic concepts, we combine/exclude overlapping concepts
  - Combine singular and plural, e.g. "oil price" and "oil prices"
  - Separate mutually exclusive important concepts, e.g. keep "commercial real estate" and "residential real estate," but drop "real estate"
  - Subsume unimportant concepts if sufficiently related, e.g. drop "consumer credit" and "bank credit," but keep "credit"
  - Exclude direct mention of policy rate, since that is discussion of the action

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3. Examples of positive and negative words

Positive	Negative
adequate	adversely
advantage	aggravate
benefit	bad
boost	burdensome
confident	collapse
conducive	concerning
desirable	decline
diligent	deficient
easier	eroded
encouraging	exacerbate
...	...

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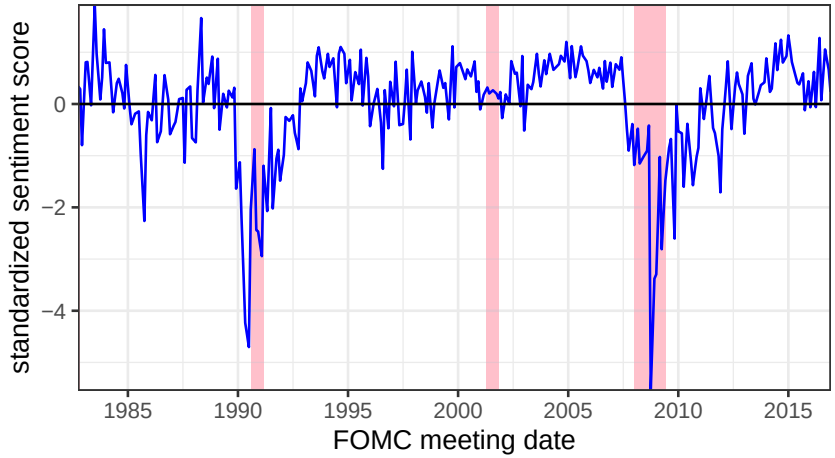
CREDIT


standardized sentiment score
0
−2
−4
1985
1990
1995
2000
2005
2010
2015
FOMC meeting date

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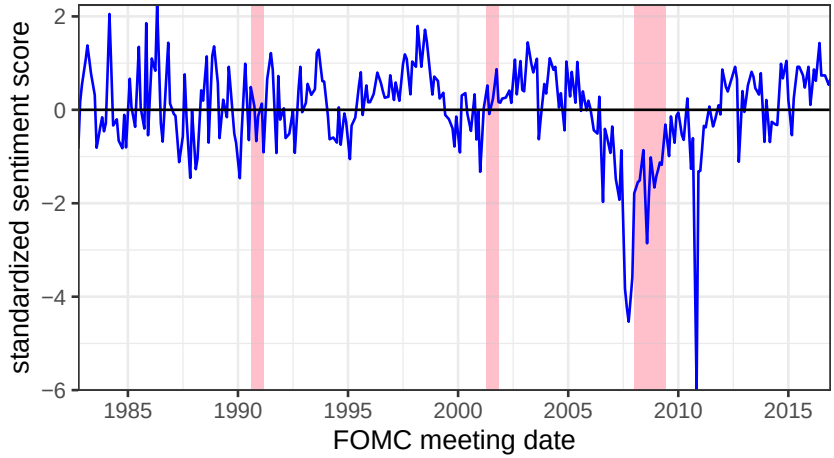
MORTGAGES



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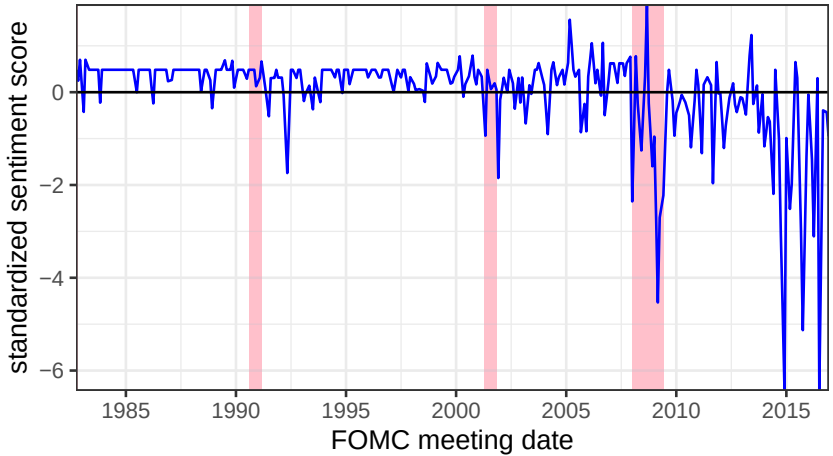
INFLATION EXPECTATIONS



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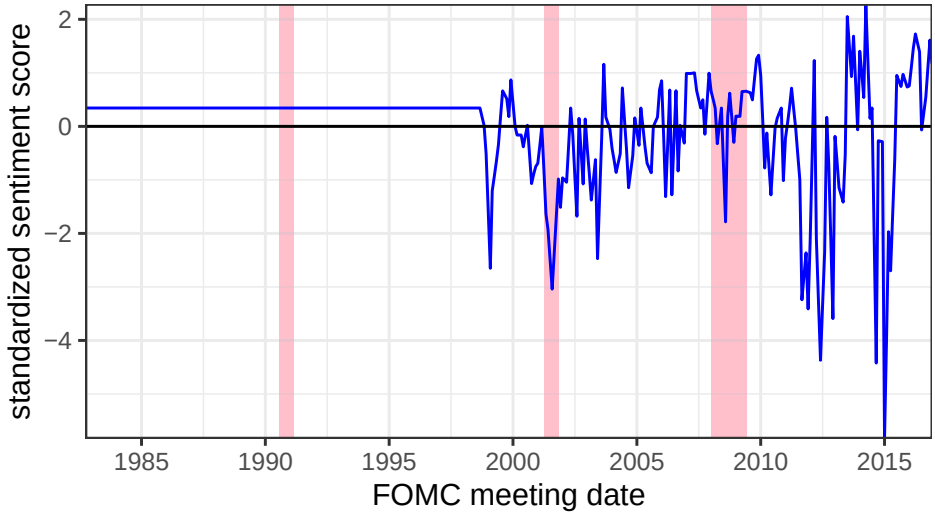
EURO AREA



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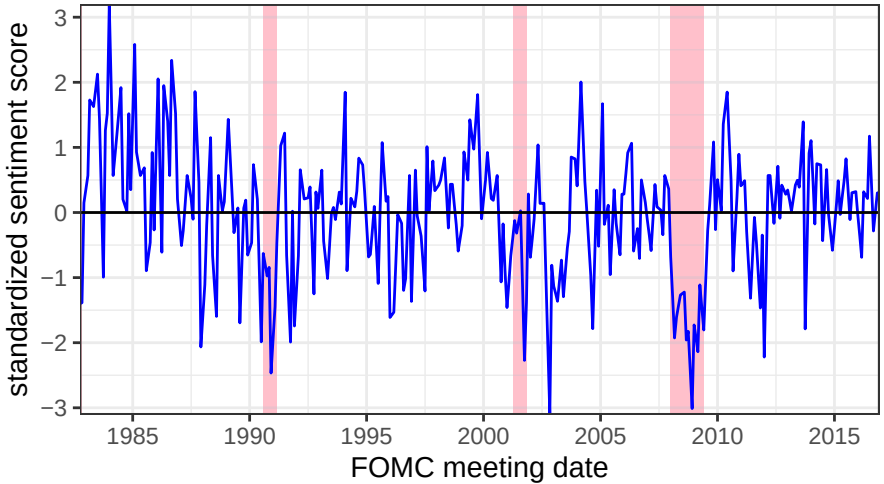
CONSUMPTION



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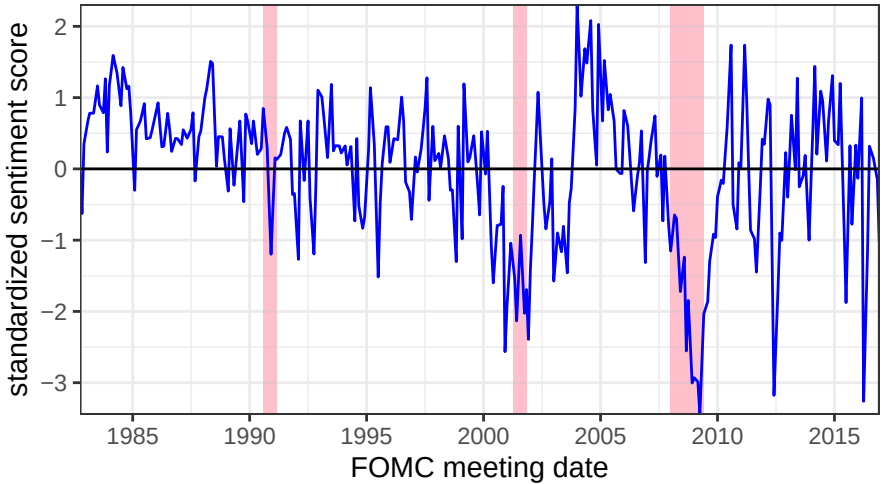
LABOR MARKET



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ADDITIONAL FORECAST ERROR RESULTS: OUTPUT GROWTH

	Panel (b): output forecast errors on LHS							
	current quarter	1 quarter ahead	1 year ahead	2 years ahead	current quarter	1 quarter ahead	1 year ahead	2 years ahead
First PC of all sentiments	0.121	0.411	0.540*	-0.171				
	[0.220]	[0.325]	[0.310]	[0.402]				
Economic activity sentiment					0.036	0.146	0.079	-0.485
					[0.228]	[0.272]	[0.251]	[0.403]
Constant	0.300*	0.139	-0.252	-0.380	0.298*	0.131	-0.268	0.442
	[0.167]	[0.276]	[0.340]	[0.750]	[0.163]	[0.299]	[0.374]	[0.717]
R-squared	0.005	0.030	0.049	0.003	0.000	0.003	0.001	0.021
Obs	206	204	198	54	206	204	198	54

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ADDITIONAL FORECAST ERROR RESULTS: INFLATION

	Panel (c): inflation forecast errors on LHS							
	current quarter	1 quarter ahead	1 year ahead	2 years ahead	current quarter	1 quarter ahead	1 year ahead	2 years ahead
First PC of all sentiments	0.148	0.170	0.142	-0.011				
	[0.101]	[0.133]	[0.173]	[0.164]				
Economic activity sentiment					0.263***	0.222*	0.236*	0.013
					[0.092]	[0.126]	[0.141]	[0.214]
Constant	-0.163	-0.136	-0.267	0.056	-0.167	-0.140	-0.271	-0.019
	[0.109]	[0.167]	[0.208]	[0.216]	[0.103]	[0.160]	[0.201]	[0.207]
R-squared	0.029	0.032	0.017	0.013	0.081	0.049	0.041	0.000
Obs	210	210	210	62	210	210	210	62

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