The Inflation Attention Threshold and Inflation Surges

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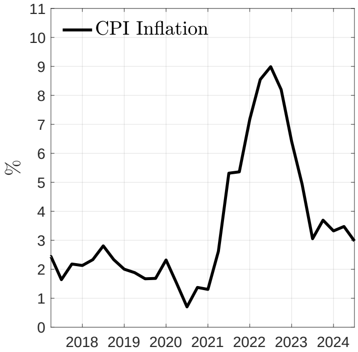
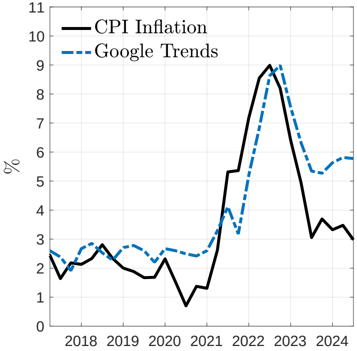
Inflation is back...

(a) Inflation



Inflation is back... on people's minds

(a) Inflation and Google Trends



Inflation expectations had a hard time catching up

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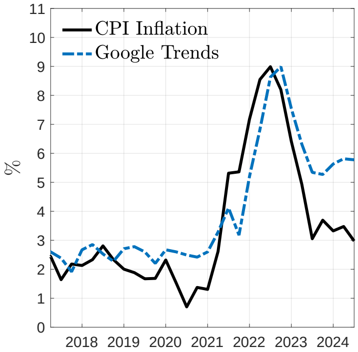
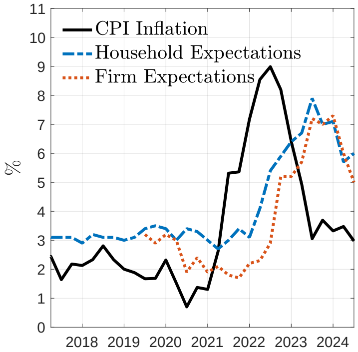


(b) Inflation and expectations



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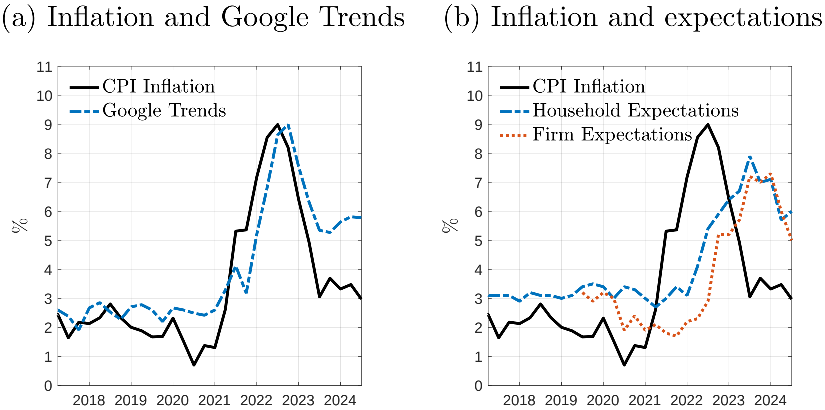

Q: When does attention to inflation change?

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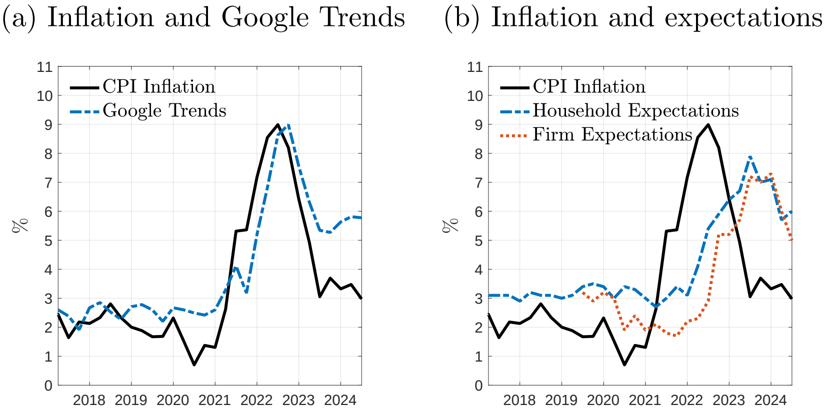

Q: When does attention to inflation change?

Q: Can attention changes explain inflation & inflation expectations dynamics?

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- Estimate attention to inflation and threshold when attention changes:

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  - exceeding threshold changes inflation dynamics (resembling recent inflation surge)
  - threshold leads to inflation asymmetry, longer 'last mile', larger central bank losses, ...

Contribution to the literature

- Drivers of recent inflation surge: Shapiro (2023), Gagliardone/Gertler (2023), Bernanke/Blanchard (2023), Benigno/Eggertsson (2023), Amiti et al. (2023), Bianchi/Melosi (2022) & Bianchi et al. (2023), Reis (2022), Schmitt-Grohe/Uribe (2024), Erceg et al. (2024)...

  ⇒ Contribution: role of attention increase in inflation surge

- Measuring attention to inflation: Cavallo et al. (2017), Pfäuti (2021), Korenok et al. (2022), Bracha/Tang (2023), Weber et al. (2023), Kroner (2023)

  ⇒ Contribution: estimate attention threshold and attention in a way that directly maps into otherwise standard macro models

- State dependency of shocks: Auerbach/Gorodnichenko (2012a,b), Ramey/Zubairy (2018), Jo/Zubairy (2023), Tenreyro/Thwaites (2016), Ascari/Haber (2022), Joussier et al. (2023)

  ⇒ Contribution: role of attention regime for inflation response

- Theory: Mackowiak/Wiederholt (2009), Paciello/Wiederholt (2014), Reis (2006a,b) Pfäuti (2021), Carvalho et al. (2022), Afrouzi/Yang (2022), Gati (2022)

  ⇒ Contribution: GE model with attention threshold, role for inflation surges

Outline

1. **Quantify Attention and Attention Threshold**
2. Role of Attention for Inflation
3. Model + Model Results

Quantifying attention to inflation

- Perceived law of motion (subscripts r indicate potential regime dependence):

$$\pi_t = (1 - \rho_{\pi,r})\underline{\pi}_r + \rho_{\pi,r}\pi_{t-1} + \nu_t, \text{ with } \nu_t \sim N(0, \sigma_\nu^2)$$

- current inflation is unobservable
- noisy signal: $s_t = \pi_t + \varepsilon_t$, with $\varepsilon_t \sim N(0, \sigma_{\varepsilon,r}^2)$, precision $\frac{1}{\sigma_{\varepsilon,r}^2}$ reflects attention

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$$\tilde{E}_t\pi_{t+1} = (1 - \rho_{\pi,r})\underline{\pi}_r + \rho_{\pi,r}\tilde{E}_{t-1}\pi_t + \rho_{\pi,r}\gamma_{\pi,r}\left(\pi_t - \tilde{E}_{t-1}\pi_t\right) + u_t$$

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$$\tilde{E}_t\pi_{t+1} = \beta_{0,r} + \beta_{1,r}\tilde{E}_{t-1}\pi_t + \beta_{2,r}\left(\pi_t - \tilde{E}_{t-1}\pi_t\right) + \epsilon_t,$$

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Rational inattention microfoundation:

Details

$$\gamma_{\pi,r} = max\left(0, 1 - \frac{\lambda_r}{\rho^2_{\pi,r}\sigma^2_{\pi,r}}\right)$$

Attention threshold

- Test for different attention levels and attention threshold $\bar{\pi}$:

$$\tilde{E}_t\pi_{t+1} = \mathbb{1}_{\pi_{t-1}\leqslant\bar{\pi}}\left(\beta_{0,L} + \beta_{1,L}\tilde{E}_{t-1}\pi_t + \beta_{2,L}\left(\pi_t - \tilde{E}_{t-1}\pi_t\right)\right)$$
$$+ (1 - \mathbb{1}_{\pi_{t-1}\leqslant\bar{\pi}})\left(\beta_{0,H} + \beta_{1,H}\tilde{E}_{t-1}\pi_t + \beta_{2,H}\left(\pi_t - \tilde{E}_{t-1}\pi_t\right)\right) + \tilde{\epsilon}_t$$

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- Estimate threshold $\bar{\pi}$ and regression coefficients jointly by minimizing SSR
- Baseline data:
  - monthly average expectations Michigan Survey of Consumers, 1978-2024
  - actual inflation: U.S. CPI inflation ▸ Time series

Empirical results: attention twice as high when inflation is above 4%

	Threshold $\bar{\pi}$	Low Att. $\widehat{\gamma}_{\pi,L}$	High Att. $\widehat{\gamma}_{\pi,H}$	p-val. $\gamma_{\pi,L} = \gamma_{\pi,H}$
Baseline	3.91%	0.18	0.35	0.000
s.e.		(0.018)	(0.042)	

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  - median expectations, quarterly frequency, NY Fed SCE (HH panel), SPF
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Attention regimes and the propagation of supply shocks

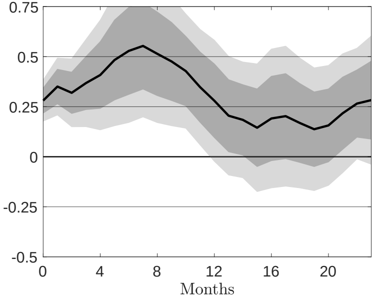
Estimate local projection:

$$y_{i,t+j} = \mathbb{1}_{i,H} \left(\alpha_{i,j}^{H} + \beta_{j}^{H} \varepsilon_t\right) + (1 - \mathbb{1}_{i,H}) \left(\alpha_{i,j}^{L} + \beta_{j}^{L} \varepsilon_t\right) + \Gamma' X_{i,t} + u_{i,t+j}$$

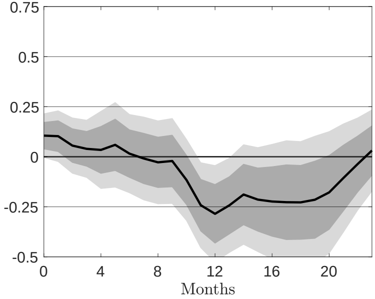
- $y_{i,t+j}$: y-o-y CPI inflation in period $t + j$ in region i
- $\mathbb{1}_{i,H} = 1$ if region i is in high-attention regime (based on Google Trends)
- ε_t : oil supply news shock, 1975M1-2023M12 (Känzig, AER 2021)
- β_j^r : effect of supply shock on inflation at horizon j in regime $r \in \{L, H\}$
- $X_{i,t}$: controls, including (lagged) aggregate inflation, regional inflation and interaction of those with the shock

Supply shocks are more inflationary in times of higher attention

(a) High-Attention Regime



(b) Low-Attention Regime



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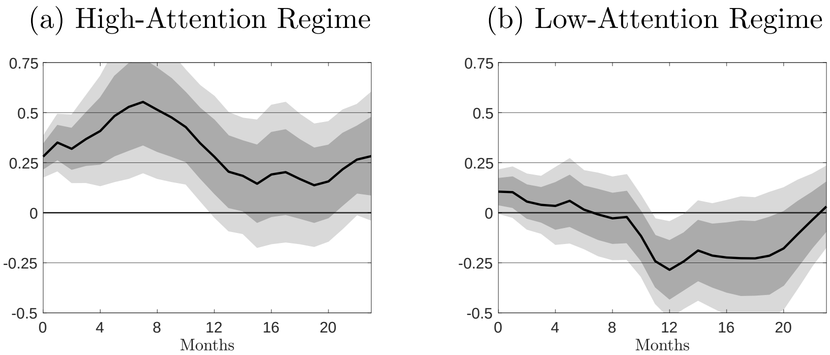

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- also note different shape: hump vs. peak on impact

Alternative approach to disentangle attention from inflation

- use interaction of Google Trends with the shock as measure of interest, and control for time- and region fixed effects (and control for region-specific inflation)

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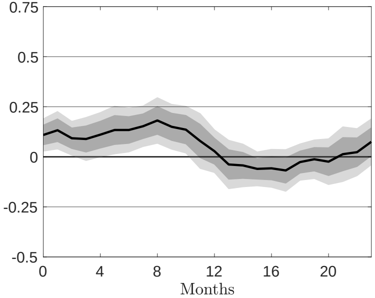

- positive interaction: shocks more inflationary in times of high attention even when controlling for time fixed effects

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New Keynesian model with limited attention and attention threshold:

- Households: consume, work, subjective expectations + limited attention ▸ Details

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- Government:
  - Fiscal authority: subsidy to firms, lump-sum taxes, issues bonds ▸ Details
  - Monetary authority: sets nominal interest rate, following Taylor rule (for now)

$$\tilde{i}_t = \rho_i \tilde{i}_{t-1} + (1 - \rho_i)\left(\phi_\pi \pi_t + \phi_x \widehat{x}_t\right)$$

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- get New Keynesian Phillips Curve with subjective expectations:

$$\pi_t = \beta \tilde{E}_t \pi_{t+1} + \kappa \widehat{x}_t + u_t$$

Households and calibration

Households' expectations:

- inflation expectations as estimated empirically
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Calibration:

- calibrate all "non-attention parameters" to standard values in the literature
- set $\gamma_{\pi,L} = 0.18$ and $\bar{\pi} = 3.91\%$ and compute implied information cost $\tilde{\lambda}$ from

$$\gamma_{\pi,r} = 1 - \frac{\tilde{\lambda}_r}{\sigma^2_{\pi,r}}$$

while increasing σ_u in high-attention regime to match $\gamma_{\pi,H} = 0.35$ jointly $\Rightarrow \sigma_{u,H} = 1.23\sigma_{u,L}$

Cost-push shock: attention shift alters inflation dynamics

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  1. large shock that pushes inflation above the threshold
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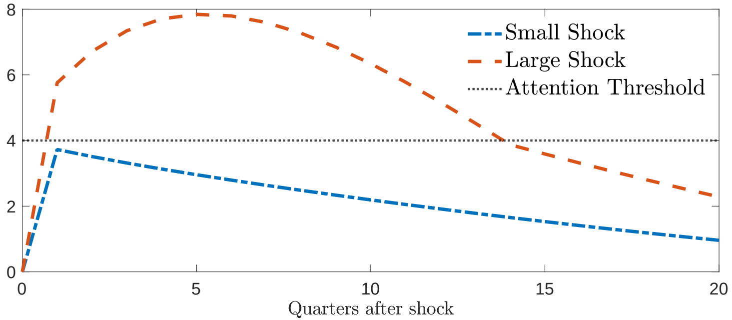

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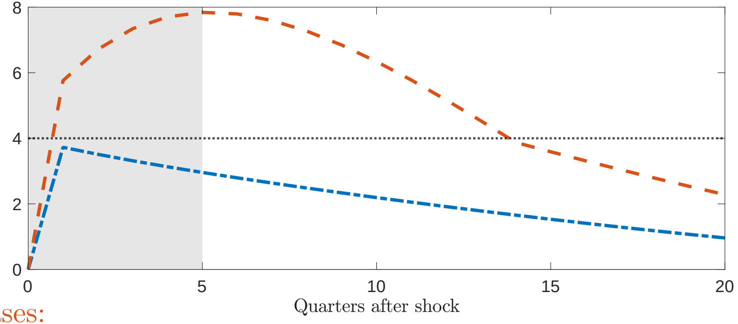

- Three phases:
  1. self-reinforcing inflation surge after shock due to attention increase

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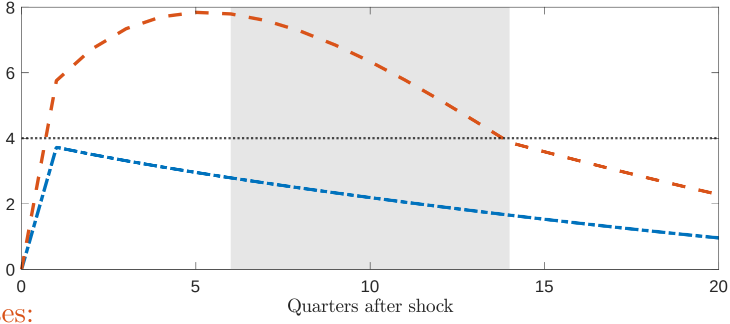
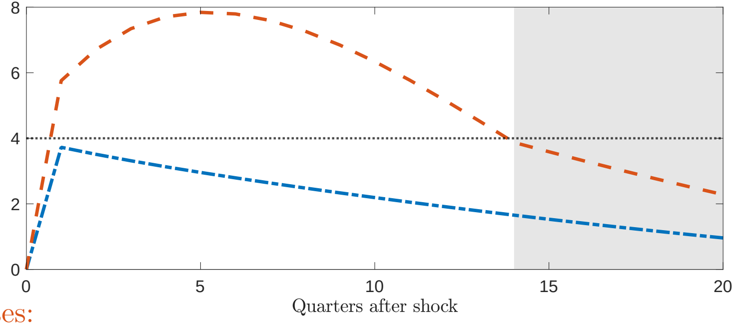


- Three phases:
  1. self-reinforcing inflation surge after shock due to attention increase
  2. relatively fast disinflation initially due to shock dying out and high attention

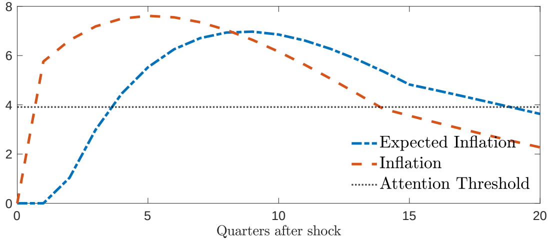
Cost-push shock: attention shift alters inflation dynamics

- Effects of cost-push shocks u_t on inflation? ▸ Equilibrium ▸ Analytical Example
  1. large shock that pushes inflation above the threshold
  2. small one that does not push inflation above the threshold



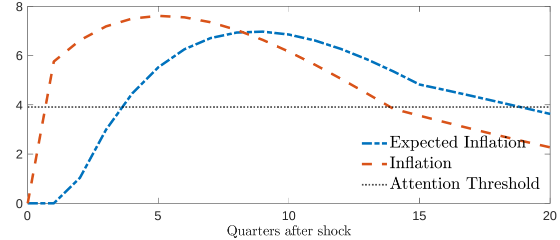
- Three phases:
  1. self-reinforcing inflation surge after shock due to attention increase
  2. relatively fast disinflation initially due to shock dying out and high attention
  3. disinflation slows down once inflation falls back below threshold

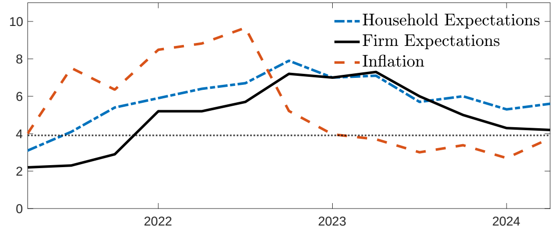
Inflation and inflation expectation dynamics: Model vs. Data



- **Model**: inflation hump-shaped and inflation expectations initially undershoot, followed by delayed overshooting

Inflation and inflation expectation dynamics: Model vs. Data





- **Model**: inflation hump-shaped and inflation expectations initially undershoot, followed by delayed overshooting
- **Data:** shows similar patterns

Additional Results

- Similar results for demand shocks ▸ IRFs
- Attention threshold induces asymmetry in inflation dynamics: thicker right tail
  ▸ Asymmetry
- Dovish monetary policy rules lead to larger central bank losses due to... ▸ Details

  ... higher inflation volatility

  ... positive average inflation due to asymmetry

Conclusion

- Recent inflation surge brought inflation back on people's minds
- I find that...

  ... attention doubles once inflation exceeds 4%

  ... attention amplifies supply shocks and played important role in recent inflation surge

  ... changes in attention matter for dynamics of inflation and inflation expectations

  ... dovish monetary policy may lead to substantial central bank losses

Appendix

Limited-Attention Model

Model of optimal attention choice:

- Agent (household or firm) needs to form an expectation about future inflation
- Acquiring information is costly (cognitive abilities, time, etc.)
- Making mistakes leads to utility losses

  ⇒ optimal level of attention depends on how costly information acquisition is, how high your stakes are and the properties of inflation itself

Setup

Agent believes that inflation follows an AR(1) process:

$$\pi' = \rho_\pi \pi + \nu,$$

with $\rho_\pi \in [0, 1]$ and $\nu \sim i.i.N(0, \sigma_\nu^2)$.
The full-information forecast is given by

$$\pi^{e*} = \rho_\pi \pi$$

Problem: current inflation is unobservable and acquiring information is costly.

Information Acquisition Problem

The agent's problem:

- Choose the form of the signal s
- to minimize the loss that arises from making mistakes, $U(s, \pi)$
- facing the cost of information $C(f) = \lambda I(\pi; s)$, with $I(\pi; s)$ being the expected reduction in entropy of π due to observing s

Information Acquisition Problem Continued

Quadratic loss function

$$U(\pi^e, \pi) = r(\underbrace{\rho_\pi \pi}_{\text{full-info}} - \pi^e)^2$$

r: stakes

Optimal signal has the form (Matejka/McKay (2015))

$$s = \pi + \varepsilon$$

where $\varepsilon \sim i.i.N(0, \sigma_\varepsilon^2)$ captures noise

σ_ε^2 is chosen optimally

Optimal Level of Attention

The optimal forecast is given by

$$\pi^e = \rho_\pi \hat{\pi} + \rho_\pi \gamma \left(s - \hat{\pi}\right),$$

where $\hat{\pi}$ is the prior belief of the agent and γ is the optimal level of attention:

$$\gamma = max\left(0, 1 - \frac{\lambda}{2r\rho_\pi^2\sigma_\pi^2}\right)$$

Attention is higher when:

- the cost of information λ is low
- the stakes r are high
- inflation is very volatile (high σ_π^2) or persistent (high ρ_π) Back

Households

Representative household, lifetime utility:

$$\tilde{E}_0 \sum_{t=0}^{\infty} \beta^t Z_t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \Xi H_t \right]$$

Households maximize their lifetime utility subject to the flow budget constraints

$$C_t + B_t = w_t H_t + \frac{1+i_{t-1}}{1+\pi_t} B_{t-1} + \frac{T_t}{P_t}, \qquad \text{for all } t$$

Yields Euler equation

$$Z_t C_t^{-\sigma} = \beta(1+i_t)\tilde{E}_t \left[Z_{t+1} C_{t+1}^{-\sigma} \frac{1}{1+\pi_{t+1}} \right]$$

and the labor-leisure condition

$$w_t = \Xi C_t^{\sigma}$$

▸ back

Final goods producer

There is a representative final good producer that aggregates the intermediate goods $Y_t(j)$ to a final good Y_t, according to

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \tag{1}$$

with $\epsilon > 1$. Nominal profits are given by $P_t \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} - \int_0^1 P_t(j) Y_t(j) dj$, and profit maximization gives rise to the demand for each variety j:

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} Y_t. \tag{2}$$

Thus, demand for variety j is a function of its relative price, the price elasticity of demand ϵ and aggregate output Y_t. The aggregate price level is given by

$$P_t = \left(\int_0^1 P_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}. \tag{3}$$

▸ back

Intermediate producers

Intermediate producer of variety j produces output $Y_t(j)$ using labor $H_t(j)$

$$Y_t(j) = H_t(j).$$

When adjusting the price, the firm is subject to a Rotemberg price-adjustment friction.

Per-period profits (in real terms) are given by

$$(1-\tau_t)P_t(j)\left(\frac{P_t(j)}{P_t}\right)^{-\epsilon}\frac{Y_t}{P_t} - w_t H_t(j) - \frac{\psi}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1\right)^2 Y_t + t_t^F(j)$$

Defining $T_t \equiv 1-\tau_t$, it follows that after a linearization of the FOC around the zero-inflation steady state, firm j sets its price according to

$$\widehat{p}_t(j) = \frac{1}{\psi+\epsilon}\left[\psi\widehat{p}_{t-1} + \epsilon\left(\widehat{mc}_t - \widehat{T}_t + \widehat{p}_t\right) + \beta\psi\tilde{E}_t^j\pi_{t+1}^j\right]$$

back

Fiscal policy

The government imposes a sales tax τ_t on sales of intermediate goods, issues nominal bonds, and pays lump-sum taxes and transfers T_t to households and $t_t^F(j)$ to firms. The real government budget constraint is given by

$$B_t = B_{t-1}\frac{1+i_{t-1}}{\Pi_t} + \frac{T_t}{P_t} - \tau Y_t + t_t^f.$$

Lump-sum taxes and transfers are set such that they keep real government debt constant at the initial level B_{-1}/P_{-1}, which I set to zero. ▸ back

Equilibrium

- Aggregate supply:

$$\pi_t = \beta \tilde{E}_t \pi_{t+1} + \kappa \widehat{x}_t + u_t$$

- Aggregate demand:

$$\widehat{x}_t = \tilde{E}_t \widehat{x}_{t+1} - \varphi \left(\tilde{i}_t - \tilde{E}_t \pi_{t+1} - r_t^* \right)$$
$$\tilde{i}_t = \rho_i \tilde{i}_{t-1} + (1 - \rho_i) \left(\phi_\pi \pi_t + \phi_x \widehat{x}_t \right)$$

+ shocks and expectation formation Analytical Example back

Numerical insights: calibration

back

Parameter	Description	Value
β	Discount factor	$\frac{1}{1+1/400}$
φ	Interest rate elasticity	1
κ	Slope of NKPC	0.057
ρ_i	Interest rate smoothing	0.7
ϕ_π	Inflation response coefficient	2
ϕ_x	Output gap response coefficient	0.125
ρ_u	Shock persistence	0.8
σ_u	Shock volatility	0.3%
Attention parameters		
$\bar{\pi}$	Attention threshold	3.91% (annualized)
$\gamma_{\pi,L}$	Low inflation attention	0.18
$\gamma_{\pi,H}$	High inflation attention	0.35
γ_x	Output gap attention	0.25

An (hopefully) illustrative example

Consider a stylized version of the model: set $\widetilde{i}_t = \phi_\pi \pi_t$, $\gamma_x = 0$ and $\tilde{E}_{-1}\widehat{x}_0 = 0$

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Focus on first three periods:

0: Steady State

1: Cost-push shock hits: $u_1 > 0$

2: Shock persists: $u_2 = u_1 > 0$

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Consider a stylized version of the model: set $\widetilde{i}_t = \phi_\pi \pi_t$, $\gamma_x = 0$ and $\tilde{E}_{-1}\widehat{x}_0 = 0$

Focus on first three periods:

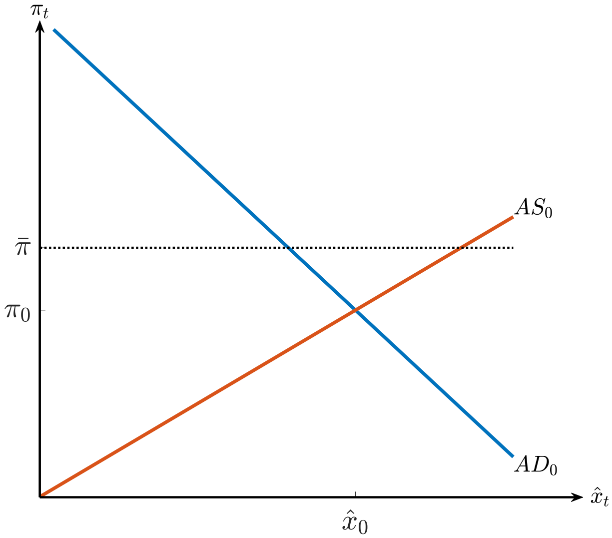
0: Steady State

1: Cost-push shock hits: $u_1 > 0$

2: Shock persists: $u_2 = u_1 > 0$

Q: What happens to inflation?

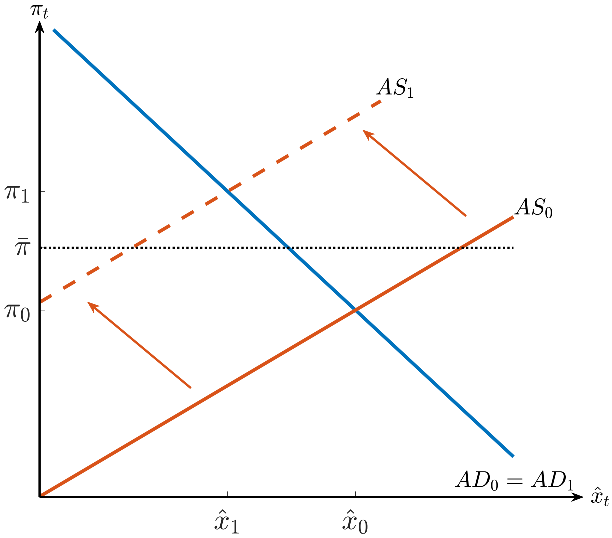
Period 0: economy in steady state



$$AS_0: \quad \pi_0 = \frac{\kappa}{1 - \beta\gamma_{\pi,L}}\widehat{x}_0$$

$$AD_0: \quad \pi_0 = -\frac{1}{\phi_\pi - \gamma_{\pi,L}}\widehat{x}_0$$

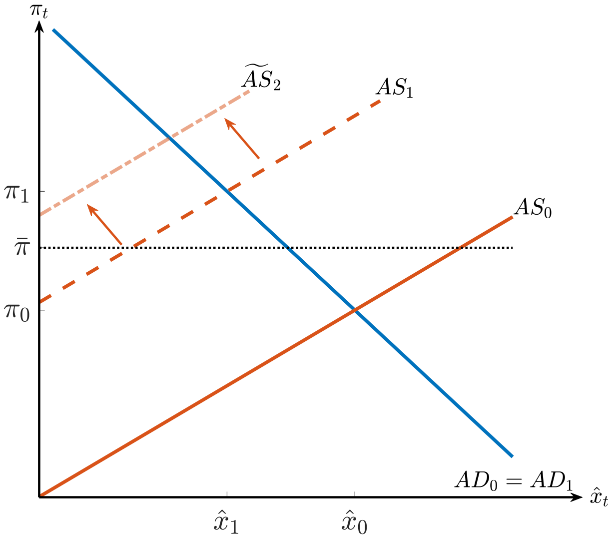
Period 1: Cost-push shock hits



$$AS_1: \quad \pi_1 = \frac{\kappa}{1-\beta\gamma_{\pi,L}}\widehat{x}_1 + \frac{1}{1-\beta\gamma_{\pi,L}}u_1$$

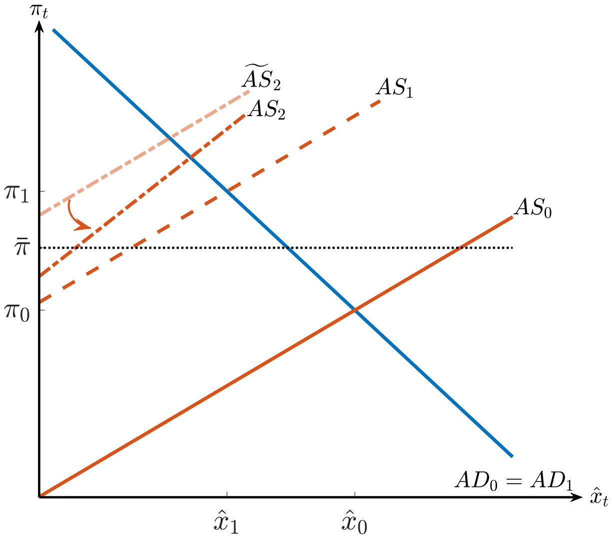
$$AD_1: \quad \pi_1 = -\frac{1}{\phi_\pi - \gamma_{\pi,L}}\widehat{x}_1$$

Period 2: AS further up due to ongoing shock & prior expectations



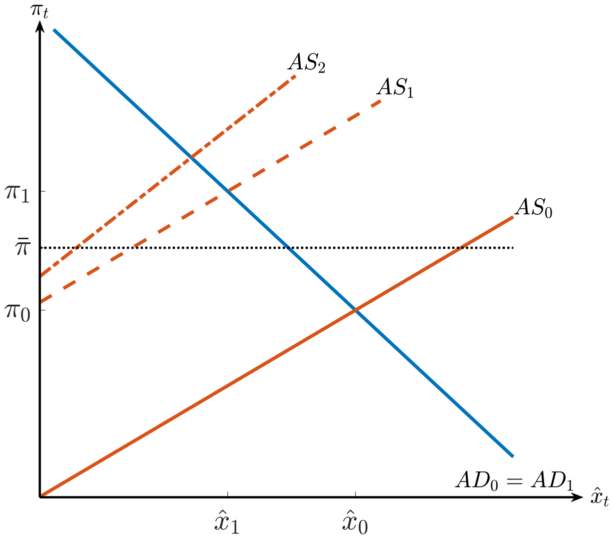
$$\widetilde{AS}_2: \quad \pi_2 = \frac{\kappa}{1-\beta\gamma_{\pi,L}}\hat{x}_2 + \frac{1}{1-\beta\gamma_{\pi,H}}u_2 + \frac{\beta(1-\gamma_{\pi,H})\gamma_{\pi,L}}{1-\beta\gamma_{\pi,H}}\pi_1$$

Period 2: AS becomes steeper due to higher attention

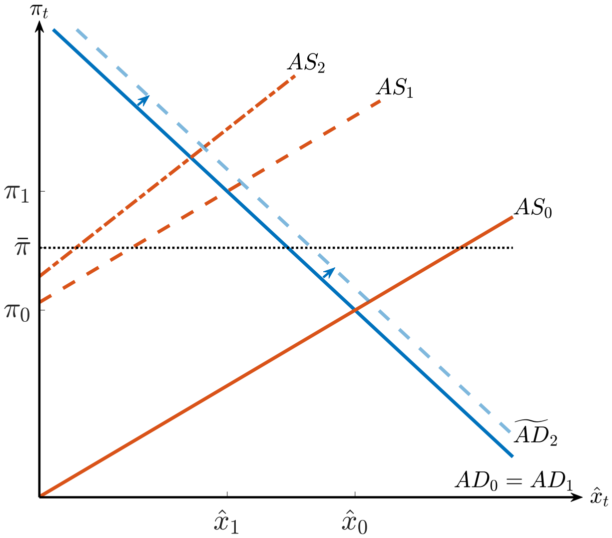


$$AS_2: \quad \pi_2 = \frac{\kappa}{1-\beta\gamma_{\pi,H}}\hat{x}_2 + \frac{1}{1-\beta\gamma_{\pi,H}}u_2 + \frac{\beta(1-\gamma_{\pi,H})\gamma_{\pi,L}}{1-\beta\gamma_{\pi,H}}\pi_1$$

Period 2: What about aggregate demand?

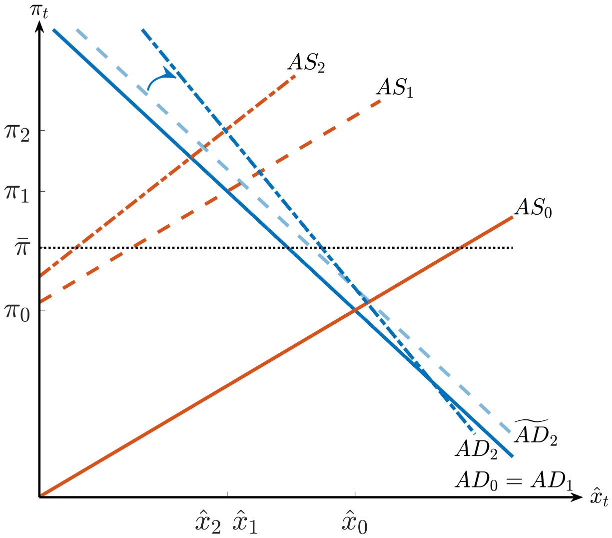


Period 2: AD shifts out due to positive prior expectations



$$\widetilde{AD}_2: \quad \pi_2 = -\frac{1}{\phi_\pi - \gamma_{\pi,L}}\widehat{x}_2 + \frac{(1-\gamma_{\pi,H})\gamma_{\pi,L}}{\phi_\pi - \gamma_{\pi,H}}\pi_1$$

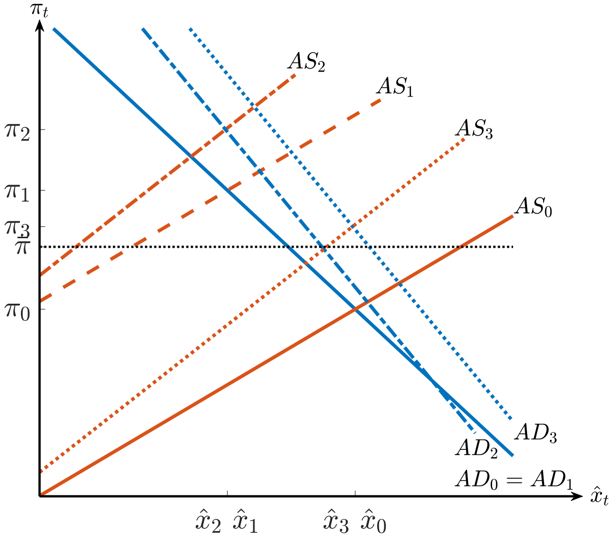
Period 2: AD becomes steeper due to higher attention



$$AD_2: \quad \pi_2 = -\frac{1}{\phi_\pi - \gamma_{\pi,H}}\widehat{x}_2 + \frac{(1-\gamma_{\pi,H})\gamma_{\pi,L}}{\phi_\pi - \gamma_{\pi,H}}\pi_1$$

▸ Period 3 ▸ back

Illustrative example: Period 3

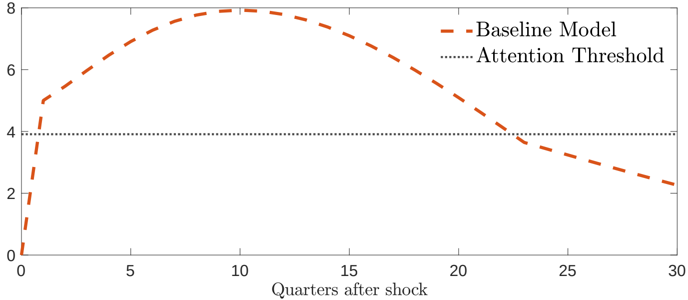


$$AS_3: \quad \pi_3 = \frac{\kappa}{1-\beta\gamma_{\pi,H}}\widehat{x}_3 + \frac{\beta(1-\gamma_{\pi,H})}{1-\beta\gamma_{\pi,H}}\tilde{E}_2\pi_3$$

$$AD_3: \quad \pi_3 = -\frac{1}{\phi_\pi-\gamma_{\pi,H}}\widehat{x}_3 + \frac{1-\gamma_{\pi,H}}{\phi_\pi-\gamma_{\pi,H}}\tilde{E}_2\pi_3$$

back

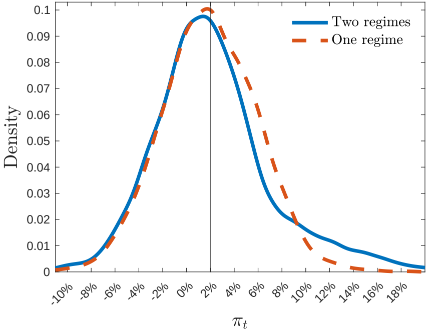
Demand shocks



▸ back

Asymmetry in Inflation Dynamics

- The attention threshold leads to an asymmetry in inflation dynamics
  - $\Rightarrow$ heightened risk of high-inflation periods



- Both models yield similar predictions for median inflation and deflation probabilities
- average inflation > 0 with 2 regimes
  $= 0$ with one regime

back

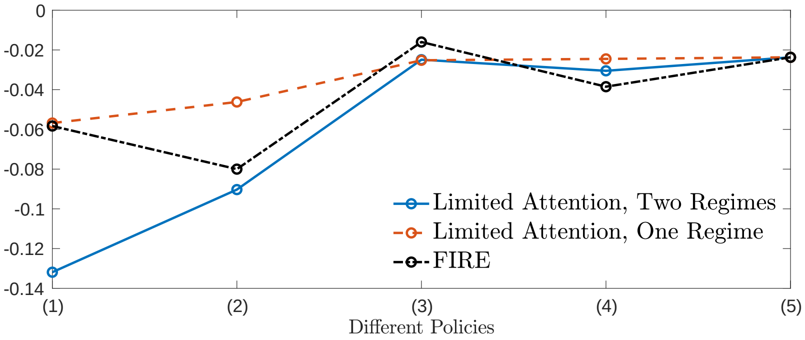
Implications of different monetary policy rules for central bank losses

Central bank loss $\equiv -\frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \Lambda \widehat{x}_t^2\right]$, with $\Lambda = 0.007$

Compare welfare implications of different policy rules:

Nr.	Name	Equation
(1)	Taylor rule with smoothing	$\tilde{i}_t = \rho_i \tilde{i}_{t-1} + (1 - \rho_i)(\phi_\pi \pi_t + \phi_x \widehat{x}_t)$
(2)	Taylor rule without smoothing	$\tilde{i}_t = \phi_\pi \pi_t$
(3)	Optimal RE commitment policy	$\pi_t + \frac{\Lambda}{\kappa}(\widehat{x}_t - \widehat{x}_{t-1}) = 0$
(4)	Optimal RE discretionary policy	$\pi_t + \frac{\Lambda}{\kappa}\widehat{x}_t = 0$
(5)	Strict inflation targeting	$\pi_t = 0$

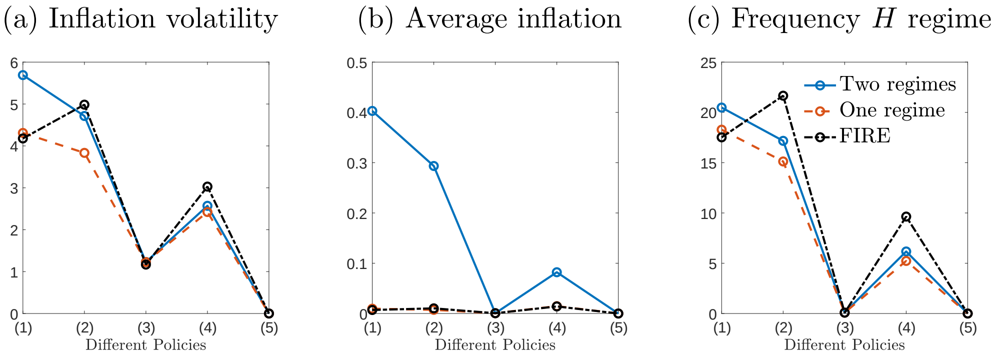
Central bank loss



- Taylor rules lead to larger central bank losses than in other models
  - especially with interest-rate smoothing

back

Asymmetry of attention threshold increases average level of inflation



- Asymmetry $\Rightarrow$ average level > 0 $\Rightarrow$ losses

back