Shocks to Inflation Expectations

IMF Research Seminar, July 27 2022

Jonathan J. Adams [1] Philip Barrett [2]

[1]University of Florida

[2]Research Department, IMF

Motivation

"The 1970s saw two periods in which there were large increases in energy and food prices, raising headline inflation for a time. [...] One likely contributing factor was that the public had come to generally expect higher inflation—one reason why we now monitor inflation expectations so carefully."

Jerome Powell, August 27, 2021

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  - What are the quantitative effects?
  - How can we identify changes to expectations?
  - What does it mean for "inflation expectations" to drive anything?

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  - Responsible for sizeable share of business cycle and interest rate volatility
- Discuss possible resolutions to the puzzle

Related Work

- VAR-based estimation of shocks to information/expectations:
  - News: Beaudry and Portier (2006), Barsky and Sims (2011), many more (see Beaudry and Portier (2014) survey)
  - Noise: Forni et al (2017), Gazzani (2020), Chahrour and Jurardo (2021)
  - Sentiments (mostly GDP): Milani (2011), Barsky and Sims (2012), Fève and Guay (2019), Levchenko and Pandalai-Nayar (2020), Clements and Galvao (2021), Lagerborg et al (2021)

- Micro-level shocks to inflation expectations: Armantier et al. (2016), Cavallo et al. (2017), Coibion et al (2018, 2020), Rosiolia (2021)

- Evidence of non-rational inflation forecasting: Massive literature. Some surveys: Coibion et al (2018), D'Acunto et al (2022), Weber et al (2022)

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- Empirical vs. theoretical discord:
  - Does inflation tend to rise when measured expectations increase?
  - Not so obvious...

Defining Sentiments and Shocks

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$$\pi_t^{e,1} = \mathbb{E}_t[\pi_{t+1}] + \zeta_t$$

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- Inflation sentiments may be persistent; driven by exogenous expectation shocks

Priors: Inflation Sentiments in the New Keynesian Model

- The canonical New Keynesian Model:

New Keynesian Phillips curve:	$\pi_t = \beta \pi_t^{e,1} + \kappa y_t$
Euler equation:	$i_t = \mathbb{E}_t[\gamma(y_{t+1} - y_t)] + \pi_t^{e,1}$
Taylor rule:	$i_t = \phi_y y_t + \phi_\pi \pi_t$

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- Inflation sentiment has two channels: firms (NKPC) and households (Euler)
- Easiest to build intuition from the static model

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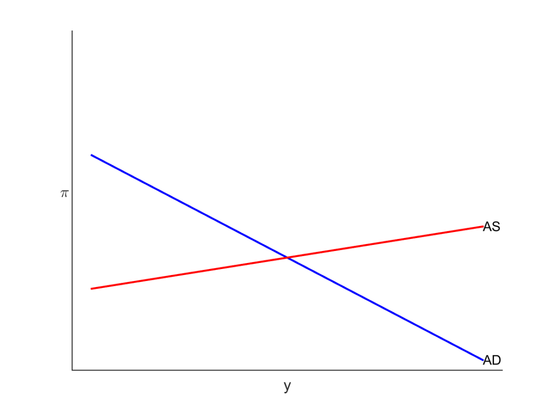
- Eggertson-Krugman style reduction:

"AS"	$\pi_t = \beta\zeta_t + \kappa y_t$
"AD"	$\phi_\pi \pi_t = -(\phi_y + \gamma) y_t + \zeta_t$

Priors: New Keynesian Response to a Sentiment Shock



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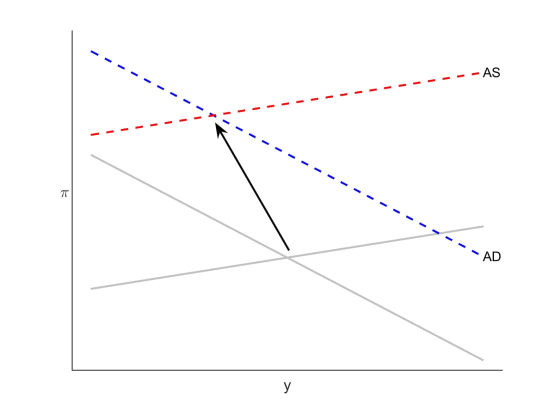

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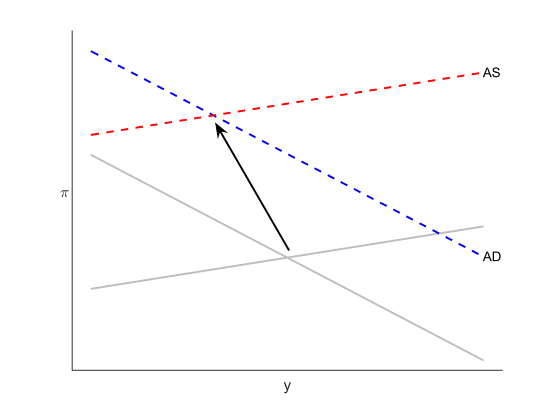

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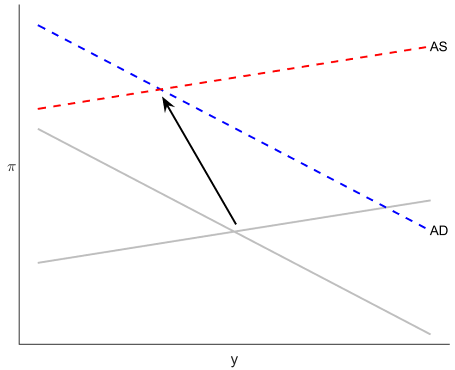

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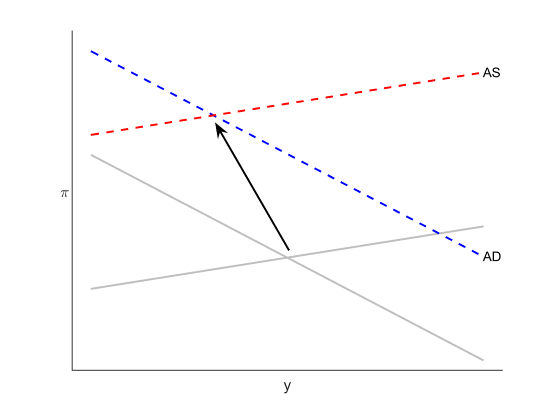

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- Central bank: $i\uparrow$, $y\downarrow$ (typical Taylor rule)

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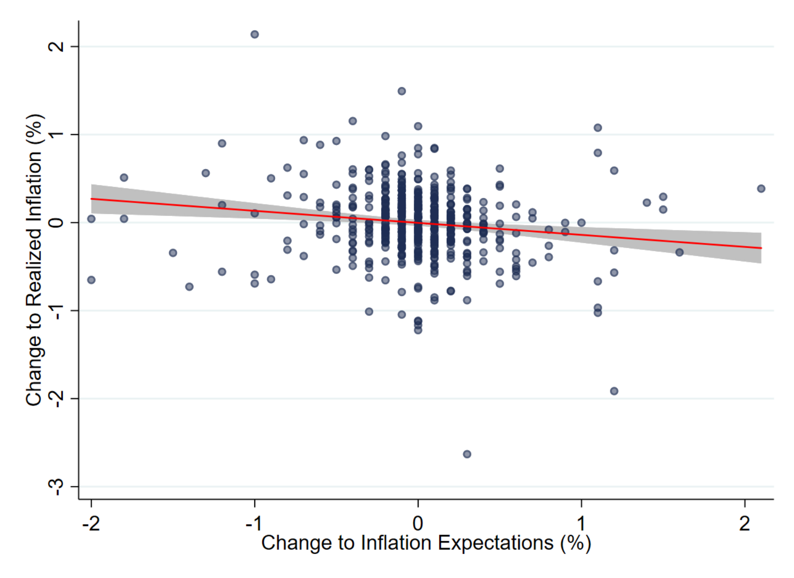
  - ... to month-over-month change in one-year-ahead realized inflation

Priors: Expected vs. Realized Inflation



Identification

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- Challenges:
  - The sentiment affects many other time series
  - $\implies$ the shock affects both the sentiment and the rational component

- Luckily, there is just enough structure to identify the shock!

Basic VAR structure

- Stack horizon h forecasts f_t^h, inflation π_t, n other series x_t:

$$\begin{pmatrix} f_t^h \\ \pi_t \\ x_t \end{pmatrix} = B \begin{pmatrix} f_{t-1}^h \\ \pi_{t-1} \\ x_{t-1} \end{pmatrix} + A\varepsilon_t$$

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- A has $(n+2)^2$ entries, Σ has $(n+3)(n+2)/2$ unique entries

Partitioning and Rational Expectations

- Given reduced form IRF ϕ_π^h, the rational expectation is

$$\mathbb{E}[\pi_{t+h}^h|\varepsilon_t] = \phi_\pi^h A \varepsilon_t$$

- Subdivide $\varepsilon_t = \begin{pmatrix} \varepsilon_t^S \\ \varepsilon_t^F \end{pmatrix}$ into $n+1$ "fundamental" shocks ε_t^F, and the "sentiment" shock ε_t^S
- Partition matrix A to match::

$$A = \begin{pmatrix} A_f^S & A_f^F \\ A_c^S & A_c^F \end{pmatrix}$$

Identifying Restrictions

Identifying assumption

The sentiment shock ε_t^S is the only contemporaneous shock that causes forecasts to deviate from rational expectations.

$\implies$ the effect of fundamental shocks on forecasts is exactly the effect on the rational expectation:

$$A_f^F = \phi_\pi^h \begin{pmatrix} A_f^F \\ A_c^F \end{pmatrix}$$

$$= (1 - \phi_{\pi,f}^h)^{-1} \phi_{\pi,c}^h A_c^F$$

Identifying Restrictions cont.

- Impose restriction on A:

$$A = \begin{pmatrix} A_f^S & (1-\phi_{\pi,f}^h)^{-1}\phi_{\pi,c}^h A_c^F \\ A_c^S & A_c^F \end{pmatrix}$$

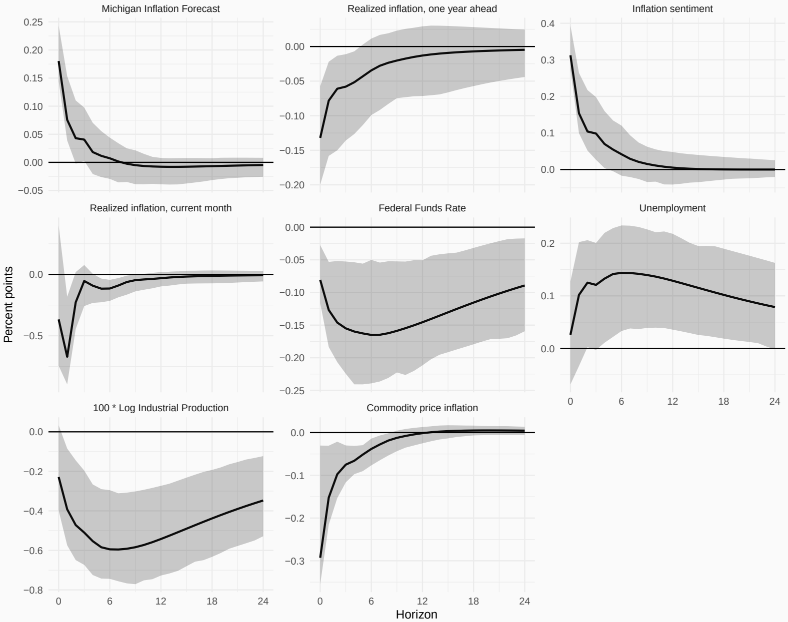
- This is enough to pin down A_f^S, A_c^S!

- A_c^F generally not identified; any unitary transformation of fundamental shocks is valid, but does not affect A_f^S, A_c^S. $\implies$ can *only* identify the sentiment shock

Regressions

Data

- Baseline: US data, as standard as possible
  - Follow Coibion (2012) (monthly analogs of Cristiano et al 1999)
  - CPI inflation, commodity PPI, industrial production, unemployment rate, FFR
  - *plus* one-year-ahead inflation forecast (Michigan Survey)
  - Jan. 1982 - May 2022
  - AIC lag selection
- But, it is crucial to get specification/expectations right
- Many robustness exercises with alternative forecasts, q. frequency + longer sample, bigger VARs, local projections, machine learning, etc.



Baseline VAR

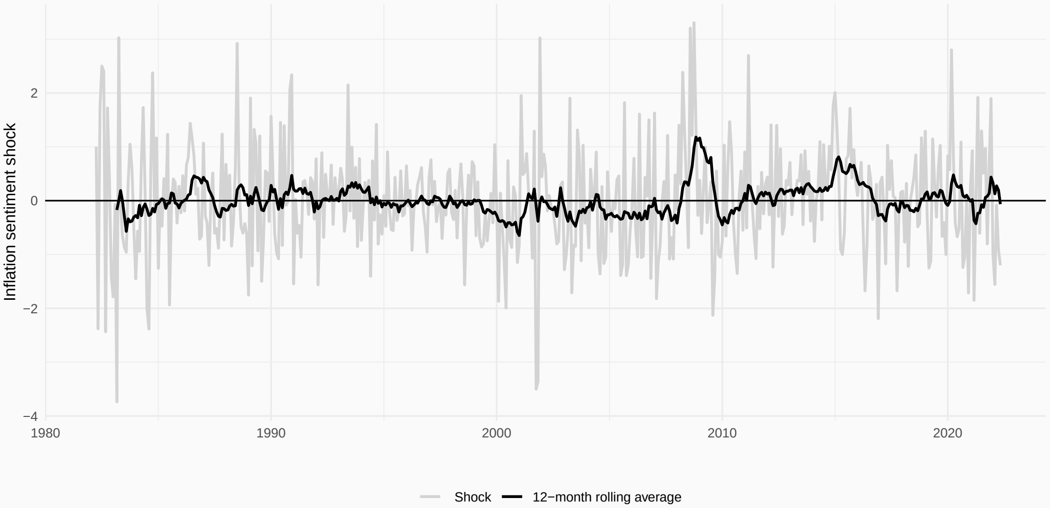
IRFs to 1 std dev sentiment shock.

Bootstrapped 90 % C.I.

Inflation, FFR in annualized units

$\pi \downarrow$, $y \downarrow$, $i \downarrow$

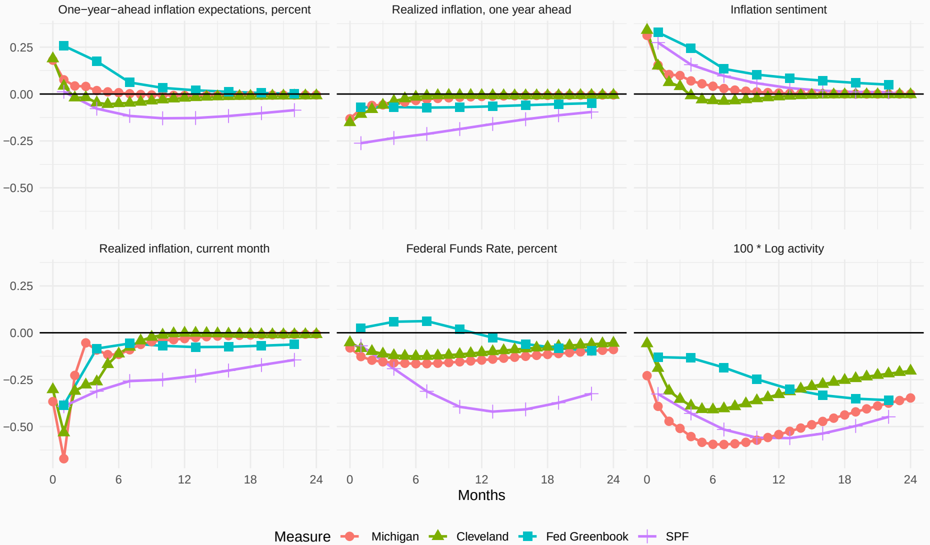
Identified Inflation Sentiments



Robustness: Alternative Forecast Measures

- Michigan Survey asks households (notoriously poor forecasters)
- Alternative forecasts:
  - Private Economists: Survey of Professional Forecasters (quarterly since 1968)
  - Central Bank: Fed Greenbook ($\sim$6-weekly since 1966)
  - "Markets": Cleveland Fed expectations measure (monthly since 1982)

Alternative Forecast Measures: Mostly Similar



Robustness: Alternative Forecast Measures cont.

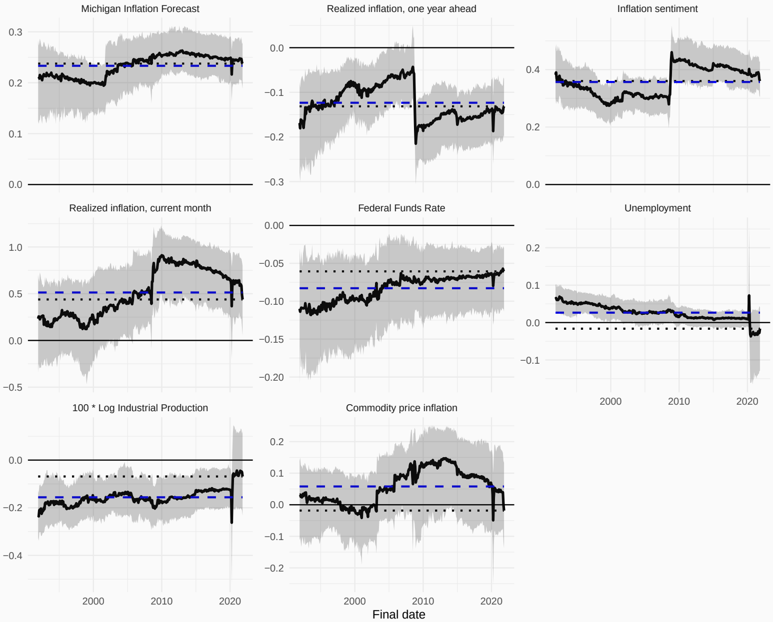
- $\pi \downarrow$, $y \downarrow$, $i \downarrow$ seems robust to how we measure expectations
- Exception is the Fed's sentiment: $\pi \downarrow$, $y \downarrow$, $i \uparrow$ looks like a policy mistake
- In all cases, sentiment shocks are important drivers of business cycles.
- ... but magnitude varies by measure

Alternative Forecast Measures: Variance Decomposition

	Michigan	Cleveland	SPF	Fed Greenbook
100 * Log activity	0.32	0.09	0.56	0.37
	(0.17, 0.51)	(0.02, 0.26)	(0.32, 0.97)	(0.08, 0.69)
Federal Funds Rate	0.18	0.09	0.42	0.15
	(0.03, 0.40)	(0.01, 0.28)	(0.16, 0.71)	(0.05, 0.43)
Realized inflation	0.09	0.17	0.62	0.33
	(0.03, 0.18)	(0.09, 0.25)	(0.34, 0.92)	(0.09, 0.60)
Year-ahead inf. exp.	0.22	0.12	0.46	0.15
	(0.08, 0.39)	(0.06, 0.21)	(0.16, 0.70)	(0.04, 0.38)

Robustness: Identification without the Benefit of Hindsight

- We estimate rational expectations using the entire sample, but forecasters at the time have less information
- *Learning-robust estimates*: rational expectation at time τ only using information available at τ
- Implies time-specific matrix A_τ; gives time-varying estimates of instantaneous shock impacts
- Sample average is the *learning-robust estimate* of contemporaneous effects



Time-Varying Shock Impacts

Solid: time-specific

Dashed: learning robust

Dotted: baseline

$\pi\downarrow, y\downarrow, i\downarrow$

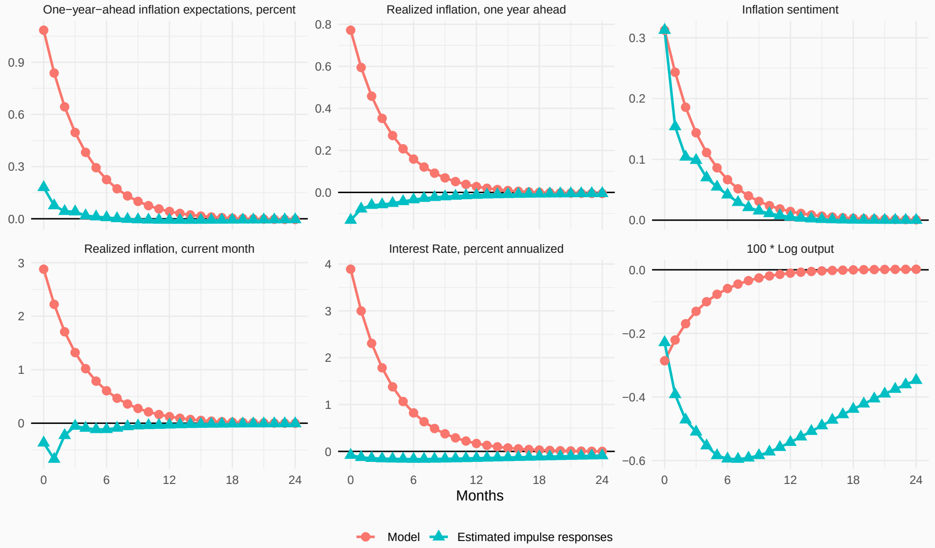
Robustness to Model Selection: Mostly Similar

- The conventional VAR is probably misspecified. What else should be included?
- We consider 26 additional macro time series. But cannot simply include all without overfitting
- Methods:
  - Factor-augmented VARs (FAVARs) ▸ IRFs
  - Machine learning approaches ▸ IRFs
- Find $\pi \downarrow$, $y \downarrow$, $i \downarrow$, but:
  - For some methods, output only declines after 1-3 month lag
  - FFR decline probably not as large as in baseline

Comparison to the New Keynesian Model: A Puzzle

- How do our results compare to a standard model?
- Stochastic process for inflation sentiment that matches our estimates
- Otherwise (mostly) canonical NK model, standard calibration
- Include a bevy of shocks to diagnose our ability to identify the sentiment

Inflation Sentiment Shock: Dynamic NK Model vs. Baseline VAR



Expectations Passthroughs and Multiplier

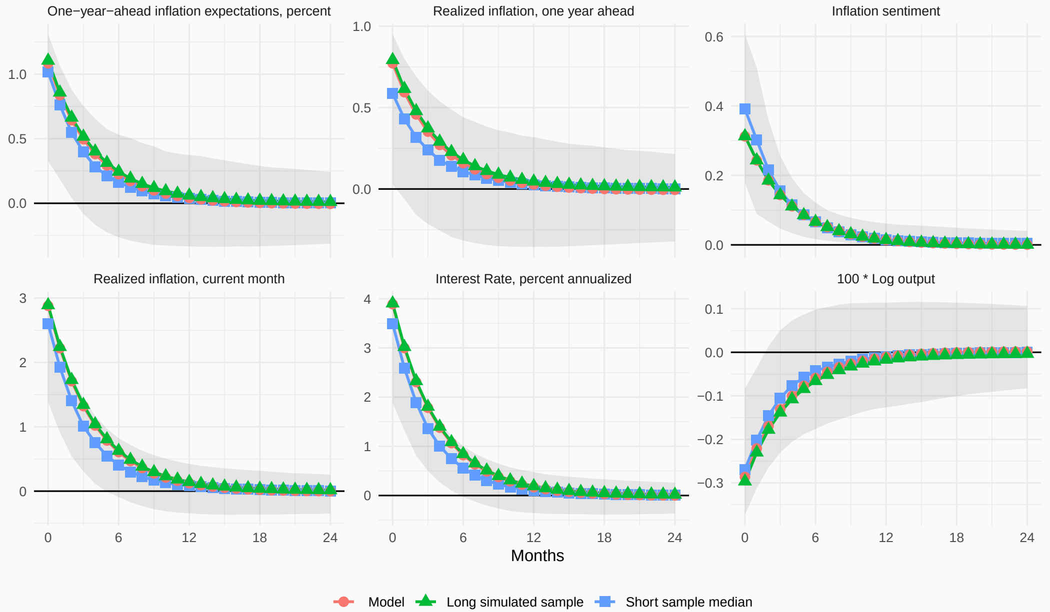
- The "expectations multiplier": how much does a shock to the sentiment affect the equilibrium expectation?
  - NK model: > 1
  - Our estimates: ~ 0.7
- The "future expectations passthrough": how much does a change in expectations affect future inflation?
  - NK model: $>> 0$
  - Our estimates: < 0
- The "immediate expectations passthrough": how much does a change in expectations affect contemporaneous inflation? (Werning 2022)
  - NK model: $>> 0$
  - Our estimates: ~ 0.33, but imprecisely estimated

Validation: The Method Works

- Does our identification strategy work on simulated data from the model?
- Include many additional shocks: TFP, monetary policy, discount factors, noise shocks
- Discount factor shocks are a problem for existing approaches
- Noise shocks also affect expectations, but through the rational channel. Agents observe noisy signal υ_t of future productivity shock ε_{t+1}:

$$\upsilon_t = \varepsilon_{t+1} + \nu_t$$

- Estimate VAR for realistic short samples



One−year−ahead inflation expectations, percent
Realized inflation, one year ahead
Inflation sentiment
Realized inflation, current month
Interest Rate, percent annualized
100 * Log output
Months
Model
Long simulated sample
Short sample median

Possible Resolutions

Possible Resolutions

A few extensions to generate $\pi \downarrow$, $y \downarrow$, $i \downarrow$:

1. Let the sentiment shock affect output expectations too
   - Assume irrational pessimism about inflation and income are connected
   - Requires a sufficiently large effect
   - Difficult for us to test in current framework; we can identify a single sentiment
2. Relax the Taylor principle

Possible Resolution: Output Sentiments

- Modify NK model, let sentiment ζ_t affect output expectations with $\varphi > 0$:

$$y_t^{e,1} = \mathbb{E}_t[y_{t+1}] - \varphi\zeta_t$$

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- Euler equation is now:

$$i_t = \gamma(y_t^{e,1} - y_t) + \pi_t^{e,1}$$

$$= \gamma(\mathbb{E}_t[y_{t+1}] - \varphi\zeta_t - y_t) + \mathbb{E}_t[\pi_{t+1}] + \zeta_t$$

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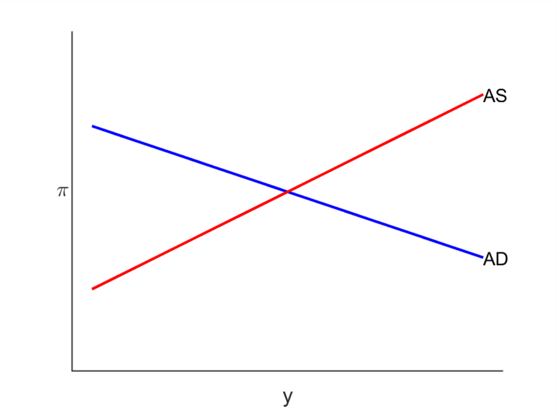
- Static system becomes:

"AS"	$\pi_t = \beta\zeta_t + \kappa y_t$
"AD"	$\phi_\pi \pi_t = -(\phi_y + \gamma)y_t + (1 - \varphi\gamma)\zeta_t$

Resolution? New Keynesian Response to a Joint Sentiment Shock



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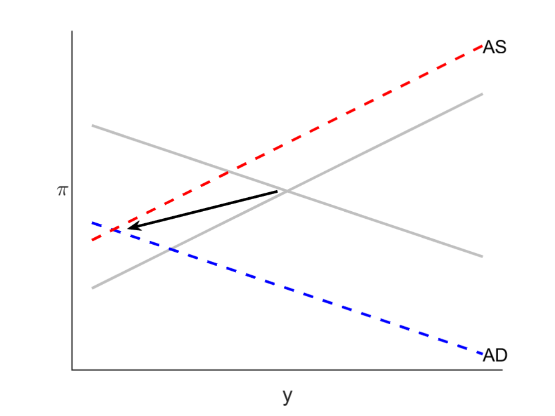

- Same effect on AS curve

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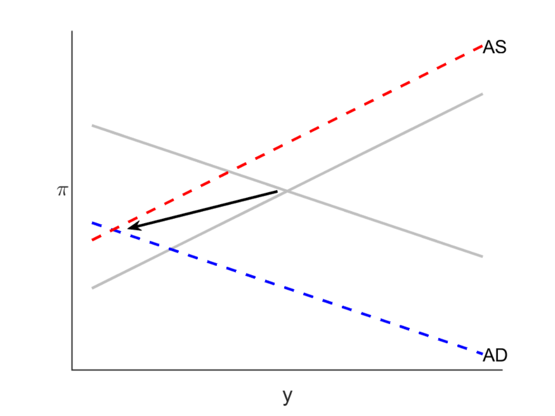

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- Households expect inflation *and large income decline*: AD curve curve shifts down

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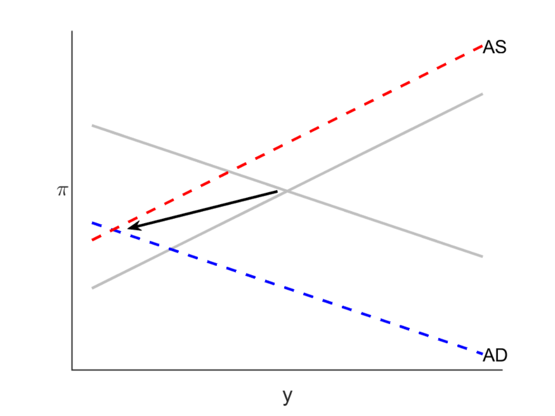

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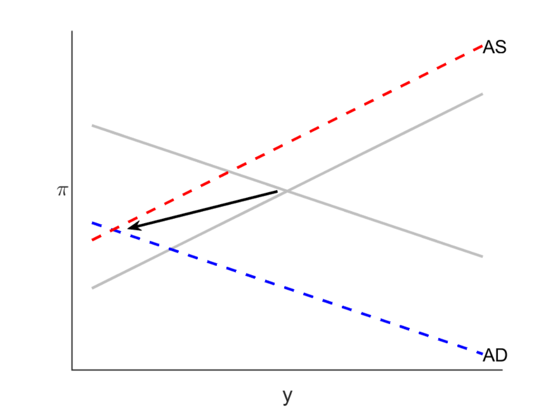
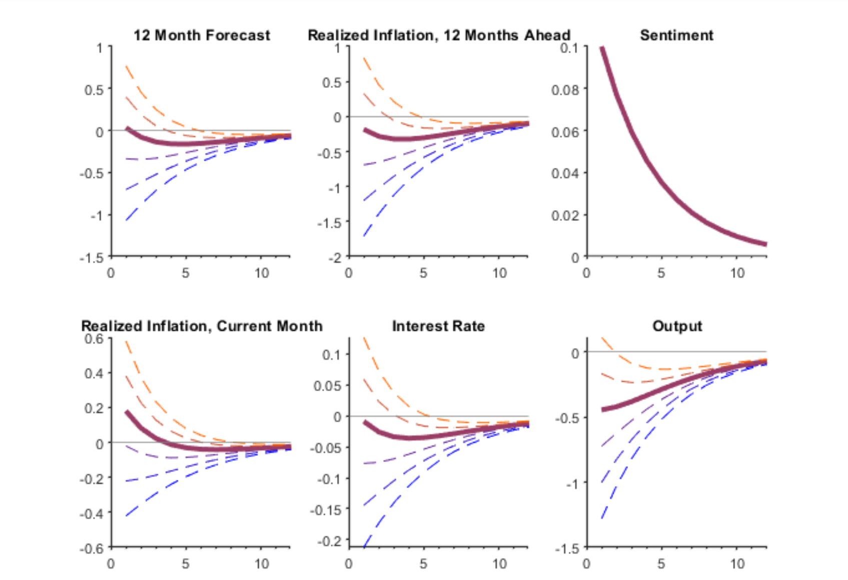


- Same effect on AS curve
- Households expect inflation *and large income decline*: AD curve curve shifts down
- Central bank responds to deflation/recession by lowering interest rates
- Summary: $\pi \downarrow$, $y \downarrow$, $i \downarrow$

Possible Resolution: Relaxing the Taylor Principle

- Sufficiently passive monetary policy yields multiple equilibria
- Suppose that some mechanism other than monetary policy selects the equilibrium (e.g. active fiscal policy)
- Are there alternative equilibria that resemble our results?

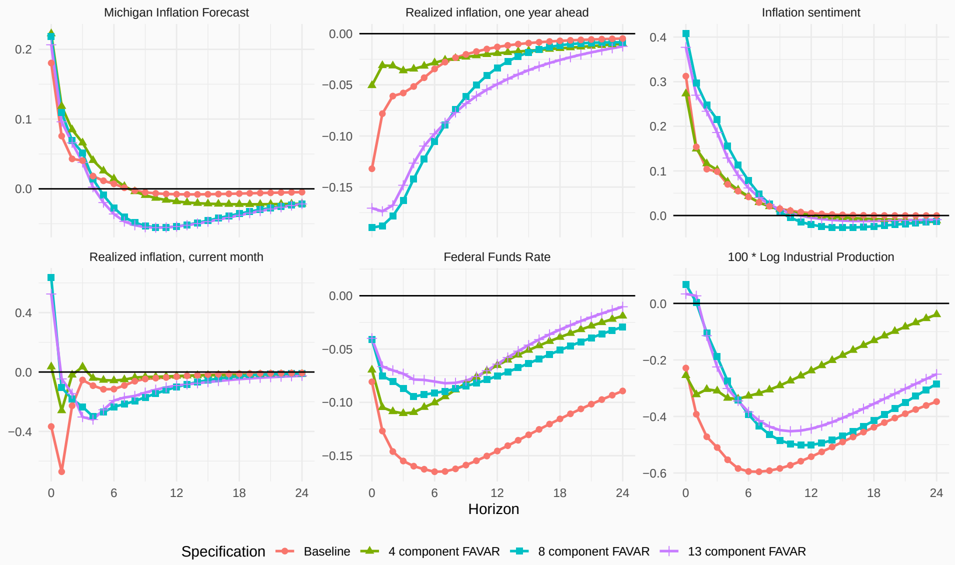
Multiple Equilibria when Taylor Principle is Relaxed



Conclusion

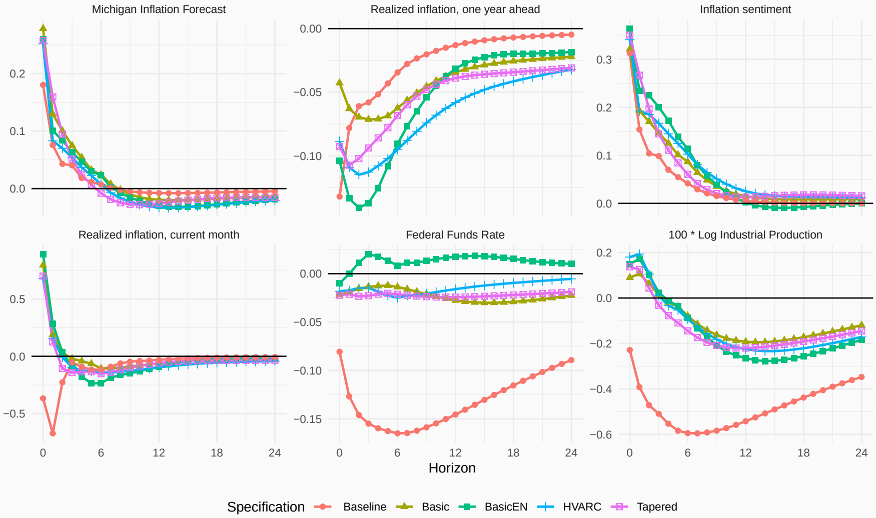
Conclusion

- We developed a new VAR approach for identifying shocks to expectations
- Many possible applications!!
- Using inflation forecasts, we find that a shock increasing inflation forecasts causes $\pi \downarrow$, $y \downarrow$, $i \downarrow$
- Surprising, given standard NK model. We have some hypotheses... much more to be done!



Michigan Inflation Forecast
Realized inflation, one year ahead
Inflation sentiment
Realized inflation, current month
Federal Funds Rate
100 * Log Industrial Production
0.2
0.1
0.0
0.00
−0.05
−0.10
−0.15
0.4
0.3
0.2
0.1
0.0
0.4
0.0
−0.4
0.00
−0.05
−0.10
−0.15
0.0
−0.2
−0.4
−0.6
0
6
12
18
24
Horizon
Specification
Baseline
4 component FAVAR
8 component FAVAR
13 component FAVAR

Back



"Basic": VAR coefficients selected by LASSO; "BasicEN": LASSO, but with an elastic net loss function; "HVARC": Component-wise lag-length; "Tapered": Lag-weighted LASSO

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