Identifying Monetary Policy Shocks: A Natural Language Approach

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MOTIVATION

- Goal: $i_t \overset{?}{\Rightarrow} Y_t$ Challenge: $i_t = f(\ _t) + \varepsilon_t$ where Y_t 2 $_t$
- Romer and Romer (2004) run regression $i_t =\ +\ i_{t\ 1} +\ X_t + \varepsilon^{RR}_t$
  - X_t contains forecasts from FOMC "Greenbooks"
  - With residuals $\hat{\varepsilon}^{RR}_t$ construct IRFs of Y_t
- Key assumptions
  1. Forecasts of Fed staff good approximation of information set $_t$
  2. Linear specification good approximation of mapping $f(\ )$

! 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 essential for clean identification

preview of findings

1. Systematic vs. exogenous monetary policy
   - Original Romer-Romer $R^2 = 0:5$ implies 50% of i are shocks
   - Our approach: $R^2 = 0:94$

2. What are monetary policy shocks?
   - FOMC decisions unrelated to sta 's analysis { \surprises to the sta "
   - 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 ") Y # P # risk premia " SP500#
   - 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 $\Rightarrow$ 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 in ation ..." gives a triple, two doubles and three singles
  - \... in ation 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

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

$$i_t = \quad + \; i_{t\ 1} + \; (\; \hat{X}_t; Z_t) + \; "_t$$

- $\hat{X}_t$: numerical forecasts: all variables, lags, di erencing
- Z_t: sentiment indicators with lags
- $(\ )$ captures non-linearity $\Rightarrow$ implement as linear-quadratic speci cation

- 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 + $\sum_{n=1}^{N} \beta_n^2$
  - 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 based on 10-fold cross-validation
  - Maximizes `out-of-sample' ability in different subsamples (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 sta 's forecasts alone ...
  - ... IF forecast for variable of interest incorporates available information e ciently
  - Argument relies on:

$$\text{Greenbook forecast of } X = E[X \mid \mathcal{I}]$$

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 e ort 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, $X_{s,t} \neq E[X_j]$
  - Information from sentiments needed to clean i_t ! want higher R^2

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 sentime other variables
- Interpretation: negative activity sentiment) positive error is consistent with negative sentiment capturing thicker upper tail
- Later: this a ects 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 speci cation)	(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 i 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

Correlation: 0.83

what are monetary policy shocks?

- One might interpret shocks as \surprises to the sta "
- We provide case studies for meetings with largest estimated shocks
- We nd 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:
  - Sta analysis suggests market had already built in a 50bp rate hike
  - Greenspan advocated a larger hike: \a mild surprise would be of signi cant value."
  - The other FOMC members agree and emphasize long-run credibility
  - Increase is 75bp, we estimate a 21bp contractionary shock

our measure vs. high frequency measures

- Alternative: use surprise changes in market 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 target 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?

our measure vs. high frequency measures

	(1) Our measure	(2) 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 surp 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 de ator, excess bond premium (EBP)
- Report 16th - 84th and 5th-95th percentiles
- Results similar with local projections approach (Jorda, 200 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 $E(u_{t+1})$ and $E(u_{t+1}) > \text{mode}(u_{t+1})$
- 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

conclusion

- Classic question in macroeconomics: what are the e ects 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 e ects on activity, in ation, 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 su ciently 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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examples of positive and negative words

Positive	Negative
adequate	adversely
advantage	aggravate
bene t	bad
boost	burdensome
con dent	collapse
conducive	concerning
desirable	decline
diligent	de cient
encouraging	eroded
excellent	exacerbate
...	...

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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): in ation 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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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
rms	0.139	merchandise	0.140	output growth (0)	0.175
economic activity	0.136	foreign economies	0.135	bus. xed 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 rms	0.130	cash	0.125	nominal output growth (+1)	0.153
labor market	0.125	core in ation	-0.124	housing starts (+1)	0.151
services	0.123	industrial production	0.123	housing starts (+2)	0.150
consumer con dence	0.118	trade de cit	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 nancial variables

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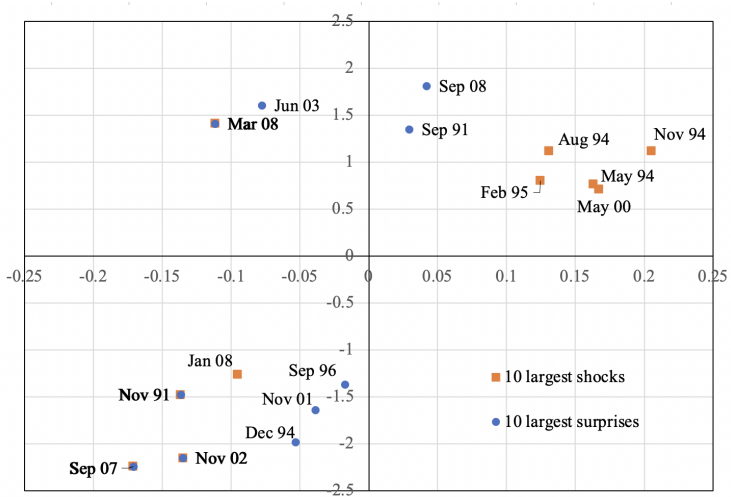
OUR MEASURE VS. HIGH FREQUENCY MEASURES



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