Identifying Monetary Policy Shocks: A Natural Language Approach

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MOTIVATION

▶ Goal: $\Delta i_t \overset{?}{\Rightarrow} Y_t$ Challenge: $\Delta i_t = f(\Omega_t) + \varepsilon_t$ where $Y_t \in \Omega_t$

▶ Romer and Romer (2004) run regression $\Delta i_t = \alpha + \beta i_{t-1} + \gamma X_t + \varepsilon_t^{RR}$

   ▶ X_t contains forecasts from FOMC "Greenbooks"

   ▶ With residuals $\hat{\varepsilon}_t^{RR}$ construct IRFs of Y_t

▶ Key assumptions

   1. Forecasts of Fed staff good approximation of information set Ω_t

   2. Linear specification good approximation of mapping $f(\cdot)$

   $\rightarrow$ this paper: both assumptions need to be revisited

THIS PAPER

- ▶ Aims to revive Romer and Romer (2004) using …

- ▶ Natural language processing:
  - ▶ Turn text in documents prepared for FOMC meetings into data

- ▶ Machine learning:
  - ▶ Include forecasts and large amount of text-based data in regression, also nonlinearly

- ▶ Including the additional information is <u>essential</u> for clean identification

PREVIEW OF FINDINGS

1. Systematic vs. exogenous monetary policy

   ▶ Original Romer-Romer: $R^2 = 0.5$ implies 50% of Δi are shocks
   ▶ Our approach: $R^2 = 0.94$

2. What are monetary policy shocks?

   ▶ FOMC decisions unrelated to staff's analysis – "surprises to the staff"
   ▶ E.g. based on non-systematic long-run credibility concerns
   ▶ Correlated with high-frequency surprises in market rates

3. Get theoretically consistent IRFs in updated sample

   ▶ $i \uparrow \;\Rightarrow\; Y \downarrow \;\; P \downarrow \;\; risk\,premia \uparrow \;\; SP500 \downarrow$
   ▶ Not the case for original Romer-Romer because forecasts lack relevant information

METHODOLOGY

STEP 1. PROCESS RAW TEXT

- ▶ Download documents for scheduled FOMC meetings
    - ▶ Beigebook & Tealbook A (earlier: Red- & Greenbook)

- ▶ Start in 1982, when Fed began targeting FFR as policy tool (Thornton, 2006)

- ▶ End in December 2016 ⇒ 276 FOMC meetings
  (some of subsequent analysis is pre-ZLB)

- ▶ Beigebook-only version allows us to extract shocks as FOMC meetings happen

STEP 2. IDENTIFY ECONOMIC CONCEPTS

▶ 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

▶ Select most frequently discussed economic concepts → final list amounts to 296
  combine/exclude

MOST FREQUENT ECONOMIC CONCEPTS

international_developments durable_goods
delinquency_rates productivity profits auto_sales reserves
manufacturing_activity deposits mexico financial_developments
trade_balance income current_account retail_sales domestic_demand
inflation_expectations industrial_production utilization euro_area
trade_deficit net_exports cpi recovery import_prices
home_sales investment hours borrowing yield nominal_gdp
brazil consumption gdp exports euro wages tourism
spread imports loans output credit lending
machinery china oil_prices liquidity
mortgage inflation equipment hiring stock_market
inventories employment japan housing energy_prices
canada weather residential_real_estate
commercial_real_estate labor_market commodity_prices
currencies germany structures leasing
vacancy_rates savings new_orders consumer_confidence
economic_growth compensation_per_hour

STEP 3. CONSTRUCT SENTIMENT

- ▶ Inspired by Hassan, Hollander, van Lent, and Tahoun (2022)

- ▶ Consider the 10 words before and after each concept's appearance

- ▶ Each *positive* word gives a score of $+1$ and each *negative* word of -1
    - ▶ Classification based on enhanced version of Loughran and McDonald (2011)

- ▶ Sum up scores within meeting and scale by total number of words

dictionary robustness

EXAMPLE: SENTIMENT AROUND "ECONOMIC ACTIVITY"
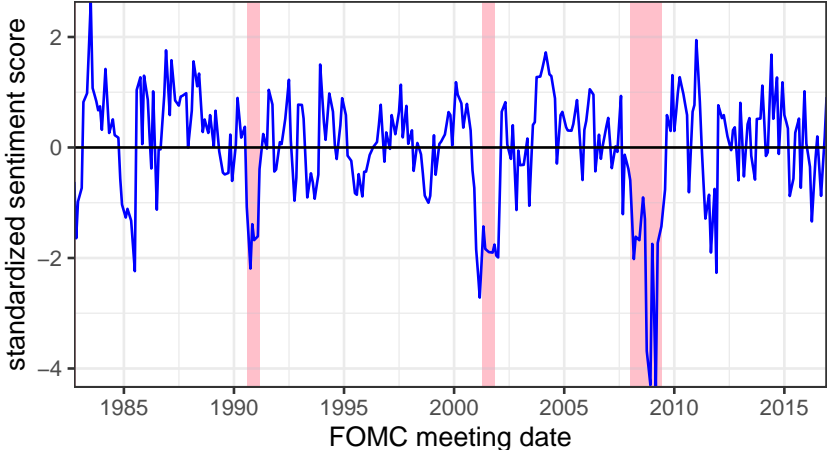
More

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: all variables, lags, differencing

- ▶ $\boldsymbol{Z_t}$: sentiment indicators with lags

- ▶ $\Gamma(\cdot)$ captures non-linearity → implement as linear-quadratic specification

- ▶ Curse of dimensionality: up to $3,226$ variables for 210 observations

- ▶ Solution: ridge regression

STEP 4. RUN RIDGE REGRESSION

▶ While OLS minimizes RSS, Ridge minimizes $RSS + \lambda \sum_n^N \beta_n^2$

  ▶ Giannone, Lenza, and Primiceri (2022): dense prediction techniques tend to be preferable for economic data

  ▶ Try alternatives, e.g. LASSO and general elastic net

▶ Optimally choose tuning parameter λ based on 10-fold cross-validation

  ▶ Maximizes 'out-of-sample' ability in different subsumples (folds)

▶ Fixed parameter ridge with large amount of information is flexible enough to also capture time-variation in the policy rule

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:

$$\text{Greenbook forecast of } X = E[X|\Omega]$$

DO SENTIMENT INDICATORS PROVIDE USEFUL INFORMATION?

▶ 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 $X \neq E[X|\Omega]$

  ▶ Information from sentiments needed to clean $\Delta i_t \rightarrow$ want higher R^2

| | 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* [0.016]	-0.114** [0.049]	-0.445** [0.190]	-0.622** [0.238]				
Economic activity sentiment					-0.026 [0.016]	-0.098** [0.048]	-0.285* [0.165]	-0.363** [0.171]
Constant	-0.019 [0.014]	-0.070** [0.033]	-0.082 [0.121]	0.059 [0.201]	-0.019 [0.014]	-0.069** [0.035]	-0.077 [0.145]	0.160 [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 (other variables)

▶ Interpretation: negative activity sentiment ⇒ positive error
  is consistent with negative sentiment capturing thicker upper tail

▶ Later: this affects whether IRFs to monetary policy shocks consistent with theory
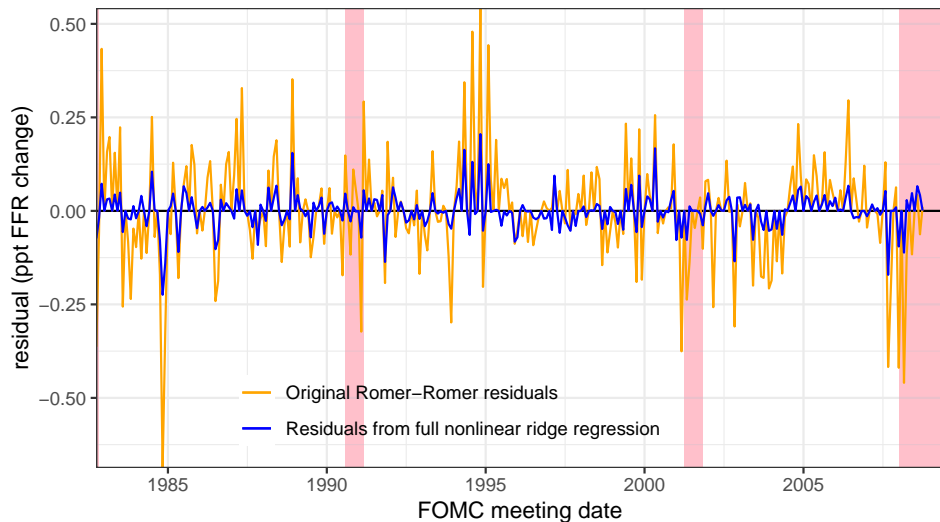
RESULTS OF THE IDENTIFICATION PROCEDURE

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 set of forecasts, human language, lags and nonlinearities all rise R^2

more details on rhs

ESTIMATED MONETARY POLICY SHOCKS

residual (ppt FFR change) vs FOMC meeting date. Orange line: Original Romer–Romer residuals. Blue line: Residuals from full nonlinear ridge regression.

Correlation: 0.83

WHAT ARE MONETARY POLICY SHOCKS?

- One might interpret shocks as "surprises to the staff"

- We provide case studies for meetings with largest estimated shocks

- We find that FOMC made decisions based on considerations not directly and **systematically** related to the economic outlook

- For **November 1994 meeting**, largest tightening shock in our sample:

  - Staff analysis suggests market had already built in a 50bp rate hike

  - Greenspan advocated a larger hike: "a mild surprise would be of significant value."

  - The other FOMC members agree and emphasize long-run credibility

  - Increase is 75bp, we estimate a 21bp contractionary shock

- ▶ Alternative: use surprise changes in <u>market</u> rates around FOMC announcements

    - ▶ Gürkaynak et al. (2005), Gertler and Karadi (2015), Swanson (2021)
    - ▶ Might contain "information effect" and "Fed response to news" (Nakamura and Steinsson, 2018; Miranda-Agrippino and Ricco, 2021; Bauer and Swanson, 2023)

- ▶ Our approach orthogonalizes changes in <u>target</u> FFR

- ▶ Practical considerations:

    - ▶ Our shocks available over longer sample, HF measures typically start in 1990's,
    - ▶ HF measures can be extracted from unscheduled meetings and speeches

- ▶ How do our shocks and surprises compare?

	(1)	(2)
	Our measure	**Original Romer-Romer**
Correlation shocks with surprises	0.49	0.36
Correlation top 10 shocks with surprises	0.77	0.61
Correlation top 10 surprises with shocks	0.51	0.18

Notes. Comparison with the FFR surprises constructed by Swanson (2021). These can directly be matched to our shocks and Romer-Romer shocks for scheduled FOMC meetings. The sample period covers 1991 to 2008.

▶ Our shocks more stongly correlated with surprises than original Romer-Romer

▶ Correlation generally higher for large shocks and large surprises graph

▶ Both methods yield imperfect measures for object of interest

WHY IT MATTERS:
THE EFFECTS OF MONETARY POLICY SHOCKS

SETTING TO ESTIMATE IRFS

▶ Directly follow monthly BVAR of Jarocinski and Karadi (2020)

▶ Shock series is 1982:10 to 2008:10, but can estimate BVAR to 2016

▶ System includes 1-year Treasury yield, log of the S&P500, log real GDP, unemployment rate, log GDP deflator, excess bond premium (EBP)

▶ Report 16th - 84th and 5th-95th percentiles

▶ Results similar with local projections approach (Jordà, 2005) (lp)

FULL NONLINEAR RIDGE VS. RR OLS
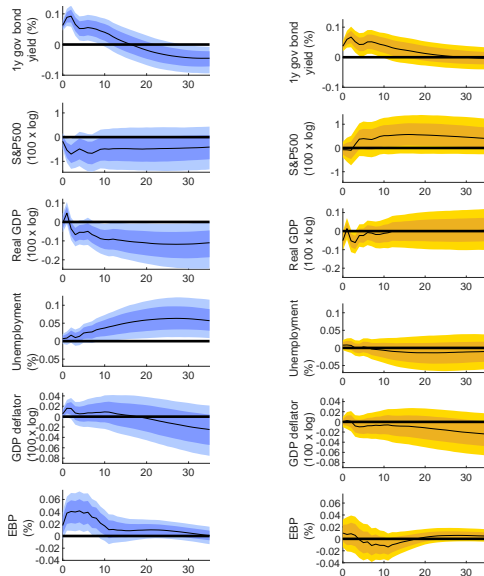
DIFFERENCES IN SHOCKS LINKED TO ERRORS IN MODAL FORECASTS
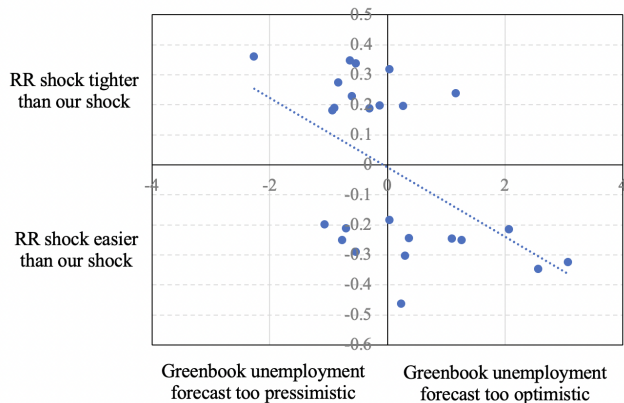
▶ When GB unemployment forecast error too optimistic (because mean > mode), Romer-Romer shock implies more easing than our shock

EXPLAINING THE IMPACT ON THE RESULTING IRFS

▶ Suppose for simplicity i_t is set based only on $\mathbb{E}(u_{t+1})$ and $\mathbb{E}(u_{t+1}) > mode(u_{t+1})$

▶ Predicting i_t with modal forecast of u_t only will imply an easing shock:
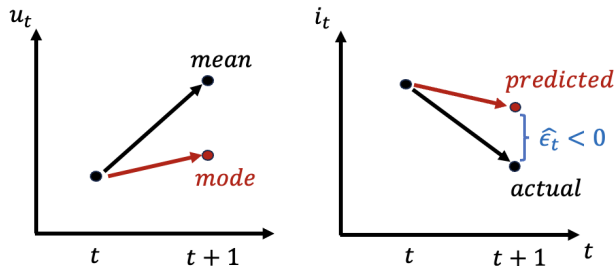
▶ But this means easing shocks are estimated when unemployment goes up!

▶ If these instances frequent enough in the sample, the resulting IRF will be incorrect

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
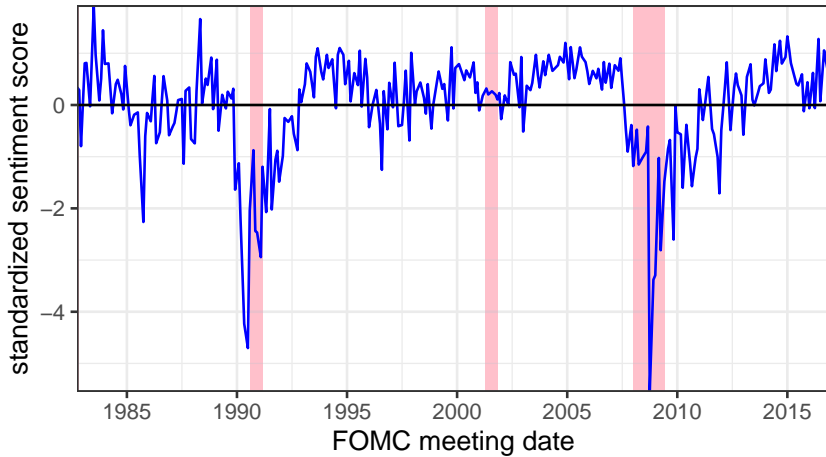
EXAMPLES OF POSITIVE AND NEGATIVE WORDS

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

ALTERNATIVE SENTIMENT CONSTRUCTION
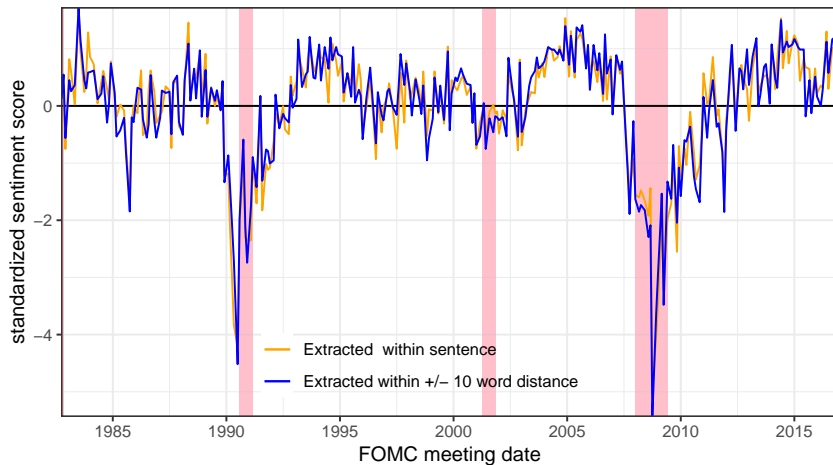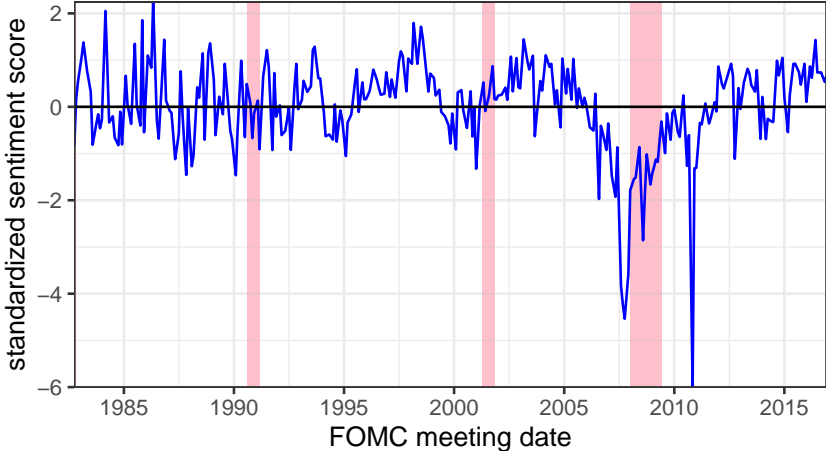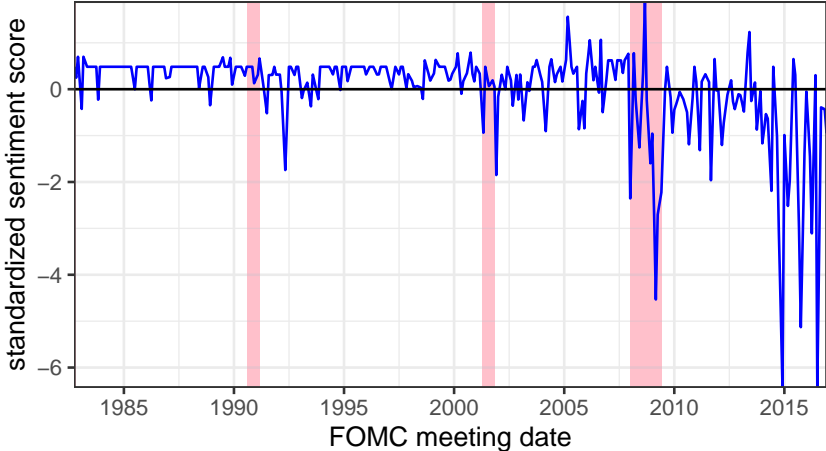
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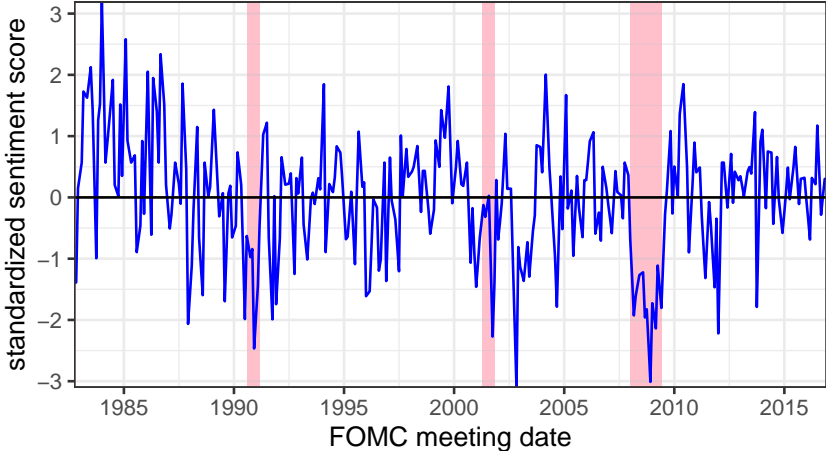
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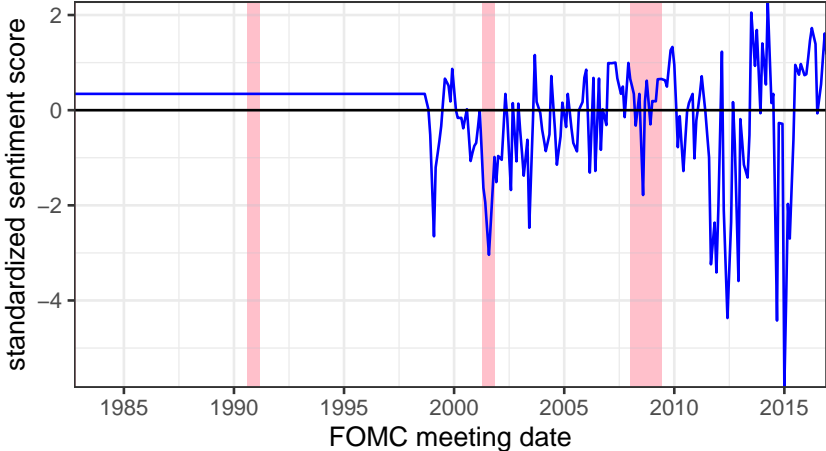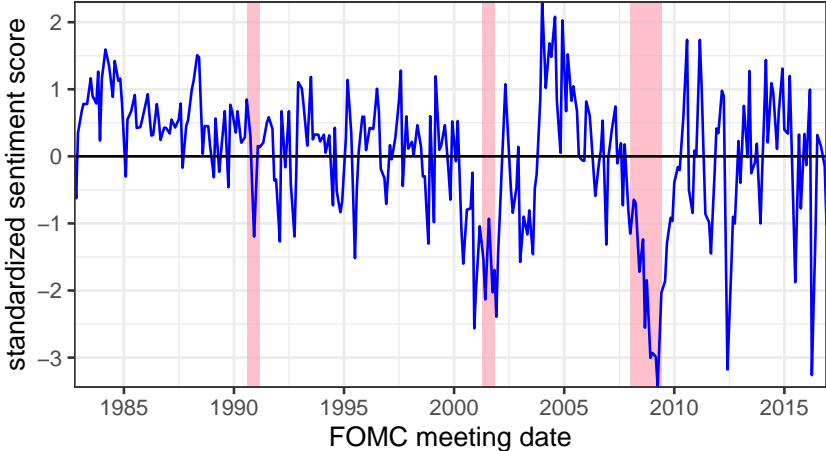
CONSUMPTION

LABOR MARKET

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

Back

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

Back

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

OUR MEASURE VS. HIGH FREQUENCY MEASURES
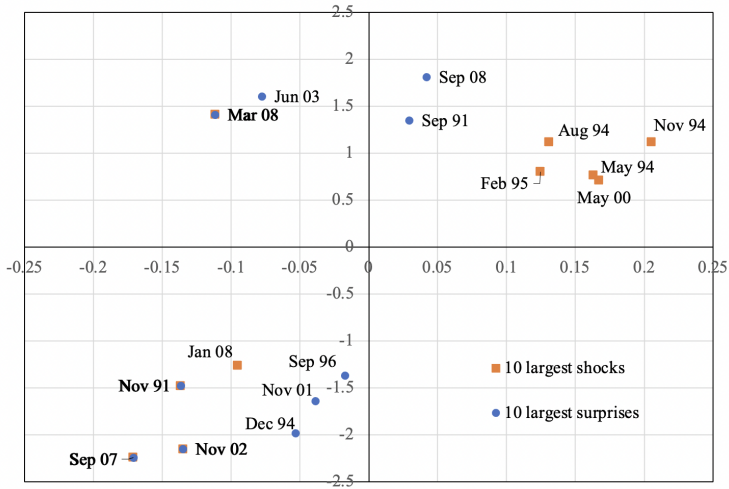
LOCAL PROJECTION RESULTS