Attention-Driven Sentiment and the Business Cycle

Rupal Kamdar
Indiana University

Walker Ray
Chicago Fed & CEPR

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Johns Hopkins University

Motivation

Expectations Matter

- Economic decisions are based on agents' perceptions and expectations
- Yet, the expectation formation process is still not fully understood
- Surveys of consumer beliefs reveal many puzzling features relative to FIRE

This Paper

- Document new facts about consumer beliefs: single factor, stagflationary beliefs
- Develop a TANK model with rational inattention to explain these facts and assess aggregate implications
- Provide evidence for the model's mechanism: attention-based, supply-side views

Preview: Single Factor Model and Stagflationary Beliefs

Single Factor Model

- Use survey data to show consumer beliefs are well-described by a single factor
- This factor behaves like sentiment where "optimistic" consumers forecast typical expansionary outcomes:
    - Falling unemployment and improving business conditions
    - Improving personal financial conditions
    - Forward- and backward-looking beliefs

Stagflationary Beliefs

- Lower "sentiment" is associated with higher inflation expectations
- $\Rightarrow$ The positive correlation in inflation and unemployment expectations are a reflection of the broader single factor phenomena (Kamdar 2019; Candia et al 2024)

Preview: TANK Model

Model Overview

- We develop a TANK model where rationally inattentive consumers face fundamental uncertainty about demand and supply shocks
- Optimal information-gathering economizes on information costs and compresses the dimensionality of consumer beliefs
- We derive conditions under which households relying on labor income
  - Optimally devote more attention to supply shocks
  - Thus, inflation is perceived as countercyclical

Dynamics

- HtM agents $\Rightarrow$ aggregate consumption reacts more to demand shocks than in RANK
- Inattention $\Rightarrow$ inattentive agent decisions underreact relative to full-information
- However, when inattentive hand-to-mouth agents make active decisions about labor supply, consumption can overreact to demand shocks $\Longrightarrow$ additional amplification

Preview: Tests of the Model Mechanism

Test the key model mechanism: attention-based supply-side view of the economy

Attention

- More "inattentive" consumers have a more stagflationary view

Supply-Side Reasoning

- Consumers who give supply-side explanations for their beliefs have a more stagflationary view

Sentiment Response to Shocks

- In local projections, beliefs reacts to supply shocks but not demand shocks

Single Factor, Stagflationary Beliefs

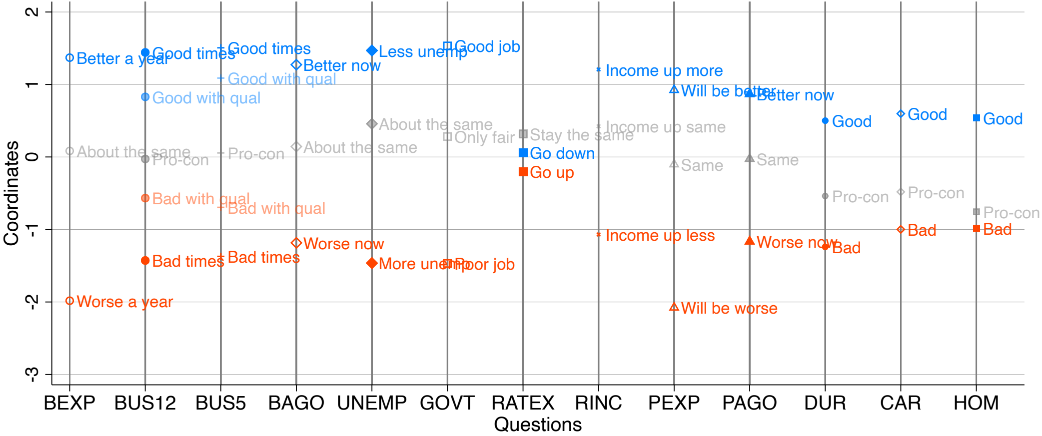
Survey Data

Michigan Survey of Consumers (MSC)

- Monthly, consumer survey of ≈ 500 (1978-present)
- Rotating panel (up to 2x)
- Questions about aggregate and personal economic conditions (forward- and backward-looking)
- Most questions have categorical answers
  - Inflation expectations and a few others are numerical
- Results are similar using the NY Fed Survey of Consumer Expectations

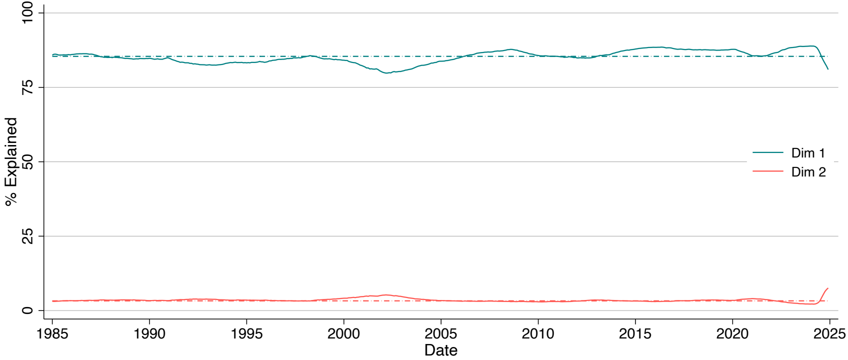
Consumers: MCA Estimated Loadings of First Component

- Baseline MCA: include all categorical questions asked continuously since 1980
- Responses associated with more traditionally "optimistic" outlooks have high and positive loadings (blue); and "pessimistic" responses have negative loadings (red)



Consumers: One-Factor Belief Structure

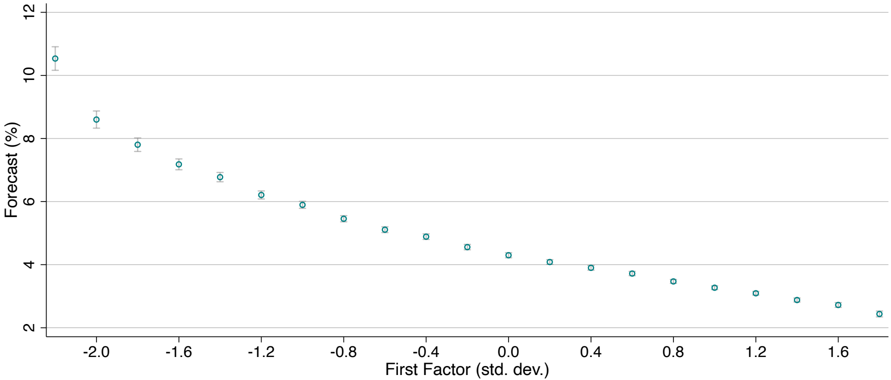
- The first component (sentiment) explains over 80% of the variation (dashed line)
- This is also true if we use rolling window MCAs (solid line)



- Estimating the MCA on demographic subgroups yields similar results in terms of (i) fraction explained and (ii) the correlation with our baseline MCA

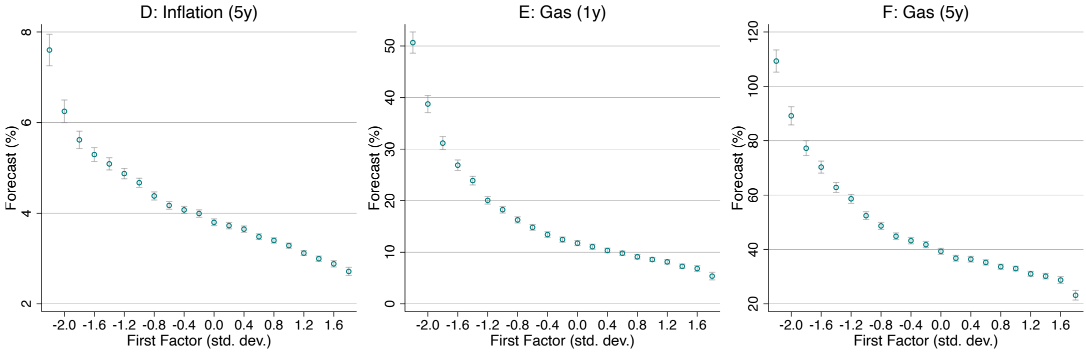
Stagflationary Beliefs: Short-Run Inflation

- The first factor (sentiment) is predictive of expected inflation
- Optimistic consumers have lower $E_{i,t}[\pi_{t+12}]$ (and vice versa) $\Rightarrow$ stagflationary beliefs



Stagflationary Beliefs: Long-Run Inflation and Gas Price Inflation

- Optimistic consumers have lower long-run inflation expectations, and lower gas price expectations (short and long horizons) ⇒ stagflationary beliefs



Stagflationary Beliefs: Robustness

- We find stagflationary beliefs across demographic groups
  - Education, income, investments, political affiliation
- We find stagflationary beliefs across time
- Alternative approach: include inflation expectations into the MCA
  - The first dimension still explains over 80% of beliefs
  - The estimated loading on inflation is negative: higher sentiment, lower inflation expectations
- Professional forecasters have a larger factor structure to their beliefs and do not have stagflationary views

Model

Model: Overview

Questions:

- Under what conditions do agents form beliefs consistent with empirics?
- What are the aggregate implications?

Model:

- Firms: differentiated firms face pricing frictions and produce using labor
- Households: some have access to financial markets ("capitalists"); others do not and consume all income each period ("hand-to-mouth") (Bilbiie, 2020)
- Innovation: add rational inattention to hand-to-mouth households (Sims, 2003)
- Shocks: aggregate discount rate ("demand") and labor disutility shock ("supply")

Households: Capitalists

- Capitalist households, $j \in (\lambda, 1]$, are denoted with "$\mathcal{K}$"
- They maximize lifetime discounted expected utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(C_t^{\mathcal{K}}, N_t^{\mathcal{K}}; \mathbf{Z}_t\right)$$

subject to:

$$C_t^{\mathcal{K}} + Q_t B_t^{\mathcal{K}} = B_{t-1}^{\mathcal{K}} + W_t N_t^{\mathcal{K}} + T_t^{\mathcal{K}}$$

- **Standard:** FIRE; choose consumption, labor, saving to max lifetime expected utility
- Note $\mathbf{Z}_t$ contains aggregate shocks (discount factor Ψ_t and labor disutility Γ_t)

$$u(C_t^j, N_t^j; \mathbf{Z}_t) = \Psi_t \left[\frac{\left(C_t^j\right)^{1-\varsigma} - 1}{1-\varsigma} - \Gamma_t \frac{\left(N_t^j\right)^{1+\varphi}}{1+\varphi} \right]$$

Model: Firms

- Firms maximize discounted expected profits:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \theta^k Q^{\mathcal{K}}_{t,t+k} \left[\left(1+\tau^{\mathcal{K}}\right) \left(P_t(i)/P_{t+k}\right) Y_{t+k}(i) - W_{t+k} N_{t+k}(i) - T^F_{t+k} \right]$$

- subject to:
    - **Production function:** $Y_t(i) = N_t(i)$
    - **CES Demand:** $C_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} C_t$
- **Standard:** Calvo, CES demand, monopolistically competitive firms, production subsidy
- **Non-standard:** Firms are owned by $\mathcal{K}$ households $\Rightarrow$ SDF is of $\mathcal{K}$ households and expectations are taken under FIRE

Model: Government

- Fiscal authority sets optimal production subsidy $\Rightarrow$ markups are zero in steady state
- The production subsidy is financed by lump-sum taxes on firms
- Profits paid to $\mathcal{K}$ households are taxed (τ^D) and redistributed to H households
- Central bank sets the nominal rate i_t

Households: Hand-to-Mouth

- Hand-to-mouth households, $j \in [0, \lambda]$, are denoted with "H"
- H households cannot borrow or save
- Face information constraints and do not observe current or past variables perfectly
- Collect noisy signals $\mathbf{s}_t^j$ (more precise signals are more costly); expectations are formed with respect to the information set (the history of signals)

$$\left\{\mathbf{s}_\tau^j\right\}_{\tau \leq t} \equiv \mathcal{I}_t^j$$

- Denote the expectation operator of household j as $E_t^j \neq \mathbb{E}_t$

Households: Hand-to-Mouth Maximization

- Budget constraint:

$$C_t^{H,j} = W_t N_t^{H,j} + T_t^H$$

- How can this bind?
  - We assume there is a head of household that collects information, tells the worker how much to work, then the shopper takes the wage income and consumes
  - Labor is the active choice and consumption is the residual
- H households maximize:

$$E_t^j \, U\left(N_t^{H,j}; \mathbf{X}_t\right) - \mu I\left(\mathbf{X}_t; \mathcal{I}_t^j \middle| \mathcal{I}_{t-1}^j\right)$$

by choosing the distribution of signals $\mathbf{s}_t^j$ and labor supply $N_t^{H,j}$, taking $\mathcal{I}_{t-1}^j$ as given

- $\mathbf{X}_t$ contains $\mathbf{Z}_t$ and anything affecting W_t and T_t^H

Model: Aggregation, Linearization, Optimality

- Average consumption and labor supply of the H households:

$$C_t^H \equiv \frac{1}{\lambda}\int_0^\lambda C_t^{H,j}\,\mathrm{d}j \text{ and } N_t^H \equiv \frac{1}{\lambda}\int_0^\lambda N_t^{H,j}\,\mathrm{d}j$$

- Aggregate consumption and labor supply (log-linearized around symmetric ss):

$$y_t = \lambda c_t^H + (1-\lambda)c_t^{\mathcal{K}} \text{ and } n_t = \lambda n_t^H + (1-\lambda)n_t^{\mathcal{K}}$$

- Capitalist household optimality conditions:

$$w_t = \gamma_t + \varsigma c_t^{\mathcal{K}} + \varphi n_t^{\mathcal{K}} \text{ and } \mathbb{E}_t\Delta c_{t+1}^{\mathcal{K}} = \varsigma^{-1}\left(i_t - \mathbb{E}_t\pi_{t+1} - v_t\right)$$

  - $\gamma_t = \log \Gamma_t$ is the aggregate labor disutility shock
  - $v_t = -\mathbb{E}_t\Delta\psi_{t+1} = -\mathbb{E}_t\Delta \log \Psi_{t+1}$ is the aggregate discount factor shock

- New Keynesian Phillips curve:

$$\pi_t = \kappa_w w_t + \beta\mathbb{E}_t\pi_{t+1}$$

Model: FIRE Benchmark

- Under full information (like in Bilbiie, 2020):

$$(\varsigma + \varphi) n_t^{H*} = \chi_n w_t - \gamma_t \quad \text{and} \quad (\varsigma + \varphi) c_t^{H*} = \chi_c w_t - \gamma_t$$

$$\text{where} \quad \chi_n \equiv 1 - \varsigma \left(1 - \tau^D / \lambda\right) \quad \text{and} \quad \chi_c \equiv 1 + \varphi \left(1 - \tau^D / \lambda\right)$$

- Optimal labor choice responds to the wage (w_t)
  - χ_n is proportional to the elasticity of labor supply to the wage
  - χ_n is a function of preferences (ς), transfers (τ^D), and share of H households (λ)
- Optimal labor choice also responds to the labor disutility shock (γ_t)
- With information frictions, H households are unable to pick n_t^{H*} perfectly
  - Nor will the average across H households be the FIRE benchmark

Model: Equilibrium

- H labor supply:

$$n_t^{H,j} = K\left(\frac{\chi_n w_t - \gamma_t}{\varsigma + \varphi} + \eta_t^j\right) + (1-K)\tilde{n}_t^{H,j}$$
$$\implies n_t^H = K\left(\frac{\chi_n w_t - \gamma_t}{\varsigma + \varphi}\right) + (1-K)m_t \quad \text{where} \quad m_t \equiv \frac{1}{\lambda}\int_0^\lambda \tilde{n}_t^{H,j}\,\mathrm{d}j$$

- Aggregate priors, m_t, is a state variable
- The optimal signal will put nonzero weight on $m_t \implies$ "infinite regress" and AR(∞) aggregate dynamics
- We have some general results about beliefs and dynamics in the paper
- One takeaway: H households will have a single factor belief structure
    - H households make one choice $\implies$ at most one signal

IID Setting: Aggregate Labor Choice

- Suppose shocks are IID
- Priors are at steady state, so H aggregate labor choice:

$$n_t^H = K n_t^{H,*} \propto K(\chi_n w_t - \gamma_t)$$

where

- $n_t^{H,*}$ is the H aggregate labor choice under the FIRE bench
- K is the Kalman gain
- w_t, the real wage, is function of both demand and supply shocks
- γ_t is the supply shock
- χ_n is proportional to the FIRE elasticity of labor supply to wage (endogenous)

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Correlations: Physical and Beliefs

- Under what conditions...
  1. is the (unconditional) correlation of output and inflation positive
  2. while posterior beliefs feature negative correlation?
- First holds if demand shocks are sufficiently volatile and/or the response of output and inflation to demand shocks is sufficiently strong

Correlations: Physical and Beliefs

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  1. is the (unconditional) correlation of output and inflation positive
  2. while posterior beliefs feature negative correlation?
- First holds if demand shocks are sufficiently volatile and/or the response of output and inflation to demand shocks is sufficiently strong
- For the second, belief correlations depend crucially on χ_n
- If $\chi_n = 0$ (log-utility and no transfers), then optimal labor choice...
  - is independent of the real wage due to offsetting income and substitution effects
  - is only a function of supply shocks, and so H households choose to only learn about supply shocks (regardless of their volatility)
  - $\Rightarrow$ Posterior beliefs inherit the properties of the model conditional on supply shocks

Correlations: Physical and Beliefs

- If $\chi_n \neq 0$, posterior beliefs of output and inflation can be negatively or positively correlated (exact conditions are in the paper)
- How would the belief correlation be positive? If $|\chi_n|$ large and volatility of supply shocks is small:
  - The optimal signal will place weight on the real wage which will be largely driven by demand rather than supply shocks
  - Posterior beliefs will inherit the conditional response of the model to demand shocks, resulting in a positive correlation in beliefs
- Under reasonable parameters: supply shocks are not very volatile and χ_n is small $\Rightarrow$ output and inflation will be positively correlated, while beliefs will feature a negative correlation

Dynamics: Analytical Second Derivatives and Intuition, Demand

- In TANK, demand shocks are amplified if $\chi_n \leq 1$ (Bilbiie, 2020)
- In limit of no H agents ($\lambda \to 0$) and no information costs ($K \to 1$), conditional responses wrt the fraction of hand-to-mouth (λ) and information costs ($-K$) are:

$$\lim -\frac{\partial^2 C_{y,v}}{\partial \lambda \partial K} = \begin{cases} > 0 & \text{if } \chi_n < 0 \\ < 0 & \text{if } 0 < \chi_n \leq 1 \end{cases}$$

  where $C_{y,v}$ is the response of output to a demand shock

- In response to a **demand shock**, in the FIRE-RANK limit, output and **wage** $\uparrow$
  - If $\chi_n < 0$, H households want to $\downarrow$ labor, due to info costs will not reduce labor as much as FIRE $\implies$ TANK amplifies demand shocks, and info costs add further amplification
  - If $0 < \chi_n \leq 1$, H households want to $\uparrow$ labor, due to info costs will not increase labor as much as FIRE $\implies$ TANK amplifies demand shocks, but info costs weaken it

First Derivs

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First Derivs

Dynamics: Analytical Second Derivatives and Intuition, Supply

- In TANK, supply shocks are mitigated if $\chi_n \leq 1$ (Bilbiie, 2020)
- In limit of no H agents ($\lambda \to 0$) and no information costs ($K \to 1$), conditional responses wrt the fraction of hand-to-mouth (λ) and information costs ($-K$) are:

$$\lim -\frac{\partial^2 C_{y,\gamma}}{\partial \lambda \partial K} > 0$$

  where $C_{y,\gamma}$ is the response of output to a supply shock
- In response to a **supply shock**, if the central bank is responding to strongly to inflation, wages will not move much and H choices will be driven by γ_t
  - H households will $\downarrow$ labor, but due to info costs by less than under FIRE $\implies$ info costs dampen reaction to supply shocks (more mitigation relative to TANK)

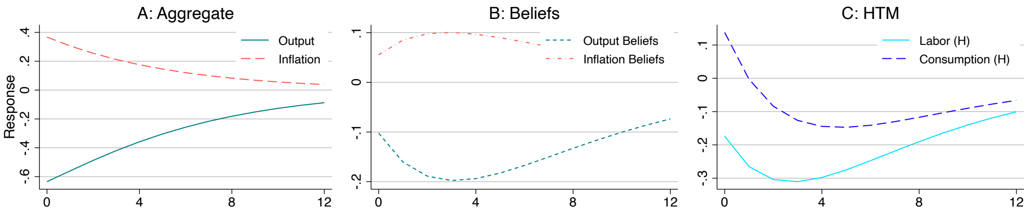
First Derivs

Dynamics: Persistent Shocks

- Shocks follow AR(1) processes
- Assume $\chi_n = 0$ (log utility and no transfers)
  - Work in progress: $\chi_n \neq 0$. Implies $AR(\infty)$ dynamics, but main results go through
- In response to supply and demand shocks, assess how
  1. the beliefs of HtM households evolve
  2. the labor and consumption decisions of HtM households evolve
  3. macroeconomic dynamics
- Assess the importance of priors, by assuming households ex-ante believe a supply-driven recession is likely
- Calibration

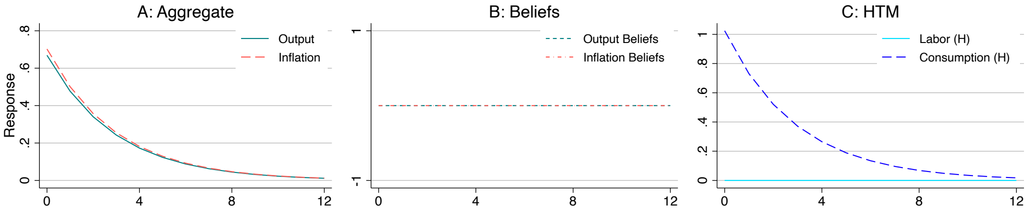
Response: Supply Shock

- In response to a supply shock, inflation rises and output falls
- H households learn about supply, their inflation beliefs rise and output beliefs fall
- H labor supply falls, but less than in FIRE, and consumption rises



Response: Demand Shock

- In response to a demand shock, inflation and output rise
- H households do not learn about demand and their beliefs are unaffected
- H labor supply is unaffected, but consumption rises



Tests of the Model

Qualitative Testable Implications

Is there empirical support for attention-based supply-side views?

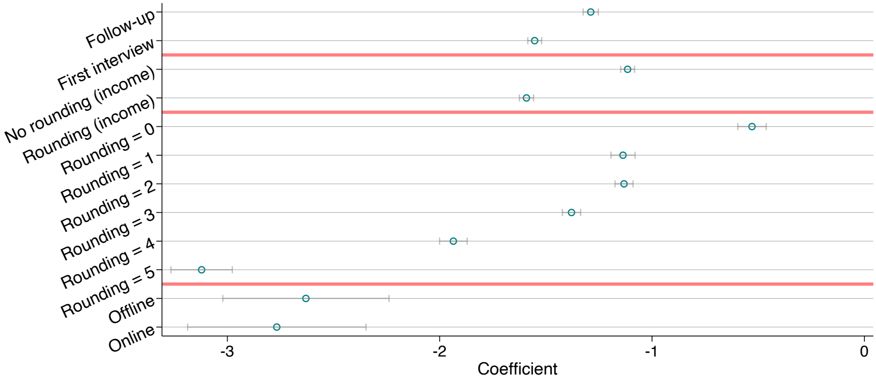
Predictions

- Less attentive households hold more stagflationary beliefs
- Respondents giving supply-based reasoning hold more stagflationary beliefs
- Sentiment responds to supply but not demand shocks
- $\Rightarrow$ Results rule out other stories for supply-side beliefs

Attention and Stagflationary Views

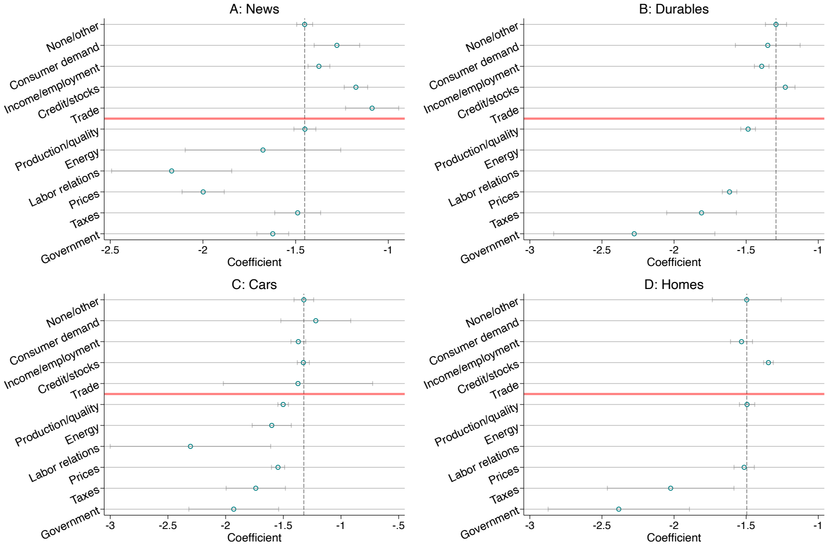
- Less attention $\implies$ more stagflationary views

$$E_{i,t}[\pi_{t+12}] = \sum_{j \in \mathcal{J}} \beta^j \hat{f}_{i,t} \times \mathbb{1}\{a_{i,t} = j\} + X_{i,t} + \epsilon_{i,t}$$

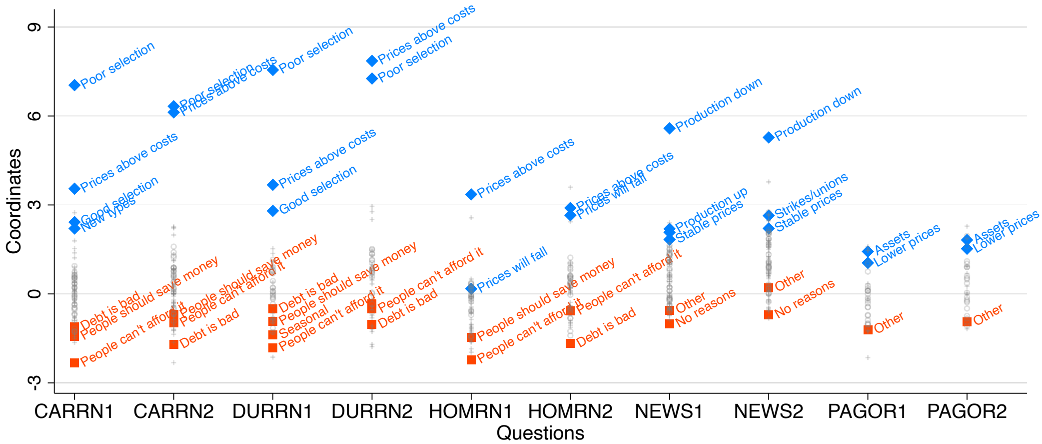


Supply-Side Reasoning and Stagflationary Views

- More "supply" reasoning $\implies$ more stagflationary views



- Include the raw reasoning categories (≈ 575) in the MCA
- First factor is essentially the same as our baseline sentiment factor
- The second factor appears to be a measure of supply-side beliefs



Supply-Side Reasoning

- We calculate the fitted second component, $\hat{r}_i, t$
- If individuals mention supply-side reasoning, they have more stagflationary beliefs

	(1)	(2)	(3)	(4)
$\hat{f}_{i,t}$	-1.404***	-0.737***	-6.941***	-14.107***
	(0.013)	(0.012)	(0.081)	(0.173)
$\hat{f}_{i,t} \times \hat{r}_{i,t}$	-0.088***	-0.018*	-1.492***	-1.513***
	(0.013)	(0.011)	(0.081)	(0.168)
R-sq	0.142	0.092	0.143	0.134
Obs.	298,691	227,166	175,962	197,386

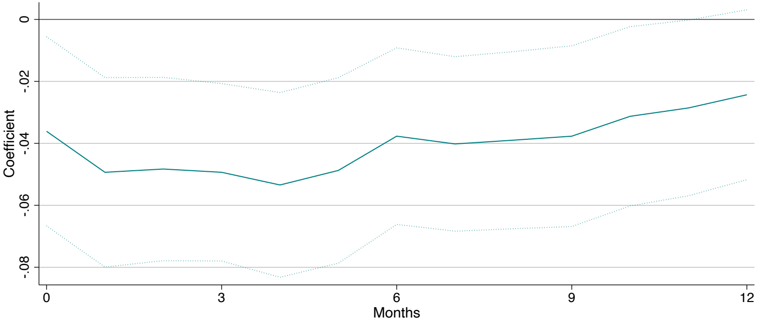
Notes: Dependent variables are (1) one-year inflation expectations, (2) five-year inflation expectations (3) one-year gas inflation expectations (4) five-year gas inflation expectations. Time fixed effects and $\hat{r}_i, t$ are included as controls.

Belief Response to Oil Supply Shocks

- Do beliefs react to supply shocks more than demand shocks?
- Conduct a local projection of the cross-section of sentiment on oil supply shocks (Kanzig, 2021) clustered at the month:

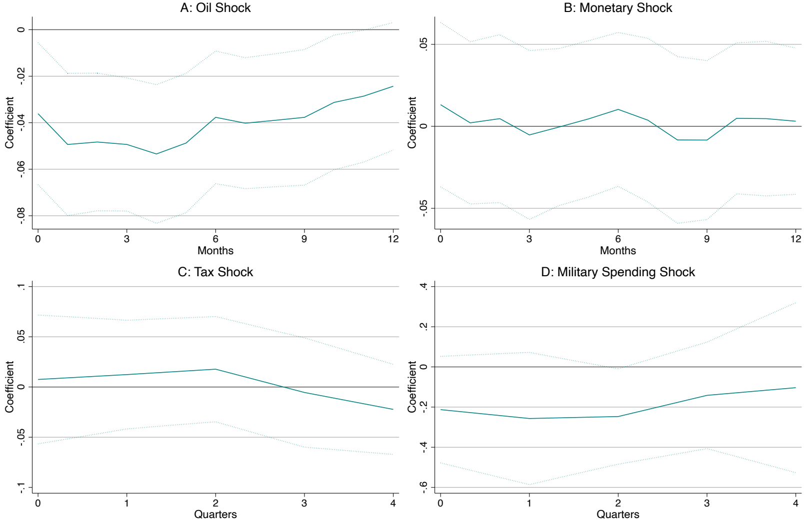
$$\hat{f}_{i,t+h} = \alpha_h + \theta_h \hat{p}_t + \Gamma_h \mathrm{X_t} + u_{i,t+h}$$

- Following a negative oil supply shock, sentiment falls



Belief Response to Demand Shocks

- Beliefs do not react to monetary policy, tax, or military spending shocks



Conclusion

- Single Factor and Stagflationary Beliefs
  - Consumers’ expectations exhibit a low-factor structure...
  - ...and believe inflation is countercyclical
- TANK Model Featuring Rational Inattention
  - Agents economize information costs and obtain a single signal (single factor belief model)
  - This strategy typically implies higher precision in beliefs about supply-driven recessions and less about demand-driven recessions (countercyclical inflation beliefs)
- Direct Evidence of Attention-Based Supply-Side Views
  - Stagflationary beliefs are strongest among (i) inattentive consumers and (ii) consumers who give supply-based reasoning
  - ... providing direct evidence for attention-based supply-side beliefs

Dynamics: First Derivatives and Intuition

- In the limit of no H agents ($\lambda \to 0$) and no information costs ($K \to 1$), conditional responses wrt the fraction of hand-to-mouth (λ) are:

$$\frac{\partial C_{y,v}}{\partial \lambda} \to \frac{\varphi(1-\chi_n)}{(\varsigma + (\varsigma+\varphi)\kappa_w \phi_\pi)^2}, \quad \frac{\partial C_{y,\gamma}}{\partial \lambda} \to \frac{\varsigma\varphi(1-\chi_n)}{(\varsigma+\varphi)(\varsigma + (\varsigma+\varphi)\kappa_w \phi_\pi)^2}$$

- Amplification of the output response to demand shocks (if $\chi_n \leq 1$)
  - A demand shock $\uparrow$ desired S consumption; output and wages $\uparrow$ in the RANK benchmark
  - A wage increase (all else equal) induces a larger positive consumption response of H households relative to S households
- Mitigation of the output response to supply shocks (if $\chi_n \leq 1$)
  - A supply shock $\downarrow$ output, but wages $\uparrow$ in the RANK benchmark
  - A wage increase (all else equal) puts more upward pressure on H consumption relative to S consumption

back

Calibration

Parameter	Value	Description	Target
Panel A:			
β	0.9975	Discount Factor	Long-run rate
ς	1.0	CRRA	Log-utility, $\chi_n = 0$
$\frac{\tau^D}{\lambda}$	0.0	Transfers	Log-utility, $\chi_n = 0$
λ	0.33	Hand-to-Mouth	Fraction 1/3
ϕ_π	1.5	Taylor Rule	Inflation Coeff.
ϕ_y	0.1	Taylor Rule	Output Coeff.
Panel B:			
φ	0.5305	$\sigma(w_t)$	1.5682
κ_w	0.198	$\rho(y_t, \pi_t)$	0.0689
ρ_v	0.7131	$\rho(y_t, y_{t-1})$	0.8074
ρ_γ	0.8242	$\rho(\pi_t, \pi_{t-1})$	0.749
σ_v	0.7616	$\sigma(y_t)$	1.5757
σ_γ	1.7847	$\sigma(\pi_t)$	1.2007
K	0.149	$\rho\left(\hat{\pi}_t^j, \pi_t\right)$	0.3306

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