# Monetary Policy with Imperfect Credibility

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NBER Fiscal and Monetary Policy Research Boot Camp

# Expectations and monetary policy

Consider a standard log-linearized NK model facing a supply shock

$$\pi_t = \kappa y_t + \beta E_t \pi_{t+1} + \mu_t$$

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- Part of the policy response to $\mu_t$ consists in affecting beliefs about future policy decisions
- This logic is at the core of key concepts shaping modern policymaking: anchoring inflation expectations, forward guidance, ...
- Question: How do policymakers convince the private sector about their future policies?

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**No credibility** — **Full credibility**

Discretion/Markov — Commitment/Ramsey

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- **Goal**: measure credibility and study optimal policy while taking these considerations into account

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- Reality is in between: credibility is often imperfect, and can be **built** and **lost**
- **Goal**: measure credibility and study optimal policy while taking these considerations into account
- Today: some advances on these topics

# Why now?

Two important macro developments post-Covid

## Largest inflation spike since 1980s

- Central Banks in advanced economies did not respond immediately
  - Did they loose credibility? What is the cost of that?
- Central Banks in emerging markets responded much faster
  - Did they gain credibility? How does credibility helped them going forward?

## Rising public debts everywhere

- High public debt makes budgets sensitive to interest-rate decisions
- Several instances of political interference with central bank independence
  - Are central banks at risk of losing their independence?
  - How does this interfere with their mandate?

# Road map

Three papers on these and related questions

1. Bond Market Views of the Fed (joint with Dovis, Jorgenson and Kirpalani)
   - Using bond market data to detect shifts in perceptions about monetary policy rules
2. Monetary Policy without an Anchor (joint with Dovis, Jorgenson and Kirpalani)
   - Formalizes the notion of "de-anchoring risk" and proposes a strategy to measure it and quantify benefits of anchored inflation expectations
3. Accounting for Credibility: Fiscal-Monetary Interactions and the Credibility of Central Banks Mandates (joint with Chaumont, Dovis, and Kirpalani)
   - Model of the credibility of inflation-targeting mandates. Framework used to measure evolution of credibility and its drivers, and understand implications for optimal policy

Common theme: tools to measure credibility and understand its causes and consequences

# Bond Market Views of the Fed

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Alessandro Dovis
University of Pennsylvania and NBER

Kasper Jorgensen
ECB

Rishabh Kirpalani
University of Wisconsin-Madison

# Motivation

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  - Rates kept at zero throughout 2021, despite rising inflation (April-November 2021)
  - Adoption of flexible average inflation targeting (August 2020)

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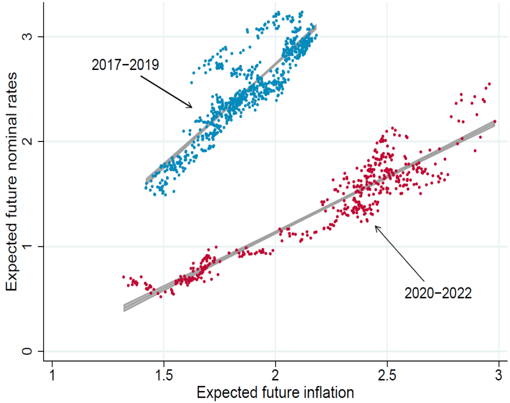
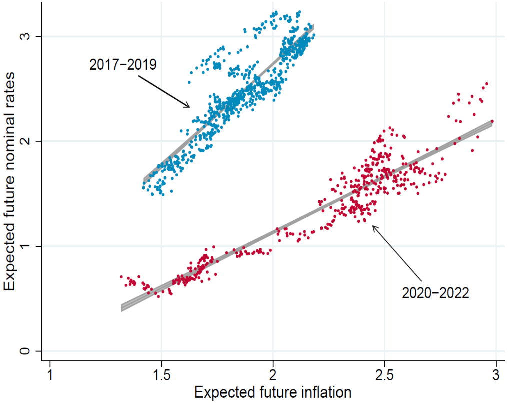
- Two questions:
  1. Did the private sector **change its views** about the Fed's reaction function?
  2. To what extent this shift contributed to **inflation dynamics**?
- This paper: answers these questions in two steps
  1. Use **bond market data** to detect shifts in the Fed's policy
  2. Combine these estimates with a NK model to **measure role of monetary policy**

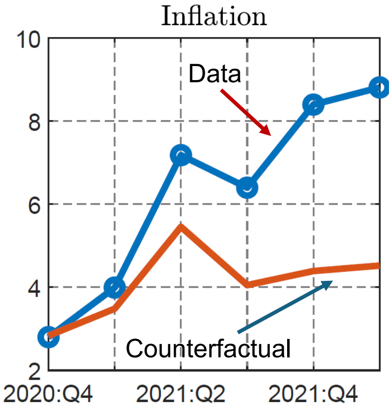
# Two main results




- Detect a decline in the sensitivity of nominal rates to inflation at [0-5] yrs horizon

# Two main results




- Detect a decline in the sensitivity of nominal rates to inflation at [0-5] yrs horizon
- Through the lens of a benchmark NK model, a policy shift of this magnitude has large effects on inflation

# Outline



▸ Literature

# This idea in a nutshell

Suppose the private sector thinks the monetary authority follows a Taylor rule

$$i_t = \rho_i i_{t-1} + (1 - \rho_i) \{i^\star + \psi_\pi (\pi_t - \bar{\pi})\} + \varepsilon_t$$

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- **Want**: **test for changes in $\psi_\pi$** and measure expected **duration** of new "regime"
- **Issues**:
  - Only few years of realized data, all at the ZLB
  - Hard (impossible?) to estimate persistence with only one spell
  - Standard endogeneity issues

# This idea in a nutshell

**Taking expectations** in year $k$, we have

$$\mathbb{E}_t\left[i_k - \rho_i i_{k-1}\right] = c + (1-\rho_i)\psi_\pi \mathbb{E}_t[\pi_k] + \mathbb{E}_t[\varepsilon_k]$$

- From bond prices we obtain high frequency information on $\mathbb{E}_t[i_k]$ and $\mathbb{E}_t[\pi_k]$
- Expectations data vs. actual realizations
  - We have information even if economy is currently at the ZLB
  - We can exploit the **term structure** (vary $k$) to measure persistence of changes in $\psi_\pi$
  - We can address endogeneity, thanks to high-frequency nature of the data

# Empirical specification

Taking first differences wrt $t$ (E.g., $\Delta\mathbb{E}_t[x_k] = \mathbb{E}_t[x_k] - \mathbb{E}_{t-1}[x_k]$), we obtain

$$\Delta\mathbb{E}_t[i_k - \rho_i i_{k-1}] = \psi_\pi \Delta\mathbb{E}_t[(1-\rho_i)\pi_k] + \Delta\mathbb{E}_t[\varepsilon_{m,k}]$$

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- We assume that forecast revisions of future policy "shocks" are small, $\Delta\mathbb{E}_t[\varepsilon_{m,k}] \approx 0$
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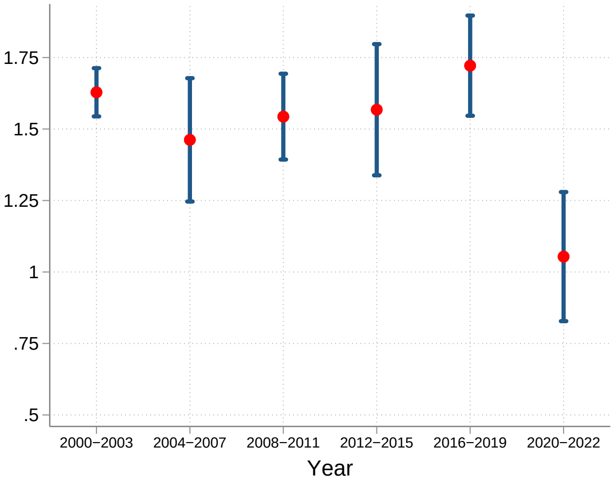
  - We **exclude monetary events** (FOMC meetings, minutes releases, governor's speeches)
- Yields on nominal and inflation-protected bonds to compute (risk-neutral) forecast revisions of nominal rates and inflation *on average* over the life of a bond ▸ Data
- Fixing $\rho_i = 0.8$, we **test for the stability of** $\psi_\pi$ by estimating

$$\Delta\mathbb{E}_t\left[\bar{i}_{t,k} - \left(\frac{k-1}{k}\right)\rho_i \bar{i}_{t,k-1}\right] = c + \sum_{s=1}^{6} \psi_{\pi,s}\left(D_{t,s} \times \Delta\mathbb{E}_t\left[(1-\rho_i)\overline{\pi}_{t,k}\right]\right) + e_t,$$

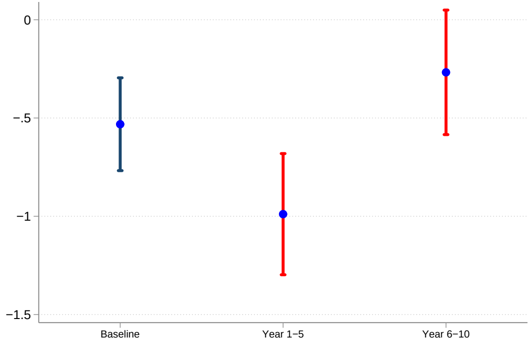
# Estimating $\psi_\pi$ across sub-samples




- **$\psi_\pi$ remarkably stable pre 2020**, **drops significantly after 2020**

# Exploiting the term structure

$$\Delta\mathbb{E}_t\left[\bar{i}_{t,k} - \rho_i \frac{k-1}{k}\bar{i}_{t,k-1}\right] = c + \psi_\pi \Delta\mathbb{E}_t\left[(1-\rho_i)\overline{\pi}_{t,k}\right] + d\left(D_t \times \Delta\mathbb{E}_t\left[(1-\rho_i)\overline{\pi}_{t,k}\right]\right) + e_t,$$




- Significant reduction in interest rate sensitivity in the 2020-2022 period
- Lower sensitivity expected in the **medium-term** ([1-5] yr horizon), not in the long-run

# Sensitivity analysis

1. Misspecification of the reaction function can lead to biased estimates of $\psi_\pi$
   - We are not controlling for the output gap. Bias may dampen sensitivity post 2020 due to larger prevalence of supply shocks in this period ▸ Details
     - Repeat the analysis conditioning **on the same type of shock** pre/post 2020
   - We are not allowing for time-variation in $i^\star$ and $\pi^\star$
     - Allow for time-variation using long-horizon forward
2. At the zero lower bound, interest rates less responsive to inflation ▸ Details
   - We control explicitly for the ZLB constraint and find comparable results
3. Risk premia and liquidity premia/convenience yields ▸ Details
   - Take out risk premium on treasuries and TIPS
   - Risk-neutral expectations recovered from Swaps

▸ Results

# Outline

# The economy in one slide

- Households have preferences

$$\mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t \tilde{\theta}_t \left( \frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{l_t^{1+\nu}}{1+\nu} \right) \right]$$

- Competitive final good firms use intermediates to produce final good

$$y_t = \left( \int_0^1 y_{i,t}^{\frac{1}{\mu_t}} \, di \right)^{\mu_t}$$

- Monopolistic competitive firms use labor to produce intermediate goods, $y_{i,t} = n_{i,t}$. They face quadratic adjustment costs when setting prices, $\frac{\phi}{2} \left( \frac{P_{i,t}}{P_{i,t-1}} \frac{1}{1+\bar{\pi}} - 1 \right)^2$
- Monetary authority follows Taylor rule with Markov switching regimes

$$1 + i_t = (1 + i_{t-1})^{\rho_i} \left\{ \bar{i} \left[ \frac{1 + d(\xi_t)\pi_t + [1 - d(\xi_t)]\bar{\pi}_t}{1 + \pi^\star} \right]^{\psi_\pi(\xi_t)} \left( \frac{y_t}{\bar{y}_t} \right)^{\psi_y} \right\}^{1-\rho_i} \exp\{\sigma_m \varepsilon_{m,t}\}$$

where $\xi_t \in \{H(awk), D(ove)\}$ is a two-state Markov chain with transition matrix $\mathbf{P}$ and $\bar{\pi}_t = \frac{1}{N} \sum_{j=0}^{N} \pi_{t-j}$

# Parameters

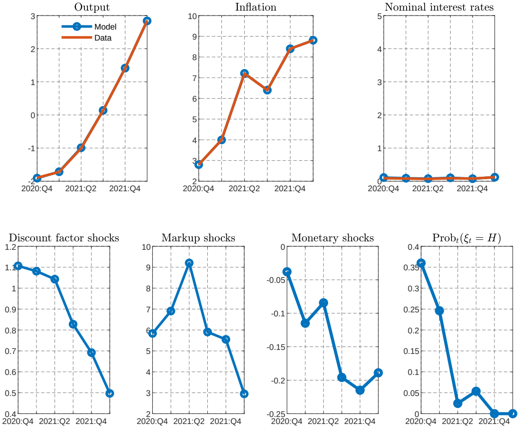
| Panel A: **Fixed parameters** | | |
|---|---|---|
| | Value | Notes |
| $\sigma$ | 1.000 | Intertemporal elasticity of substitution of 1 |
| $\nu$ | 1.000 | Frish elasticity of 1 |
| $\chi$ | 0.833 | Normalize output to 1 in steady state |
| $\overline{\mu}$ | 1.200 | 20% markup in steady state |
| $\pi^{\star}$ | 0.005 | Inflation target of 2% |
| $\beta$ | 0.995 | Annualized real interest rate of 2% in steady state |
| $N$ | 12.000 | 3 year horizon when averaging inflation in the $D$ regime |
| $P_{HH}$ | 0.994 | 40 years expected duration of $H$ regime |

| Panel B: **Estimation of single regime model** | | | | | |
|---|---|---|---|---|---|
| Parameter | Posterior mean | 90% interval | Prior distribution | Prior mean | Prior st. dev. |
| $\phi$ | 58.35 | [39.94,75.97] | Gamma | 80.00 | 10.00 |
| $\psi_\pi(H)$ | 2.52 | [2.09,2.95] | Normal | 1.50 | 0.50 |
| $\psi_y$ | 0.29 | [0.18,0.39] | Normal | 1.50 | 0.50 |
| $\rho_i$ | 0.90 | [0.87,0.92] | Beta | 0.50 | 0.29 |
| $\rho_\mu$ | 0.83 | [0.73,0.93] | Beta | 0.50 | 0.29 |
| $\rho_\theta$ | 0.94 | [0.92,0.97] | Beta | 0.50 | 0.29 |
| $\sigma_\mu \times 100$ | 2.67 | [1.85,3.48] | InvGamma | 1.00 | Inf |
| $\sigma_\theta \times 100$ | 0.17 | [0.14,0.20] | InvGamma | 1.00 | Inf |
| $\sigma_m \times 100$ | 0.18 | [0.15,0.20] | InvGamma | 1.00 | Inf |

| Panel C: **Parameters of Dovish rule** | | |
|---|---|---|
| | Value | Notes |
| $\psi_\pi(D)$ | 0.66 | Point estimates of $d$, 1-5 yrs. **Data: -1.00, Model: -1.00** |
| $P_{DD}$ | 0.83 | Point estimates of $d$, 6-10 yrs. **Data: 0.00, Model: -0.03** |

# Filtering

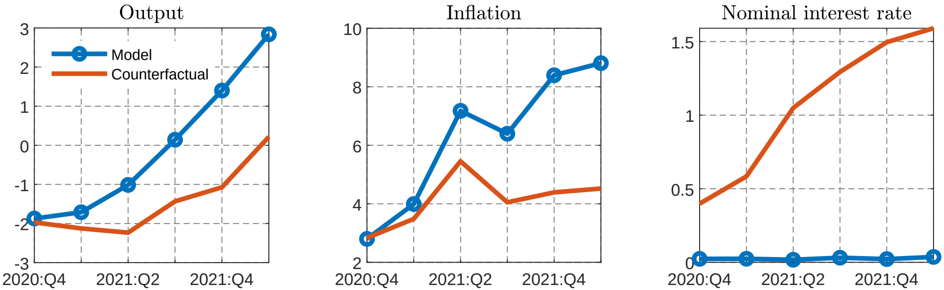
What realization of shocks do we need to fit the data post covid (2020:Q4-2022:Q1)?




- High markup shocks, increasing demand and a more Dovish monetary authority

# Role of monetary policy during the pandemic

What if there was no shift in the policy regime post 2020?




- Without a shift in the policy regime, inflation would have peaked at 5%

# Why is the change in the monetary rule so consequential?

Let's start from the log-linearized Phillips curve and Euler equation

$$
\begin{aligned}
\hat{\pi}_t &= \kappa \left(\hat{y}_t + \mu_t\right) + \beta \mathbb{E}_t[\hat{\pi}_{t+1}] \\
\hat{y}_t &= -\frac{1}{\sigma}\left(\hat{r}_t + \hat{\theta}_t\right) + \mathbb{E}_t[\hat{y}_{t+1}]
\end{aligned}
$$

# Why is the change in the monetary rule so consequential?

Iterating forward these relationships we obtain

$$\begin{aligned}\hat{\pi}_t &= \kappa \sum_{j=0}^{\infty} \beta^j \mathbb{E}_t[\hat{y}_{t+j}] + \kappa \sum_{j=0}^{\infty} \beta^j \mathbb{E}_t[\hat{\mu}_{t+j}] \\ \hat{y}_t &= -\frac{1}{\sigma} \sum_{j=0}^{\infty} \mathbb{E}_t[\hat{r}_{t+j}] - \frac{1}{\sigma} \sum_{j=0}^{\infty} \mathbb{E}_t[\hat{\theta}_{t+1+j}]\end{aligned}$$

So, the difference between inflation across the two regimes is approximated by

$$\begin{aligned}\hat{\pi}_t^D - \hat{\pi}_t^{\mathrm{H}} &= -\frac{\kappa}{\sigma}\Big\{ \left(r_t^D - r_t^H\right) + (1+\beta)\left[\mathbb{E}_t(r_{t+1}|\xi_t = D) - \mathbb{E}_t(r_{t+1}|\xi_t = H)\right] \\ &+ (1+\beta+\beta^2)\left[\mathbb{E}_t(r_{t+2}|\xi_t = D) - \mathbb{E}_t(r_{t+2}|\xi_t = H)\right] + \dots \Big\},\end{aligned}$$

Sensitivity **increasing** in $j$. Due to "forward guidance puzzle" **and** forward-looking nature of inflation

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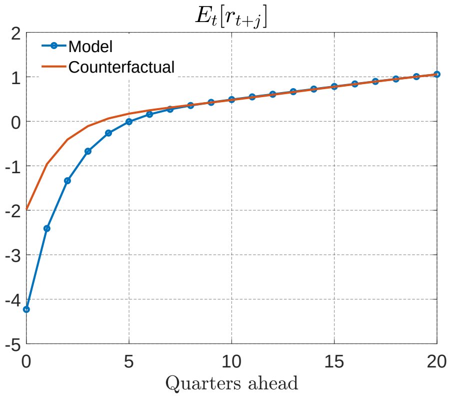



- Difference in real rates across two regimes empirically plausible
- Large effects on inflation due to "forward guidance puzzle" (squared)

# Conclusion

- Test for perceived shifts in the monetary policy rule using bond market data
- Evidence of a reduction in the sensitivity of nominal interest rates to inflation during the pandemic. Can plausibly be interpreted as a shift in the policy rule
- When coupled with an off-the-shelf NK model, this change in the policy regime has quantitatively important implications for the dynamics of inflation over this episode
- Shift in medium-term expectations, but long-run sensitivity "anchored"
  - Different in emerging markets like Brazil and Turkey
  - "Monetary Policy without an Anchor": A theory to explain differences in the policy responses to the Covid shock and in the degree of "anchoring" of inflation expectations between emerging and advanced economies

# Literature

- Estimation of monetary policy rules: Clarida, Gali and Gertler (2000), De Bortoli, Gali and Gambetti (2020), Hamilton, Pruitt and Borger (2011), Bauer, Pflueger and Sunderam (2022)
  - We exploit high-frequency identification to test for a shift in the monetary policy rule
- High-frequency identification of monetary shocks: Kuttner (2001), Piazzesi and Swanson (2008), Gertler and Karadi (2015), Nakamura and Steinsson (2018), Bauer and Swansson (2023)
  - We use monetary events to identify shifts in the policy rule (rather than effects of shocks)
- Drivers of recent spikes in inflation: Gagliardoni and Gertler (2023), Comin, Johnson and Jones (2023), Doh and Yang (2023), Bianchi, Faccini, and Melosi (2023).
  - We detect shift in policy rule and assess the impact on recent inflation dynamics
- Macro effects of regime shifts in monetary policy: Bianchi (2013), Bianchi and Ilut (2017), Bianchi, Lettau and Ludvigson (2022), Bianchi, Ludvigson and Ma (2023), McCkay and Wolf (2024), Caravello, McKay, Wolf (2024)

Return

# The data

- Daily data on nominal and real (TIPS) yields on zero-coupon bonds (ZCBs) from Gurkaynak, Sack and Wright (2007, 2008). Main sample: 2000-2022

- Yields on ZCBs maturing in year $k$ are linked to expectations of future short-term rate

$$i_t^{(k)} = \mathbb{E}_t^{\mathcal{Q}} \left[ \frac{1}{k} \sum_{i=0}^{k-1} i_{t+i}^{(1)} \right] = \mathbb{E}_t \left[ \bar{i}_k \right] + \text{term premium}_{k,t}$$

- Inflation compensation are linked to expectations of future inflation

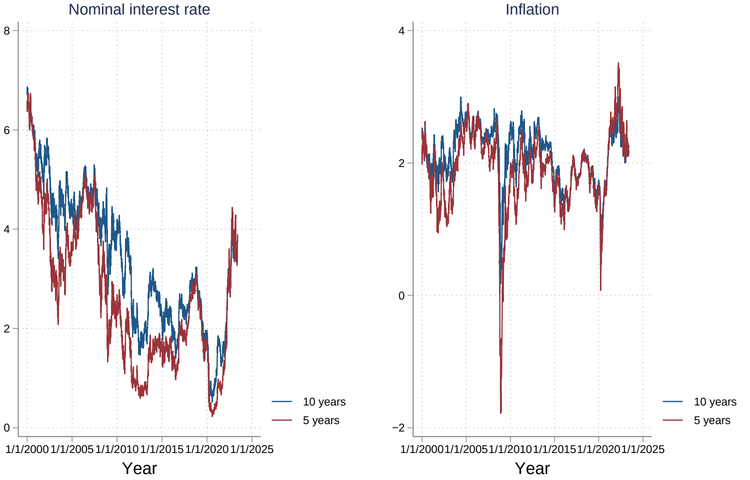
$$IC_t^{(k)} = i_t^{(k)} - r_t^{(k)} = \mathbb{E}_t^{\mathcal{Q}} \left[ \frac{1}{k} \sum_{i=1}^{k} \pi_{t+i} \right] = \mathbb{E}_t \left[ \bar{\pi}_k \right] + \text{inflation risk premium}_{k,t}$$

- Use different maturities to obtain forward rates. E.g. expected inflation in year $k$ is

$$\mathbb{E}_t^{Q} \left[ \pi_k \right] = (k - t) \times \mathbb{E}_t^{Q} \left[ \bar{\pi}_k \right] - (k - 1 - t) \times \mathbb{E}_t^{Q} \left[ \bar{\pi}_{k-1} \right]$$

Return

# The time path of risk-neutral expectations




- Liquidity premium during financial crises (TIPS not as liquid as treasuries). We exclude 2008 and 2020:M1-2020:M6 from the sample

Return

# Misspecification bias: Output gap

- Suppose conduct of monetary policy is described by

$$i_k = \rho_i i_{k-1} + (1-\rho_i)\left\{i_k^\star + \psi_\pi\left(\pi_k - \bar{\pi}\right) + \psi_y \tilde{y}_k\right\} + \varepsilon_k$$

- Taking expectations, first differencing and averaging across $k$ as before

$$\Delta\mathbb{E}_t[\bar{i}_k - \rho_i \bar{i}_{k-1}] = (1-\rho_i)\psi_\pi \Delta\mathbb{E}_t[\bar{\pi}_k] + (1-\rho_i)\psi_y \Delta\mathbb{E}_t[\bar{\tilde{y}}_k]$$

- OLS does not identify $\psi_\pi$ but

$$\hat{\psi}_\pi^{\mathrm{OLS}} \rightarrow \psi_\pi + \psi_y \frac{\mathrm{Cov}\left(\Delta\mathbb{E}_t[\,\bar{\pi}_k\,], \Delta\mathbb{E}_t[\bar{\tilde{y}}_k]\right)}{\mathrm{Var}\left(\Delta\mathbb{E}_t[\,\bar{\pi}_k]\right)}$$

# Detecting a structural break in the policy rule

$$\hat{\psi}_{\pi}^{\text{OLS}} \to \psi_{\pi} + \psi_{y} \frac{\text{Cov}\left(\Delta\mathbb{E}_t[\,\bar{\pi}_k\,], \Delta\mathbb{E}_t[\bar{\tilde{y}}_k]\right)}{\text{Var}\left(\Delta\mathbb{E}_t[\,\bar{\pi}_k]\right)}$$

- A reduction in $\hat{\psi}_{\psi}^{\text{OLS}}$ between two sub-samples could signal two things
  - A shift in the policy rule
  - A change in the type of shocks the Fed is facing (E.g. larger **supply shocks** than before)

- **Our approach**: test for a break in $\psi_{\pi}$ **conditioning on the same type of shock**
  - Forecasts updates around "monetary events" and oil shocks. Test for a break in $\psi_{\pi}$ in 2020
  - Assumption: **conditional** correlation between inflation and the output gap constant across sub-samples **under the null hypothesis of no shift in policy**

# The logic of the test in the 3-equations NK model

## The bias in the 3-equations NK model

Consider the log-linearized 3-equations NK model. Then

$$\hat{\psi}_{\pi}^{\text{OLS,m}} \to \psi_{\pi} + \psi_{y}\frac{1-\beta\rho_{y}}{\kappa},$$

where $\kappa$ is the slope of the Phillips curve, $\beta$ is the rate of time preference and $\rho_y$ solves

$$\rho_{y} = \left[\rho_{i} + \frac{\sigma\rho_{y}}{\rho_{y} - \left[1-\sigma\kappa\left(\frac{\rho_{y}}{1-\beta\rho_{y}}\right)\right]}(1-\rho_{i})\left(\psi_{y} + \psi_{\pi}\frac{\kappa}{1-\beta\rho_{y}}\right)\right]$$

- Under the null hypothesis of no change in the policy rule, the asymptotic bias of $\hat{\psi}_{\pi}^{\text{OLS,m}}$ is constant across sub-samples as long as $(\kappa, \sigma, \beta)$ are constant
- A reduction in $\hat{\psi}_{\pi}^{\text{OLS,m}}$ across the two sub-samples indicates a reduction in $\psi_{\pi}$ ($\rho_y$ not sensitive to $\psi_{\pi}$ in standard calibrations)

# Results

Baseline specification:

$$\Delta\mathbb{E}_t\left[\bar{i}_{t,k}-\rho_i\frac{k-1}{k}\bar{i}_{t,k-1}\right]=c+\psi_\pi\Delta\mathbb{E}_t\left[(1-\rho_i)\overline{\pi}_{t,k}\right]+d\left(D_t\times\Delta\mathbb{E}_t\left[(1-\rho_i)\overline{\pi}_{t,k}\right]\right)+e_t,$$

| | (1) Baseline | (2) Mon shocks | (3) Oil shocks | (4) $i^\star$ and $\pi^\star$ | (5) Risk premia | (6) ZLB | (7) ZLB, options |
|---|---|---|---|---|---|---|---|
| $d_{[1-10]}$ | $-0.53^{\star\star\star}$ | $-0.87^{\star\star}$ | $-1.16$ | $-0.15^{\star\star\star}$ | $-0.19$ | $-0.30$ | -0.57 |
| | (0.12) | (0.43) | (1.18) | (0.06) | (0.20) | (0.21) | (0.34) |
| $d_{[1-5]}$ | $-0.99^{\star\star\star}$ | $-1.94^{\star\star\star}$ | $-1.99^{\star}$ | $-0.29^{\star\star\star}$ | $-1.02^{\star\star\star}$ | $-1.09^{\star\star\star}$ | $-1.23^{\star\star\star}$ |
| | (0.16) | (0.51) | (1.14) | (0.10) | (0.12) | (0.27) | (0.35) |
| $d_{[6-10]}$ | $-0.27^{\star}$ | $-0.69$ | $-0.04$ | $-0.22$ | $0.16^{\star\star\star}$ | 0.23 | 0.14 |
| | (0.16) | (0.41) | (1.25) | (0.16) | (0.05) | (0.15) | (0.40) |
| N. obs. | 3558 | 455 | 62 | 3558 | 3558 | 3558 | 2373 |

Return

# Controlling for a binding ZLB

Suppose interest rates follow the process

$$\begin{aligned} \hat{i}_k &= \rho_i i_{k-1} + (1-\rho_i)\left\{i_k^\star + \psi_\pi(\pi_k - \bar{\pi}) + \psi_y \tilde{y}_t\right\} + \varepsilon_k \\ i_k &= \max\left\{\hat{i}_k, 0\right\} \end{aligned}$$

If $\varepsilon_k | \mathcal{I}^t \sim \mathcal{N}(0, \sigma_\varepsilon)$, then we have

$$\mathbb{E}_t[\, i_k \,] = \rho_i \mathbb{E}_t[\, i_{k-1} \,] + (1-\rho_i)\left\{\mathbb{E}_t[i_k^\star] + \psi_\pi \mathbb{E}_t[\pi_k - \bar{\pi}] + \psi_y \mathbb{E}_t[\tilde{y}_t]\right\} + \underbrace{\frac{\varphi\left(\frac{\mathbb{E}_t[\hat{i}_k]}{\sigma}\right)}{1 - \Phi\left(\frac{\mathbb{E}_t[\hat{i}_k]}{\sigma}\right)}\sigma}_{f}$$

Approximate the expression around $\mathbb{E}_t[i_{k-1}] = \bar{i}_{k-1}$, $\mathbb{E}_t[i_k^\star] = i^\star$, $\mathbb{E}_t[\pi_k] = \bar{\pi}$, $\mathbb{E}_t[\tilde{y}_k] = 0$

$$\mathbb{E}_t\left[ i_k - \rho_i \left(1 + \frac{1}{\sigma} f_k'\right) i_{k-1} \right] = (1-\rho_i)\left(1 + \frac{1}{\sigma} f_k'\right)\left\{\mathbb{E}_t[i_k^\star] + \psi_\pi \mathbb{E}_t[\pi_k - \bar{\pi}] + \psi_y \mathbb{E}_t[\tilde{y}_t]\right\}$$

# Controlling for a binding ZLB

For each $k$ and sub-period $s$, we construct $\{f'_k\}$ by setting:

- $i^\star \Rightarrow$ sample average of the Laubach-Williams series in each sub-period $s$
- $\bar{i}_{k-1} \Rightarrow$ sample average of $\mathbb{E}_t^Q[i_{k-1}]$ in each sub-period $s$
- We set $\sigma = 0.03$, a fairly conservative value for this exercise

We then perform our analysis using the following equation

$$\Delta\mathbb{E}_t[\,\bar{i}_k\,] - \frac{1}{10}\sum_{k=1}^{10}\rho_i\left(1+\frac{1}{\sigma}f'_k\right)\Delta\mathbb{E}_t[\,i_{k-1}\,] = \psi_\pi\frac{1}{10}\sum_{k=2}^{10}\rho_i\left(1+\frac{1}{\sigma}f'_k\right)\Delta\mathbb{E}_t[\,(1-\rho_i)\pi_k\,] + \eta_t$$

▸ Return

# Controlling for risk premia

- Most asset pricing models predict expected inflation, inflation compensation and nominal bond yields to functions of the same underlying factors $X_t$

- To approximate the relation between expected inflation and these factors, we estimate the following relation

$$SPF_t^{(n)} = \beta_{n,0} + \beta_{n,1} IC_t^{2y} + \beta_{n,2} IC_t^{5y} + \beta_{n,3} IC_t^{10y} + \beta_{n,4} i_t^{2y} + u_t^{(n)}$$

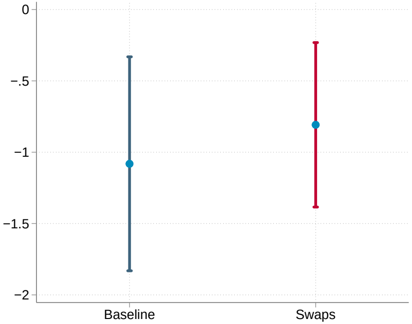
  over rolling sub-samples, where $SPF_t^{(n)}$ is the average inflation expectation at horizon $n$ in the Survey of Professional Forecasters. We use the estimated $\beta$'s to construct daily inflation expectations

- We use the Fed board term structure model to infer $\mathbb{E}_t[\bar{i}_k]$

- We repeat our analysis with $\{\mathbb{E}_t[\bar{i}_k], \mathbb{E}_t[\bar{\pi}_k]\}$.

# Repeating the analysis using swaps

- Nominal and real treasuries may have different liquidity/convenience properties
- We repeat the analysis constructing expected inflation and nominal interest rates using
  - Overnight Index Swaps (OIS) tied to the federal funds rate
  - Inflation-Linked Swaps (ILS)
- Data limitations: need to start in 2005 and focus on the 5 years horizon




Return

# Road map

Three papers on these and related questions

1. Bond Market Views of the Fed (joint with Dovis, Jorgenson and Kirpalani)
   - Using bond market data to detect shifts in perceptions about monetary policy rules
2. **Monetary Policy without an Anchor** (joint with Dovis, Jorgenson and Kirpalani)
   - Formalizes the notion of "de-anchoring risk" and proposes a strategy to measure it and quantify benefits of anchored inflation expectations
3. Accounting for Credibility: Fiscal-Monetary Interactions and the Credibility of Central Banks Mandates (joint with Chaumont, Dovis, and Kirpalani)
   - Model of the credibility of inflation-targeting mandates. Framework used to measure evolution of credibility and its drivers, and understand implications for optimal policy

Common theme: tools to measure credibility and understand its causes and consequences

# Monetary Policy without an Anchor

Luigi Bocola
Stanford University, CEPR and NBER

Alessandro Dovis
University of Pennsylvania and NBER

Kasper Jorgensen
ECB

Rishabh Kirpalani
University of Wisconsin-Madison

*The views in this paper are those of the authors and do not necessarily reflect those of the ECB or its staff*

# Motivation

- The **risk of de-anchoring** of inflation expectations key consideration for policymakers during inflationary episodes

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  - Countries that tightened the most (E.g. Brazil) explicitely mention "de-anchoring risk"

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- Questions:
  1. Was Brazil more at risk of a de-anchoring than other countries?
  2. What are the macroeconomic costs/benefits of keeping inflation expectations anchored?

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- Questions:
  1. Was Brazil more at risk of a de-anchoring than other countries?
  2. What are the macroeconomic costs/benefits of keeping inflation expectations anchored?

- This paper: **Model** + **Data** to
  - Formalize trade-off faced by central bank when inflation expectations can de-anchor
  - Quantify risk of de-anchoring and benefits of maintaining inflation expectations anchored

# Theory and measurement

- New Keynesian model with optimal monetary policy
  - Main twist: private sector **uncertain** about the policymaker's type, learns from actions
  - Changes in interest rates → update beliefs on policymaker's type → inflation expectations
  - **Reputation channel**: when private sector uncertain/economy faces inflationary shocks, more incentives to act as a "hawk"

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- Key measure: Elasticity of long-run inflation expectations to monetary surprises
  - If elasticity large, acting more "dovishly" leads to large increases in inflation expectations
  - The more elastic inflation expectations are, the stronger the reputation building motives

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  - The more elastic inflation expectations are, the stronger the reputation building motives
- Quantitative strategy: Estimate elasticity, combine it with model for counterfactual

# Results

- Estimate elasticity of inflation expectations to monetary policy surprises
  - Sizable long-run elasticity for Brazil
  - Not significantly different from zero for US, euro area, UK, Mexico and Chile
- Combine estimates with model to assess role of reputation in Brazil
  - Reputation building motives strong
    - Especially when private sector is uncertain about conduct of monetary policy
    - Equivalent to a 9-fold increase in the slope of the Phillips curve
  - Large gains from reputation: higher reputation reduces inflation on average (from 6.75% to 4.75%), and allow CB to "look-through" supply shocks

# Literature

- Reputation and monetary policy: Barro and Gordon (1983), Backus and Driffil (1985), Rogoff (1985), Amador and Phelan (2024), Lu, King and Pasten (2016), Gati (2024), King and Lu (2022), Carvello, Carrasco and Martinez-Buera (2025)
  - Strategy to quantify the strength of reputation channel
- Measures of de-anchoring: Coibion, Gorodnichenko (2025), Bernanke (2007), Carvalho, Eusepi, Moench and Preston (2023)
  - "Elasticity" of inflation expectations more informative about risk than their "level"
- Monetary shocks and inflation expectations: Gurkaynak, Sack and Swanson (2005), Nakamura and Steinsson (2018), De Pooter et al. (2014), Bonomo et al. (2024)
- Monetary policy and inflation spikes post Covid: Gagliardone and Gertler (2023), Comin, Johnson and Jones (2023), Bocola, Dovis, Jorgensen and Kirpalani (2024), Nakamura, Riblier and Steinsson (2025), . . .
  - Combine high-frequency bond market data with structural model to assess role of monetary policy in emerging markets during this episode

# Outline

# Environment

- Baseline New Keynesian model. Private sector behavior summarized by

$$\begin{aligned}
\pi_t(1+\pi_t) &= y_t \frac{\left[\mu_t \chi y_t^{\nu} c_t - 1\right]}{\phi[\mu_t - 1]} + \beta \mathbb{E}_t \left[ \left( \frac{c_{t+1}}{c_t} \right)^{-1} \pi_{t+1} \left(1 + \pi_{t+1}\right) \right] \\
\frac{1}{1+i_t} &= \beta \mathbb{E}_t \left[ \left( \frac{c_{t+1}}{c_t} \right)^{-1} \frac{1}{(1+\pi_{t+1})} \right] \\
y_t &= c_t + \frac{\phi}{2} \pi_t^2
\end{aligned}$$

where $y_t = Y_t / z_t$, $c_t = C_t / z_t$, $\pi_t = P_t / P_{t-1}$ and $z_t$ a technology shock

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- $i_t$ chosen by Central Bank (CB) without commitment. Objective function at $t$:

$$R_t = -\alpha\left(\theta_t, \varepsilon_t\right) \pi_t^2 - \left[1 - \alpha\left(\theta_t, \varepsilon_t\right)\right] \left( \frac{y_t - y^\star}{y^\star} \right)^2$$

  - $\theta_t \in \left\{ \theta^H, \theta^D \right\}$ is the CB "type". Markov process with transition matrix $P_\theta$
  - $\varepsilon_t$ is an iid Gaussian "monetary shock"

# Information sets, timing and expectations

Private sector doesn't observe $(\theta_t, \varepsilon_t)$, learns CB type from actions

- Private sector prior about CB being a Hawk: $\rho$
  - We refer to $\rho$ as the CB **reputation**
- At the beginning of each period the shocks $s = (\mu, z)$ and $(\theta, \varepsilon)$ are realized
- The monetary authority chooses the level of the nominal interest rate, $\bar{i}$
- Private sector updates its prior $\rho$ using Bayes rule

$$\rho'\left(\theta^H | s, \rho, \bar{i}\right) = \frac{\rho\phi\left(\varepsilon : i\left(\theta^H, \varepsilon, \rho, s\right) = \bar{i}\right) P_{HH} + (1-\rho)\phi\left(\varepsilon : i\left(\theta^D, \varepsilon, \rho, s\right) = \bar{i}\right) P_{HD}}{\rho\phi\left(\varepsilon : i\left(\theta^H, \varepsilon, \rho, s\right) = \bar{i}\right) + (1-\rho)\phi\left(\varepsilon : i\left(\theta^D, \varepsilon, \rho, s\right) = \bar{i}\right)}$$

- The private sector chooses output/inflation

# Equilibrium

A Markov perfect equilibrium is $i(s, \rho, \theta, \varepsilon)$, $y(s, \rho, i)$, $\pi(s, \rho, i)$, $c(s, \rho, i)$, a value function for the CB $V(s, \rho, \theta, \varepsilon)$, and a law of motion for reputation such that

- The government strategy and value function solve the decision problem
- The equilibrium outcome satisfies the Phillips curve, the Euler equation and the resource constraint
- The law of motion for reputation satisfies Bayes' rule

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The problem of the Central Bank:

$$V(s, \rho, \theta, \varepsilon) = \max_i R(\pi(s, \rho, i), y(s, \rho, i); \alpha(\theta, \varepsilon)) + \beta \mathbb{E}^{cb}[V(s', \rho'(s, \rho, i), \theta', \varepsilon')]$$

given $y(s, \rho, i)$, $\pi(s, \rho, i)$, $c(s, \rho, i)$ and the law of motion for reputation

# Equilibrium

A Markov perfect equilibrium is $i(s,\rho,\theta,\varepsilon)$, $y(s,\rho,i)$, $\pi(s,\rho,i)$, $c(s,\rho,i)$, a value function for the CB $V(s,\rho,\theta,\varepsilon)$, and a law of motion for reputation such that

- The government strategy and value function solve the decision problem
- The equilibrium outcome satisfies the Phillips curve, the Euler equation and the resource constraint
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The equilibrium outcome can be characterized by solving:

$$V(s,\rho,\theta,\varepsilon) = \max_{y,\pi,c} R(\pi, y; \alpha(\theta,\varepsilon)) + \beta\mathbb{E}\left[V(s',\rho',\theta',\varepsilon')\middle| s,\theta\right]$$

$$\begin{aligned}
\pi(1+\pi) &= y\frac{[\mu_t \chi y^\nu c - 1]}{\phi[\mu - 1]} + \beta\mathbb{E}\left[\left(\frac{c'}{c}\right)^{-1}\pi'\left(1+\pi'\right)\middle| s,\rho'\right] \\
y &= c + \frac{\phi}{2}\pi^2 \\
\rho' &= \rho'\left(\theta^H | s,\rho,y\right)
\end{aligned}$$

# Outline

# Simplified economy

- No inflation-bias, $y^{\star} = y^{\text{fp}} \equiv (\mu\chi)^{-\frac{1}{\nu+\sigma}}$
  - $\pi_D^{ss} = \pi_H^{ss} = 0$
  - Log-linearize equilibrium conditions around zero-inflation steady state

$$\pi_t = \kappa \hat{y}_t + \beta \mathbb{E}_t \left[\pi_{t+1}\right] + \hat{\mu}_t$$

$$R(\hat{y}_t, \pi_t; \alpha_t) = -\frac{1}{2}\left[\alpha_t \pi_t^2 + (1-\alpha_t)\hat{y}_t^2\right]$$

where $\hat{y}_t = \log y_t - \log y^*$

- Permanent types. Unknown at $t = 1$, revealed at $t = 2$
  - No monetary shock from $t \geq 2$

# Perfect information benchmark

From $t \geq 2$ the problem of the Central Bank problem reduces to static problem

$$\max_{\pi,\hat{y}} R(\pi, \hat{y}; \alpha(\theta)) \qquad \text{s.t.} \qquad \pi = \kappa\hat{y} + \beta\mathbb{E}[\pi_2(\theta, \hat{\mu}')|\hat{\mu}] + \hat{\mu}$$

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Optimality condition:

$$\underbrace{\alpha(\theta)\pi\kappa}_{R_\pi \frac{\partial \pi}{\partial \hat{y}}} = \underbrace{-[1-\alpha(\theta)]\hat{y}}_{-R_y}$$

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Substituting in the Phillips curve, we obtain

$$\pi_2(\theta,\hat{\mu}) = \frac{[1-\alpha(\theta)]}{[1-\alpha(\theta)](1-\beta\rho_\mu)+\alpha(\theta)\kappa^2}\hat{\mu}$$

$$\hat{y}_2(\theta,\hat{\mu}) = \frac{-\alpha(\theta)\kappa}{[1-\alpha(\theta)](1-\beta\rho_\mu)+\alpha(\theta)\kappa^2}\hat{\mu}$$

- The higher $\alpha(\theta)$, the smaller the sensitivity of inflation to $\mu$

# Monetary policy with imperfect information

In period 1, the decision problem is

$$\max_{\pi,\hat{y}} R(\pi, \hat{y}; \alpha(\theta, \varepsilon)) + \beta \mathbb{E}[V(\hat{\mu}', \theta)|\hat{\mu}] \qquad \text{s.t.} \qquad \pi = \kappa \hat{y} + \beta\, \Pi_2(\hat{y}; \hat{\mu}, \rho_0) + \hat{\mu},$$

where

$$\Pi_2(\hat{y}; \hat{\mu}, \rho_0) = \rho_1(\hat{y}; \hat{\mu}, \rho_0)\mathbb{E}[\pi_2(\theta^H, \hat{\mu}')|\hat{\mu}] + [1 - \rho_1(\hat{y}; \hat{\mu}, \rho_0)]\mathbb{E}[\pi_2(\theta^D, \hat{\mu}')|\hat{\mu}]$$

Key difference with perfect info: CB actions affect inflation expectations via **reputation**

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Key difference with perfect info: CB actions affect inflation expectations via **reputation**

The optimality condition becomes

$$\alpha(\theta, \varepsilon_1)\pi_1\left[\kappa + \beta\,\Pi_2'(\hat{y}; \hat{\mu}, \rho_0)\right] = -[1 - \alpha(\theta, \varepsilon_1)]\hat{y}_1$$

# Zooming on $\Pi_2'(\hat{y};\hat{\mu},\rho_0)$

$$\Pi_2'(\hat{y};\hat{\mu},\rho_0) = \frac{\partial \rho_1(\hat{y};\hat{\mu},\rho_0)}{\partial \hat{y}} \mathbb{E}\left[\pi_2\left(\theta^H,\hat{\mu}'\right) - \pi_2\left(\theta^D,\hat{\mu}'\right)|\hat{\mu}\right]$$

Elasticity is **non-negative**. Suppose $\hat{\mu} > 0$. Then

- Private sector updates toward the Dove when it sees higher output, $\frac{\partial \rho_1(\hat{y};\hat{\mu},\rho_0)}{\partial \hat{y}} < 0$
- Because $\mathbb{E}[\pi_2(\theta^H,\hat{\mu}') - \pi_2(\theta^D,\hat{\mu}')|\hat{\mu}] < 0$, we have $\Pi_2'(\hat{y}_1;\mu,\rho_0) > 0$

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Elasticity is **state-dependent**

- Equals zero when $\rho_0 = \{0, 1\} \Rightarrow$ Elasticity larger when private sector uncertain
- Equals zero when $\hat{\mu} = 0 \Rightarrow$ Elasticity larger when economy hit by a supply shock

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# The reputation channel

**Proposition**

*The central bank is more "Hawkish" when its type is unknown. That is, if $\mu > 0$, then $\hat{y}_1$ is lower than in the Markov equilibrium under perfect information, strictly so if $\rho_0 \in (0, 1)$.*

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$$\alpha(\theta, \varepsilon_1)\pi_1 \left[\kappa + \beta\, \Pi_2'(\hat{y}_1; \mu, \rho_0)\right] = -[1 - \alpha(\theta, \varepsilon_1)]\hat{y}_1$$

- With perfect info, reducing output when $\mu > 0$ has the benefit of reducing inflation
  - By the slope of the Phillips curve $\kappa$

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- With perfect info, reducing output when $\mu > 0$ has the benefit of reducing inflation
  - By the slope of the Phillips curve $\kappa$
- With **imperfect information**, there is an **additional benefit**
  - By lowering output, CB improves reputation. Higher reputation reduces inflation
  - "As if" Phillips curve is steeper

# Measuring the reputation channel

Incentives to acquire reputation depend on $\Pi_2'(\hat{y}_1;\mu,\rho_0)$. This elasticity can be estimated using "high-frequency" methods

## Proposition

*Let* $\Delta\mathbb{E}[i_1(\hat{y}_1;\mu,\rho_0)]$ *be a "monetary surprise"*

$$\Delta\mathbb{E}\left[i_1(\hat{y}_1;\mu,\rho_0)\right] = i_1\left(\hat{y}_1;\mu,\rho_0\right) - \mathbb{E}\left[i_1\left(\hat{y}_1(\mu,\rho_0,\theta,\varepsilon);\mu,\rho_0\right)\middle|\mu,\rho_0\right],$$

*and* $\Delta\mathbb{E}\left[\pi_2(\hat{y}_1;\mu,\rho_0)\right]$ *be the revision in expected inflation in period 2 after the realization of monetary policy. Then, we have*

$$\frac{\Delta\mathbb{E}\left[\pi_2(\hat{y}_1;\mu,\rho_0)\right]}{\Delta\mathbb{E}[i_1(\hat{y}_1;\mu,\rho_0)]} \approx -\frac{\Pi_2'(\bar{y};\mu,\rho)}{\sigma - \left(1+\sigma\frac{1-\beta}{\kappa}\right)\Pi_2'(\bar{y};\mu,\rho)}$$

# Trade-off in the infinite-horizon economy

In the infinite-horizon economy, one more consideration for the Central Bank:

$$\left\{ R_{\pi,t} \left( \kappa + \frac{\partial \mathbb{E}_t[\pi_{t+1}]}{\partial \rho_{t+1}} \frac{\partial \rho_{t+1}}{\partial y_t} \right) + R_{y,t} \right\} \frac{\partial y_t}{\partial i_t} + \beta \frac{\partial \mathbb{E}_t^{cb}[V_{t+1}]}{\partial \rho_{t+1}} \frac{\partial \rho_{t+1}}{\partial y_t} \frac{\partial y_t}{\partial i_t} = 0$$

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As in 2-period model

Value of reputation

Higher reputation is valuable, $\partial \mathbb{E}_t^{\text{cb}}[V_{t+1}]/\partial \rho_{t+1} > 0$:

- Inflation expectations less sensitive to $\hat{\mu}$ if CB perceived to be more Hawkish
- It allows CB to achieve better inflation/output trade-off for each $\hat{\mu}$

# Trade-off in the infinite-horizon economy

In the infinite-horizon economy, one more consideration for the CB:

$$-\left\{R_{\pi,t}\kappa + R_{y,t}\right\}\frac{\partial y_t}{\partial i_t} = \beta\left\{R_{\pi,t}\frac{\partial \mathbb{E}_t\left[\pi_{t+1}\right]}{\partial \rho_{t+1}} + \frac{\partial \mathbb{E}_t^{cb}\left[V_{t+1}\right]}{\partial \rho_{t+1}}\right\}\frac{\partial \rho_{t+1}}{\partial i_t}$$

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Apply envelope theorem

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"Wedge" relative to perfect info

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In the infinite-horizon economy, one more consideration for the CB:

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Gains from stabilizing inflation expectations

Sensitivity of inflation expectations *sufficient statistic* for reputation building motives

- CB deviates from "standard" policy prescription and acts more hawkishly when inflation expectations very sensitive to their actions

# Outline

1 The model

2 Mechanisms in a simplified version of the model

3 Empirical analysis

4 Quantifying the reputation mechanism

# Taking stock

$$-\left\{R_{\pi,t}\kappa + R_{y,t}\right\}\frac{\partial y_t}{\partial i_t} = \sum_{k=1}^{\infty}\beta^k \mathbb{E}_t^{cb}\left\{R_{\pi,t+k-1}\frac{\partial \mathbb{E}_t\left[\pi_{t+k}\right]}{\partial \rho_{t+1}}\right\}\frac{\partial \rho_{t+1}}{\partial i_t}$$

Equation relates (unobservable) "reputation wedge" to (potentially observable) sensitivity of inflation expectations to policy changes

We use this relation to discipline size of reputation mechanism in the model

1 Measure empirically $\frac{\partial \mathbb{E}_t[\pi_{t+j+1}]}{\partial \rho_{t+1}}\frac{\partial \rho_{t+1}}{\partial i_t}$

2 Use elasticities as calibration targets

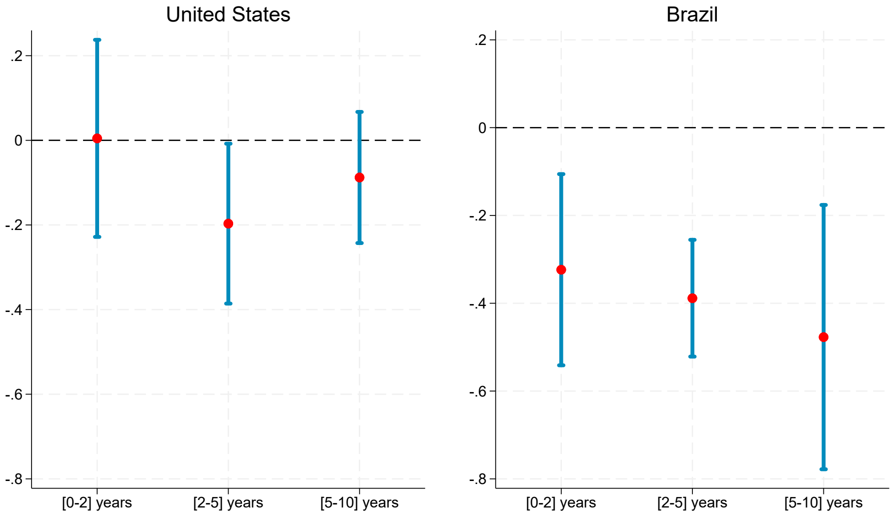
# Data and baseline specification

- Countries: Brazil, Chile, Mexico, Euro area, US, UK. Sample: 2010-2024
- Two measures of long-run inflation expectations
  - Five year/five year break-even inflation (daily frequency)
  - Professional forecasters surveys (monthly/quarterly)
- Monetary policy surprises computed using short-term rates
  - 3mo OIS for emerging market economies
  - 1yr OIS for Euro area, US and UK
- Baseline specification

$$\Delta\mathbb{E}_t[\bar{\pi}_{k,k+s}] = a_{(k,s)} + b_{(k,s)}\Delta\mathbb{E}_t[i_t] + e_{(k,s),t}$$

$b_{(k,s)}$ measures sensitivity of inflation expectations between $k$ and $k+s$ years from $t$

# Brazil vs US



# Results

*Panel A: Market-based results*

| | Brazil | Chile | Mexico | Euro area | UK | US |
|---|---|---|---|---|---|---|
| $b_{(5y5y)}$ | $-0.48^{\star\star\star}$ | $-0.05$ | $0.02$ | $0.03$ | $-0.05$ | $-0.09$ |
| | $(0.18)$ | $(0.05)$ | $(0.07)$ | $(0.06)$ | $(0.07)$ | $(0.09)$ |
| $R^2$ | $0.08$ | $0.03$ | $0.00$ | $0.00$ | $0.01$ | $0.00$ |
| Sample | 2010-2024 | 2010-2023 | 2010-2024 | 2010-2024 | 2010-2024 | 2010-2024 |
| # obs. | 92 | 104 | 109 | 134 | 143 | 114 |

*Panel B: Survey-based results*

| | Brazil | Chile | Mexico | Euro area | UK | US |
|---|---|---|---|---|---|---|
| $b$ | $-0.18^{\star\star}$ | $-0.00$ | $0.03$ | $0.11$ | $0.29$ | $-0.04$ |
| | $(0.09)$ | $(0.02)$ | $(0.06)$ | $(0.08)$ | $(0.23)$ | $(0.06)$ |
| $R^2$ | $0.22$ | $0.00$ | $0.00$ | $0.05$ | $0.02$ | $0.00$ |
| Sample | 2010-2024 | 2010-2024 | 2010-2024 | 2010-2024 | 2010-2024 | 2010-2024 |
| # obs. | 92 | 117 | 106 | 57 | 47 | 54 |

- Large long-run elasticities for Brazil
- Not significantly different from zero for other countries

# Outline

# Quantitative analysis

- Focus on Brazilian experience
  - Substantial policy uncertainty pre-Covid: a "Dovish" regime pre-2016 and a more "Hawkish" regime post 2016 (Bonomo et al., 2024)
  - Among the first countries to raise interest rates after the pandemic, with CB explicitely citing risk of a de-anchoring of inflation expectations
  - Strong sensitivity of long-run inflation expectations to monetary surprises
- Questions:
  - How important are reputation building motives?
  - What are the macroeconomic effects of reputation gains?

# Parametrization

- Data: (De-trended) output, inflation and nominal interest rates
- Parametrization of the model in two steps:
  - Fix $[\beta, \nu, \chi, \phi, \bar{\mu}, \rho_z, \sigma_z]$ to standard values
  - Choose $[\rho_\mu, \sigma_\mu, y^\star, \theta_H, \theta_D, P_\theta, \sigma_\varepsilon]$ to fit a set of targets
    - Standard deviation, autocorrelation and cross-correlation of output, inflation, and nominal interest rates
    - Average inflation and nominal interest rates in "dovish" and "hawkish" regime
    - Elasticity of inflation expectations (four years ahead) to monetary surprises
  - Given the high degree of monetary policy uncertainty over this period, we compute the (average) model-implied elasticity conditioning on $\rho_t \in (0.4, 0.6)$

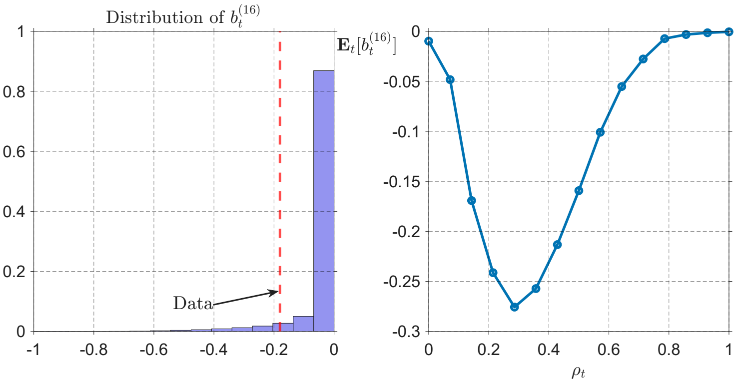
▸ Parameter values

# Model fit

| Moment | Data | Model |
|---|---|---|
| Stdev($\log Y_t$) | 1.95 | 2.02 |
| Stdev($\pi_t$) | 2.01 | 1.82 |
| Stdev($i_t$) | 2.78 | 3.27 |
| Acorr($\log Y_t$) | 0.90 | 0.84 |
| Acorr($\pi_t$) | 0.92 | 0.91 |
| Acorr($i_t$) | 0.95 | 0.45 |
| Corr($\log Y_t, \pi_t$) | -0.23 | 0.00 |
| Corr($\log Y_t, i_t$) | -0.45 | -0.39 |
| Corr($\pi_t, i_t$) | 0.81 | 0.54 |
| Mean($\pi_t$\|Dove) | 6.68 | 6.45 |
| Mean($i_t$\|Dove) | 10.83 | 10.73 |
| Mean($\pi_t$\|Hawk) | 4.23 | 4.60 |
| Mean($i_t$\|Hawk) | 8.42 | 7.06 |
| $b^{(16)}$ | -0.18 | -0.15 |

- Model fits reasonably well output, inflation and nominal interest rates in the sample
- Produces a sizable elasticity of long-run inflation expectations to monetary surprises

# Elasticity: model vs data




Two key ingredients to produce sizable long-run elasticity:

- Slow learning: $P_\theta = 0.995$ and $\sigma_\varepsilon = 2.4$
- Inflation bias: $y^\star > 1.016 \times y^{\mathrm{fp}}$

# Quantifying the reputation channel

To assess strenght of reputation, compare benchmark to economy with "myopic" CB

$$R_{\pi,t}\kappa = -R_{y,t}$$

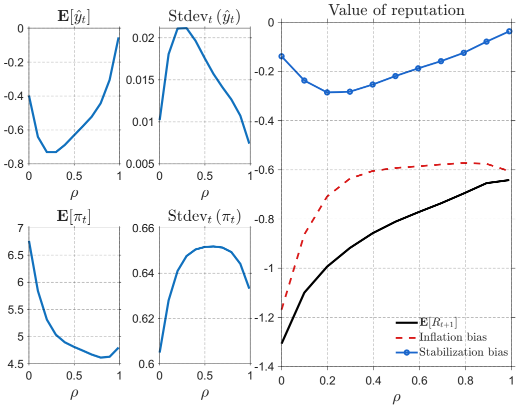
| | Benchmark | Myopic | Benchmark | Myopic |
|---|---|---|---|---|
| Moment | High uncertainty | | Low uncertainty | |
| Mean($\pi_t$) | 4.42 | 5.61 | 5.12 | 5.30 |
| Stdev($\pi_t$) | 1.54 | 1.83 | 1.83 | 1.95 |
| Mean($\hat{y}_t$) | -0.84 | -0.41 | -0.54 | -0.30 |
| Stdev($\hat{y}_t$) | 0.68 | 0.13 | 0.70 | 0.13 |
| $\text{Mean}\left(\frac{R_t^{bench} - R_t}{\text{abs}\left(R_t^{bench}\right)}\right)$ | 0.00 | -0.37 | 0.00 | -0.13 |

- Reputation moderates inflationary pressures (at the cost of higher output volatility)
- Ignoring reputation leads to substantial losses for the CB
- Effects stronger in periods of high policy uncertainty

# The value of reputation

$$\mathbb{E}_t^{cb}[R_{t+1}|\theta, s, \rho] \approx -\mathbb{E}_t\left\{[1-\alpha_{t+1}(\theta)]\,\mathbb{E}_t\left[\frac{y_{t+1}-y^\star}{y^\star}|\varepsilon_{t+1}\right]^2 + \alpha_{t+1}(\theta)\mathbb{E}_t\left[\pi_{t+1}|\varepsilon_{t+1}\right]^2\right\}$$

$$-\mathbb{E}_t\left[[1-\alpha_{t+1}(\theta)]\,Var_t\left(\frac{y_{t+1}-y^\star}{y^\star}|\varepsilon_{t+1}\right) + \alpha_{t+1}(\theta)Var_t\left[\pi_{t+1}|\varepsilon_{t+1}\right]\right].$$



# Two observations

1 Long-run inflation expectations not a good indicator of "de-anchoring" *risk*

- Inflation expectations flat for $\rho_t \geq 0.1$
- But inflation expectations very sensitive to policy choices for $\rho_t \in (0.1, 0.7)$

2 Model can rationalize different monetary policy responses to the post-pandemic inflation episode

- Nakamura, Riblier and Steinsson (2025): high-credibility countries tigthened less aggressively and yet observed similar inflation dynamics
- Consistent with the "reputation dividend" that we document ▸ IRFs

# Conclusions

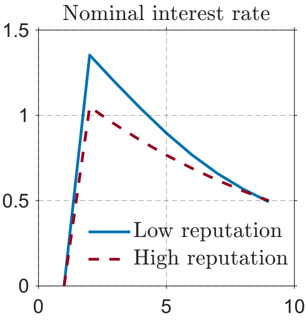
- Studied the trade-offs central banks face in keeping inflation expectations "anchored"
  - Short run output distortions vs. lower and more stable inflation expectations
- Sufficient statistic to gauge strength of reputation mechanism: pdv of elasticity of inflation expectations to interest rate surprises
  - Estimated by applying high-frequency methods to bond market data
  - Elasticity sizable for some emerging market economies
- Applied framework to Brazil
  - Reputation building motives key driver of monetary policy, especially when policy uncertainty is high
  - Gains in reputation improved substantially the inflation/output trade-off

# Calibration

| Parameter | Value | Note |
|---|---|---|
| $\phi$ | 133.333 | Adjustment cost, inflation |
| $1/\sigma$ | 1.000 | Intertemporal elasticity of substitution |
| $\nu$ | 1.000 | Frisch elasticity of labor supply |
| $\beta$ | 0.990 | Discount rate |
| $\bar{\mu}$ | 1.200 | Average markup |
| $\chi$ | 0.833 | Disutility of labor |
| $\rho_z$ | 0.950 | Persistence, productivity shocks |
| $\sigma_z$ | 0.065 | Standard deviation, productivity shocks |
| $\rho_\mu$ | 0.900 | Persistence, markup shocks |
| $\sigma_\mu$ | 0.013 | Standard deviation, markup shocks |
| $\delta$ | 1.016 | Output target |
| $\theta_H$ | 0.500 | Weight on inflation, Hawk |
| $\theta_D$ | 0.150 | Weight on inflation, Dove |
| $P_\theta$ | 0.995 | Probability of remaining in a policy regime |
| $\sigma_\varepsilon$ | 2.400 | Standard deviation, monetary shocks |

Return

# IRFs to markup shocks: high vs low reputation




Return

# Road map

Three papers on these and related questions

1. Bond Market Views of the Fed (joint with Dovis, Jorgenson and Kirpalani)
    - Using bond market data to detect shifts in perceptions about monetary policy rules
2. Monetary Policy without an Anchor (joint with Dovis, Jorgenson and Kirpalani)
    - Formalizes the notion of "de-anchoring risk" and proposes a strategy to measure it and quantify benefits of anchored inflation expectations
3. **Accounting for Credibility: Fiscal-Monetary Interactions and the Credibility of Central Banks Mandates** (joint with Chaumont, Dovis, and Kirpalani)
    - Model of the credibility of inflation-targeting mandates. Framework used to measure evolution of credibility and its drivers, and understand implications for optimal policy

Common theme: tools to measure credibility and understand its causes and consequences

# Accounting for Credibility: Fiscal-Monetary Interactions and the Credibility of Central Bank Mandates

Luigi Bocola
Stanford University and NBER

Alessandro Dovis
University of Pennsylvania and NBER

Gaston Chaumont
University of Rochester

Rishabh Kirpalani
University of Wisconsin-Madison

# Motivation

- In 1980s and 1990s, monetary policy delegated to
  - **Independent central banks**
  - **Inflation targeting mandates**

  Goal: isolate monetary policy from fiscal considerations
- However, governments can always take independence away
- Effectiveness depend on credibility of delegation

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- However, governments can always take independence away
- Effectiveness depend on credibility of delegation

## Questions

- When delegation to independent central bank more likely to work?
- Role of institution's credibility vs fundamentals for inflation and debt

# What we do

- Economy in the tradition of Sargent-Wallace
  - The government delegates monetary policy to an inflation-targeting central bank, but retains the option to renege
  - Two shocks:
    - **Fiscal fundamental**: Marginal utility of government expenditures
    - **Reputational losses**: Costs of undermining central bank independence

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- Economy endogenously fluctuates between two regimes
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  - **Fiscal-dominant**: Inflation target not satisfied

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- Economy endogenously fluctuates between two regimes
  - **Monetary-dominant**: Inflation target satisfied
  - **Fiscal-dominant**: Inflation target not satisfied
- Imperfect credibility of mandate influences optimal policy
  - Inflation target and debt affect probability of reneging in the future

# Results

- Apply model to interpret disinflationary episodes (Colombia, Chile and USA)
- Model generates disinflation in two ways
  - **Fiscal fundamentals**: lower $\theta_t \rightarrow$ lower inflation and lower debt
  - **Institutions**: higher $\xi_t \rightarrow$ credible target and lower inflation
- Use data on $\{\pi_t, \Delta_t, B_t/Y_t\}$ to learn the relative role of $\theta_t$ and $\xi_t$
  - Credibility = probability of monetary dominance next period
- **Key result**: sustained disinflations with high debt require credible institutions

# Related literature

- Optimal fiscal-monetary policy: Sargent and Wallace (1981), Lucas and Stokey (1983), Nicolini (1998), Aiyagari et al. (2002), Calvo (1978), Chang (1998), Alvarez, Kehoe, and Neumeyer (2004), Espino et al. (2023)
  - Flexible model that span a large class of sustainable equilibrium outcomes
- Monetary-fiscal dominance: Leeper (1991), Bianchi (2013), Bianchi and Ilut (2017), Bianchi, Faccini, and Melosi (2023), Cochrane (2023), Witheridge (2024);
  Loose-commitment: Debortoli and Nunes (2010), Debortoli et al. (2014), and Debortoli and Lakdawala (2016)
  - Endogenous policy and endogenous regime
- Fiscal and monetary history: Sargent (1982), Sargent, Williams, and Zha (2009), Kehoe and Nicolini (2022)
  - Decomposition based on government incentives
- Deeper model of reputations/institutions: Atkeson, Chari, and Kehoe (2001), Piguillem and Schneider (2016), Dovis and Kirpalani (2021), King and Liu (2021) Halac and Yared (2022), Ramirez (2024), Kostadinov and Roldan (2020)
  - Credibility measure to discipline and discriminate mechanisms

# Outline

- Sargent-Wallace like economy
- Policy determination
- Two types of disinflations
- Quantify the role of fundamentals and institutions

# Environment

- Closed economy
- State $s_t$
- Stand-in household preferences

$$\sum_{t=0}^{\infty} \sum_{s^t} \beta^t \Pr\left(s^t\right) \mathcal{U}\left(C\left(s^t\right), L\left(s^t\right), \frac{M\left(s^{t-1}\right)}{P\left(s^t\right)}, G\left(s^t\right)\right)$$

with

$$\mathcal{U}\left(C, L, \frac{M}{P}, G\right) = C - \nu(L) + v\left(\frac{M}{P}\right) + \theta\left(s_t\right) u(G)$$

- Resource constraint

$$C\left(s^t\right) + G\left(s^t\right) \leq L\left(s^t\right)$$

- Impatient – $\hat{\beta} \leq \beta$ – government finances $G$ with
  - distortionary labor income taxes
  - real debt
  - money

# Implementability conditions

Economy admits simple representation in which

- Gov't has indirect utility function

$$U(\Delta, s) + v(\phi)$$

  over primary surpluses, $\Delta$, and real value of money balances, $\phi$

- Government chooses $\Delta$, $\phi$, and real debt $b$ subject to
  - Government budget constraints
  - Money demand (Euler equation for money holdings)

# Indirect utility function

- From labor supply condition, define tax revenues as

$$(1-\tau) = \nu'(L) \to T \equiv \tau L = (1-\nu'(L))\,L$$

- Let $\Delta$ be **primary surplus**, define **disutility over surpluses**

$$U(\Delta, s) = \max_{L,G} (L-G) - \nu(L) + \theta(s)\,u(G)$$

subject to

$$(1-\nu'(L))\,L - G \geq \Delta$$

- $U$ is decreasing and concave in $\Delta$

- If $\theta(s_H) > \theta(s_L)$ then $U_\Delta(\Delta, s_H) < U_\Delta(\Delta, s_L)$

# Implementable fiscal-monetary outcomes

A fiscal and monetary outcome $\{\Delta(s^t), b(s^t), \phi(s^t), \mu(s^t)\}$ is implementable iff

- GBC:

$$b\left(s^{t-1}\right) + \phi(s^t) = \Delta\left(s^t\right) + \beta b\left(s^t\right) + \mu\left(s^t\right)\phi\left(s^t\right)$$

- Euler equation for money holdings:

$$\mu\left(s^t\right)\phi\left(s^t\right) = \beta \sum_{s_{t+1}} \Pr\left(s_{t+1}|s_t\right) \underbrace{\phi\left(s^{t+1}\right)\left[1 + v'\left(\phi\left(s^{t+1}\right)\right)\right]}_{\equiv H\left(\phi\left(s^{t+1}\right)\right)}$$

- Surplus feasibility $\Delta(s^t) \leq \max_L (1 - \nu'(L))L$

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- Surplus feasibility $\Delta(s^t) \leq \max_L (1 - \nu'(L))L$
- Inflation $\pi(s^t) = \frac{\mu(s^t)\phi(s^t)}{\phi(s^{t+1})}$

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- Surplus feasibility $\Delta(s^{t}) \leq \max_{L}(1-\nu'(L))L$
- Inflation $\pi(s^{t}) = \frac{\mu(s^{t})\phi(s^{t})}{\phi(s^{t+1})}$
- Value for the government

$$V\left(s^{t}\right) = U\left(\Delta\left(s^{t}\right), s_{t}\right) + v\left(\phi\left(s^{t}\right)\right) + \hat{\beta}E_{t}V\left(s^{t+1}\right)$$

# Ramsey outcome

Inflation targeting mandates are way to implement Ramsey outcome

- Suppose $v(\phi) = \kappa \frac{\phi^{1-\eta}}{1-\eta}$ for $\eta \in (0, 1)$. Then,
  - Ramsey outcome follows the Friedman-rule
  - Constant inflation $1 + \pi_R = \beta \left(1 + \kappa (\phi^*)^{-\eta}\right)$

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- Ramsey outcome is not time consistent
    - Ex-post gov't wants to reduce value of real money balances

- Consider policy without commitment: multiple SPE
    - How can government manipulate private agents' expectations?
    - What are costs of deviation from promised plan?

# Our approach

- Gov't tries to commit to inflation next period
  - Promise to deliver inflation $\pi^*$ next period $\iff \phi'$
  - Delegate monetary policy to independent CB with inflation targeting mandate
- But can deviate
  - Take independence away and re-optimize
- Costs if promised inflation not delivered: $\xi(s)$
  - Stands for reputation losses, coordination to worse eqlbrm, institutional details

# Recursive formulation

- State $S = (b, \phi, s)$ where $\phi$ is promised target
- Two "regimes"
  - **Monetary dominance**: Gov't respect target, value $V_{md}$
  - **Fiscal dominance**: Gov't deviates from set target, value $V_{fd}$
- Gov't value
$$V(b, \phi, s) = \max \{V_{md}(b, \phi, s), V_{fd}(b, s) - \xi(s)\}$$
- $\eta(S)$: indicator for whether target respected next period

# Monetary dominance

Respect set target $\phi$

$$V_{md}\left(b,\phi,s\right)=\max_{\Delta,b',\mu,\phi'} U\left(\Delta,\theta\right)+v\left(\phi\right)+\hat{\beta}\sum_{s'}\Pr\left(s'|s\right)V\left(b',\phi',s'\right)$$

subject to

$$\begin{aligned}\Delta &= b+\phi-\beta b'-\mu\phi\\ \mu\phi &= J\left(b',\phi',s\right)=\text{ expected marginal benefits of money holdings}\end{aligned}$$

New inflation target is

$$1+\pi^*=\frac{\mu\phi}{\phi'}$$

# Fiscal dominance

Deviate from set target $\phi$

$$V_{fd}(b,s) = \max_{\phi,\Delta,b',\mu,\phi'} U(\Delta,\theta) + v(\phi) + \hat{\beta}\sum_{s'} \Pr(s'|s)\, V(b',\phi',s')$$

subject to

$$\begin{aligned} \Delta &= b + \phi - \beta b' - \mu\phi \\ \mu\phi &= J(b',\phi',s) = \text{ expected marginal benefits of money holdings} \end{aligned}$$

# Fiscal dominance

Deviate from set target $\phi$

$$V_{fd}\left(b,s\right)=\max_{\phi,\Delta,b',\mu,\phi'}U\left(\Delta,\theta\right)+v\left(\phi\right)+\hat{\beta}\sum_{s'}\Pr\left(s'|s\right)V\left(b',\phi',s'\right)$$

subject to

$$\begin{aligned}\Delta &= b+\phi-\beta b'-\mu\phi\\ \mu\phi &= J\left(b',\phi',s\right)=\text{ expected marginal benefits of money holdings}\end{aligned}$$

Optimal $\phi_{fd}$:

$$\underbrace{-U'\left(\Delta_{fd},\theta\right)}_{\text{MC of primary surpluses}}=\underbrace{v'\left(\phi_{fd}\right)}_{\text{MB of real balances}}$$

Tight correlation b/w deficits $\left(-\Delta_{fd}\right)$ and $\phi_{fd}$

# Credibility of mandates

Target is satisfied if

$$\begin{aligned} V_{md}(b', \phi', s') &\geq V_{fd}(b', s') - \xi(s') \\ &= \max_{\phi_{fd}} V_{md}(b', \phi_{fd}, s') - \xi(s') \end{aligned}$$

Depends on

- Target level $\phi'$: less ambitious target $\rightarrow$ higher credibility
- Institutions/reputational cost $\xi$: higher (expected) cost $\rightarrow$ higher credibility
- Fiscal fundamentals: If $\theta \downarrow$ (or $b \downarrow$) $\rightarrow$ higher credibility

# Optimal inflation target

- Inflation target
$$1 + \pi^* = \frac{\mu\phi}{\phi'} = \frac{J(\phi')}{\phi'} \text{ decreasing in } \phi'$$
- Target $\phi'$ distorted downward relative to Ramsey outcome
  - Lower $\phi$ increases incentives to respect target $(V_{md} > V_{fd} - \xi')$
  - This increases expected marginal value of money as $\phi' > \phi'_{fd}$
- Incentive to reduce $\phi'$ (raise the inflation target) is smaller if $\xi'$ is large

# Optimal debt issuance

- Debt issuance distorted downward relative to Ramsey outcome

$$-U'(\Delta,\theta)\left(1-\left|\frac{\partial J}{\partial b'}\right|/\beta\right)+\frac{\hat{\beta}}{\beta}E\frac{\partial V}{\partial b'}=0$$

  - **Incentive wedge** $\left|\frac{\partial J}{\partial b'}\right| \geq 0$
  - $\left|\frac{\partial J}{\partial b'}\right|$ zero in Ramsey outcome

- Reduce debt issuance to incentivize next period gov't to
  - respect target more often
  - set higher $\phi_{fd}$ in case of switch to fiscal dominance

- Incentive to reduce debt are smaller if $\xi'$ is large

# Flexible model

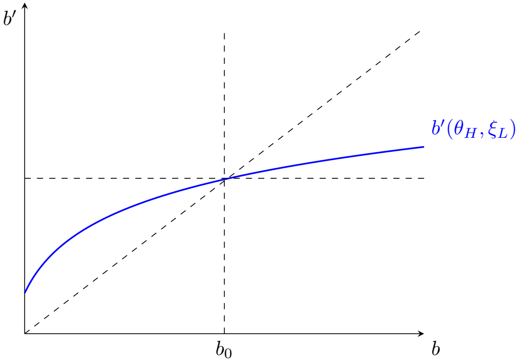
The model nests

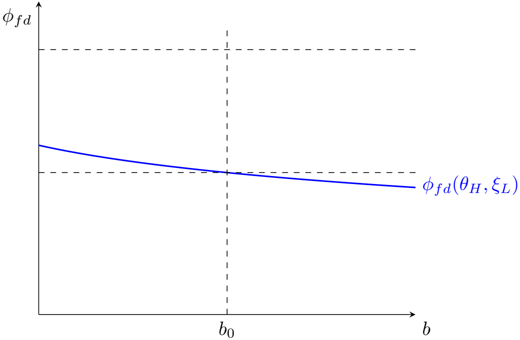
- Ramsey outcome if $\xi$ large enough $\rightarrow$ always monetary dominance
- Markov outcome if $\xi = 0 \rightarrow$ always fiscal dominance
- Fluctuations between regimes
  - Sudden, like in Sargent "End of 4 big inflations"
  - Gradual, like Volcker disinflation

# Two types of disinflations

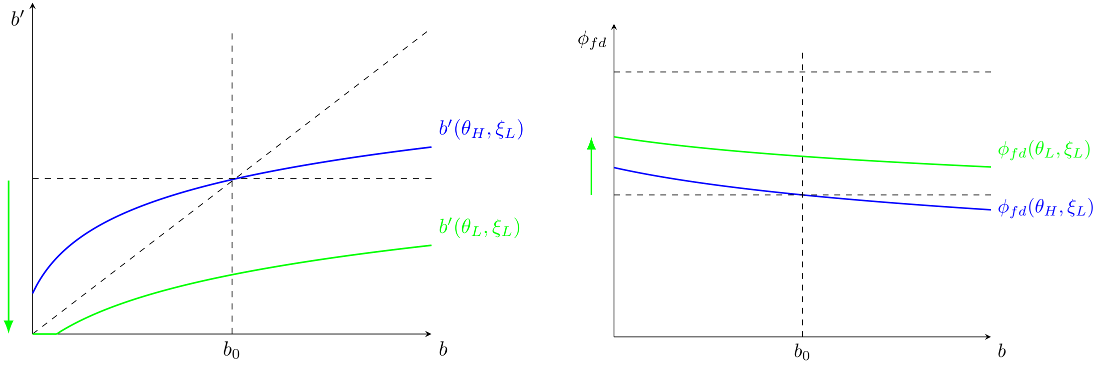
- **Fundamental disinflation**
  - Low inflation because low marginal value of public spending
  - Associated with declining path of public debt
- **Institutional disinflation**
  - Low inflation because increase in cost of interfering with monetary policy
  - Associated with rising path of public debt

# Dynamics



# Fundamental disinflation: $\theta_H \to \theta_L$



# Fundamental disinflation: $\theta_H \to \theta_L$

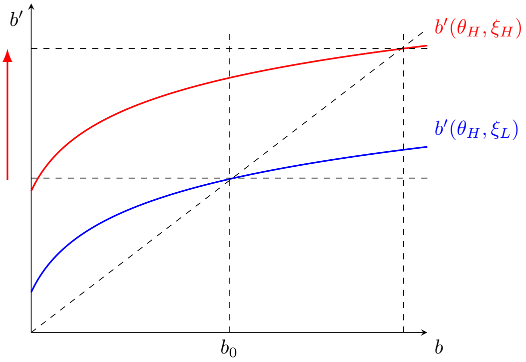
Inflation goes down because

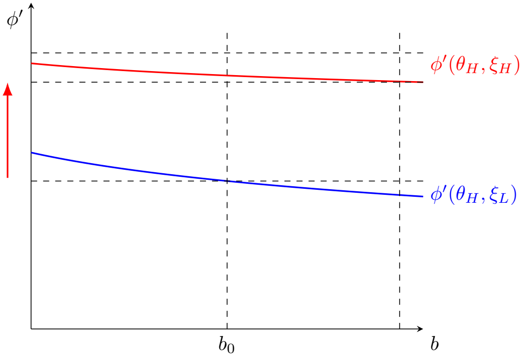
- Lower marginal value of public spending
- Lower need to reduce value of nominal liabilities and generate seigniorage

Debt goes down because

- Tax smoothing motive

# Institutional disinflation: $\xi_L \to \xi_H$



# Institutional disinflation: $\xi_L \to \xi_H$

Inflation goes down because

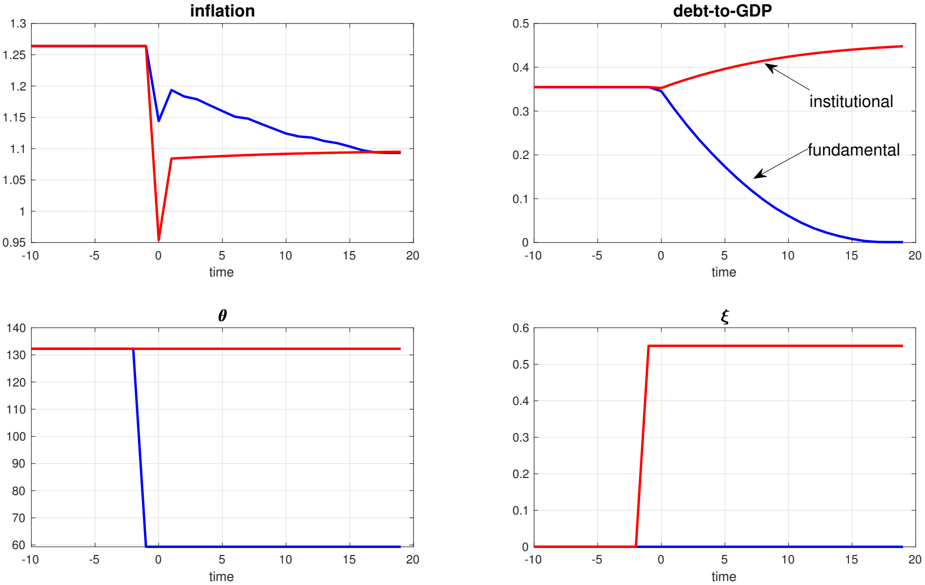
- Monetary dominance: high $\xi \to$ meet inflation target
- Inflation target goes down (less need to induce future gov't to satisfy target)

Debt goes up because

- Lower need need to incentivize future gov't not to inflate too much
- Increase in real value of gov't liabilities, $b + \phi$, and reduction in seigniorage revenues, $\beta E[v'(\phi')\phi']$

$$\beta(b' + \phi') = (b + \phi) - \beta E[v'(\phi')\phi'] - \Delta$$

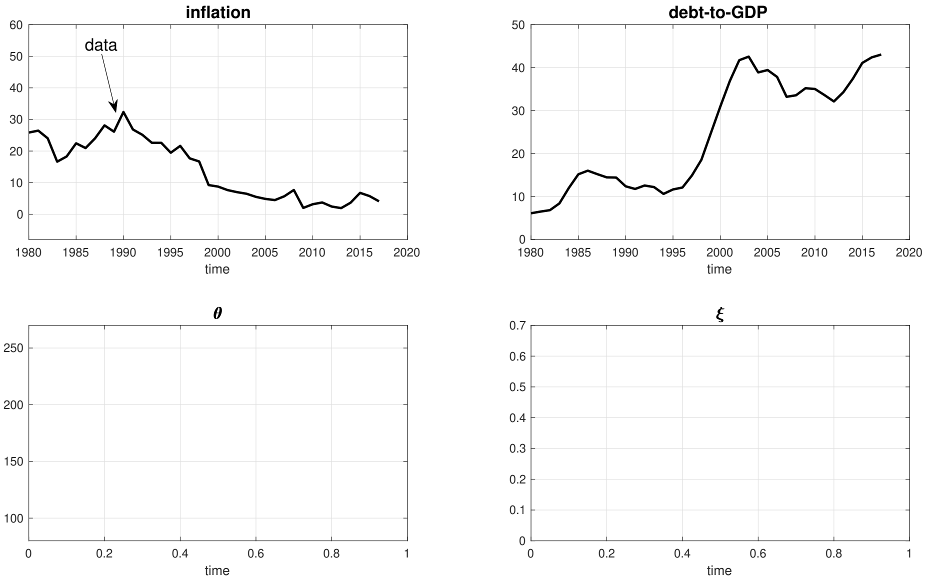
# Two types of disinflations



# Quantifying role of fundamentals and institutions

- Calibrate model to match $\{\pi_t, \Delta_t, B_t/Y_t\}$ for
  - LATAM economies (1960-2017)
  - United States (1960-2023)
- Use a particle filter to find shocks $\{\xi_t,\ \theta_t\}$ that fit the data
- Quantify role of fundamentals and institutions
- Measure of credibility: Probability of monetary-dominant next period
- Consider some case studies
  - Colombia
  - Chile
  - United States

# Colombia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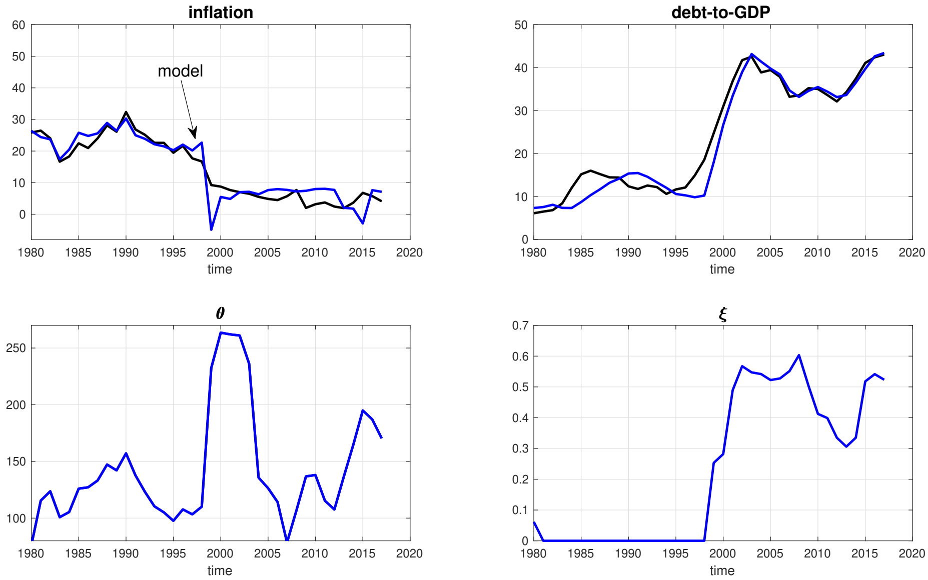
# Colombia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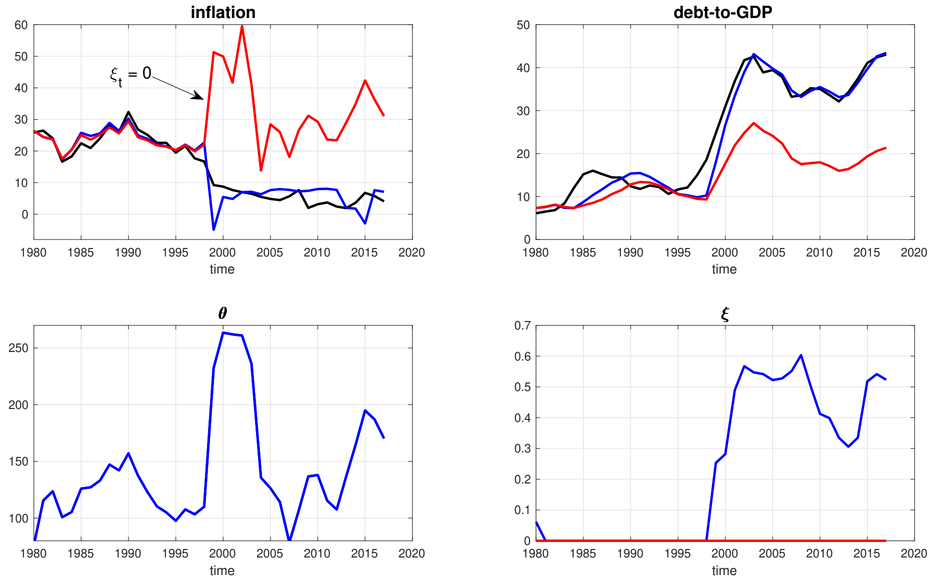
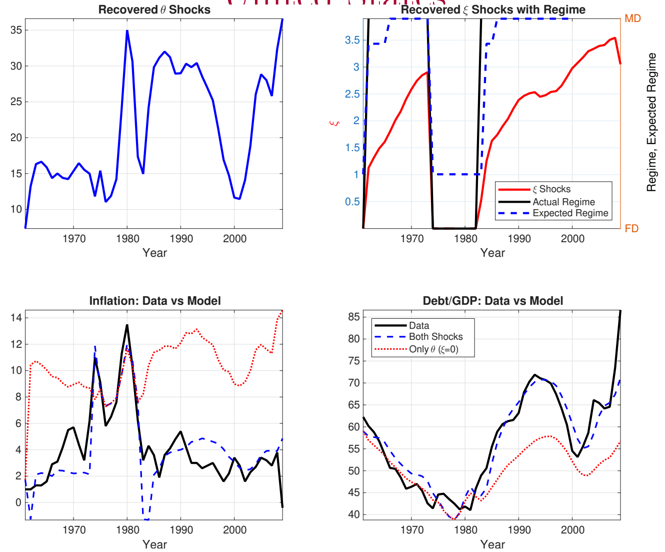
# Colombia



# United States




Decline in credibility in the 70s followed by an increase in 1981

# Conclusion

- Theory of endogenous fluctuations between fiscal and monetary dominance
- Successful disinflationary episodes can be driven by
  - Fundamentals
  - Credible institutions
- Different implications for debt and inflation dynamics
- Use this insight to
  - Account for determinants of disinflations
  - Measure of credibility of delegation to independent central bank
- High credibility necessary to support high debt with low inflation