Bond Market Views of the Fed

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

Motivation

- Large increase in **inflation** after the pandemic. Possible "inflationary" factors: supply chain disruptions, expansionary fiscal policies, ...

- Another factor: Changes in the Fed monetary policy framework
  - Statement on long run growth and monetary policy strategy (August 2020)
  - *"Inflation has risen, largely reflecting transitory factors"* (April-November 2021)

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

This idea in a nutshell

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

$$i_t = i^\star + \psi_\pi \left(\pi_t - \bar{\pi}\right) + \varepsilon_t$$

- **Want**: **Test for changes in ψ_π** and measure expected **duration** of new "regime"
- **Issue**: Only few years of realized data (all at the ZLB), endogeneity

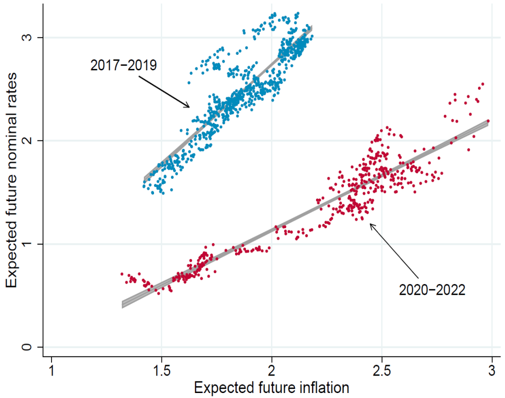
This idea in a nutshell

Taking expectations in year $k > t$, and using $\mathbb{E}_t[\varepsilon_k] = 0$, we have

$$\mathbb{E}_t[i_k] = c + \psi_\pi \mathbb{E}_t[\pi_k]$$

- From bond market prices we obtain daily data on $\mathbb{E}_t[i_k]$ and $\mathbb{E}_t[\pi_k]$
- With 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 ψ_π

Main empirical result



- Detect a **change in ψ_π** post 2020

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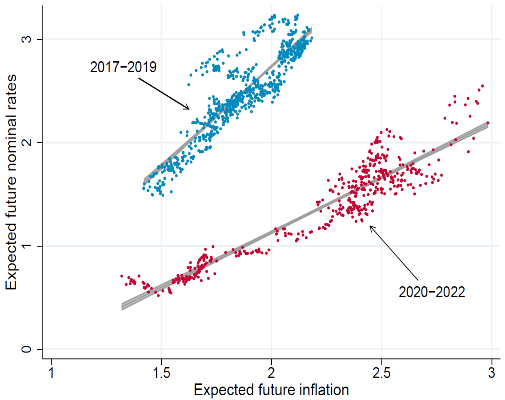

- Detect a **change in ψ_π** post 2020
- Relevant at a **[0-5] years** forecasting horizon. Long-run sensitivity "anchored"

Counterfactual analysis

- Estimate benchmark NK model with
    - Supply, demand, and monetary policy shocks
    - Markov-Switching regimes about monetary policy rule ("Historical" vs. "FAIT")
    - **Parameters of FAIT regime chosen to replicate high-frequency evidence**
- Model accounts for the rise in inflation through the interactions of
    - **Negative supply/positive demand shocks**
    - **Monetary authority less responsive to inflation**
- Counterfactual: What if there was no shift in the monetary policy rule?
    - **Inflation would have have peaked at 5%** (rather than 9%)

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), Cuciniello (2024)
    - 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), Ferrante et al. (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)

Outline

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

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

▸ Data

Conceptual framework

Suppose conduct of monetary policy described by a Taylor rule. In year k we have

$$i_k = \rho_i i_{k-1} + (1 - \rho_i) \left\{ i_k^\star + \psi_\pi (\pi_k - \bar{\pi}) \right\} + \varepsilon_{m,k}$$

Conceptual framework

Taking expectations at date t, this becomes

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

Conceptual framework

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

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

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Assumptions:

- Daily forecast revisions of future monetary policy shocks are small, $\Delta\mathbb{E}_t[\varepsilon_{m,k}] \approx 0$
  - In a typical day we do get news about monetary policy
- Daily forecast revisions of the natural rate $i_k^\star$ are negligible, $\Delta\mathbb{E}_t[i_k^\star] \approx 0$

Empirical specification

Test for the stability of ψ_π: Split full sample into six sub-samples of roughly equal length (4 years) and estimate by OLS

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

- Fix $\rho_i = 0.8$ (annual), consistent with structural estimates of Taylor rule and assume (for now) $\Delta\mathbb{E}_t^Q\left[\bar{i}_k\right] \approx \Delta\mathbb{E}_t\left[\bar{i}_k\right]$ and $\Delta\mathbb{E}_t^Q\left[\bar{\pi}_k\right] \approx \Delta\mathbb{E}_t\left[\bar{\pi}_k\right]$

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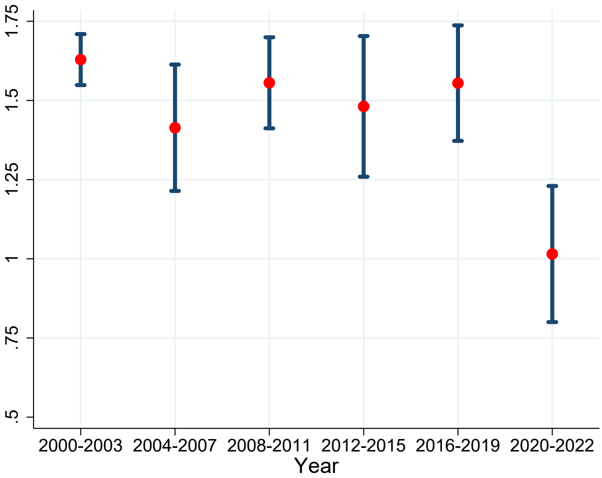
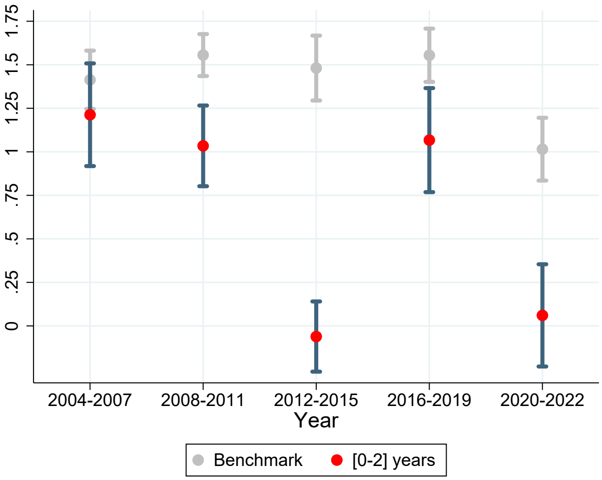
- Benchmark: expected average inflation and nominal rate over the next 10 years
- Split average over the next 10 years into three
  - Expectation over the next 2 years
  - Expectation between 3 and 5 years from now
  - Expectation between 6 and 10 years from now

Estimating ψ_π across sub-samples, Benchmark



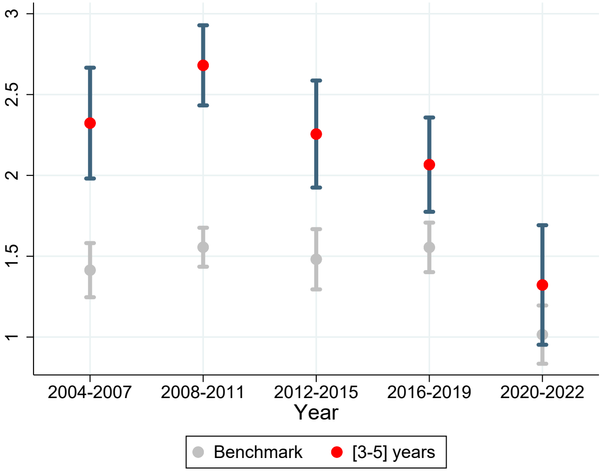
- ψ_π **remarkably stable pre 2020**, **drops significantly after 2020**

Estimating ψ_π across sub-samples, Short-run horizon



- At the [0-2] horizon, **smaller sensitivity post 2008** (ZLB, forward guidance, ...)

Estimating ψ_π across sub-samples, Medium-run horizon



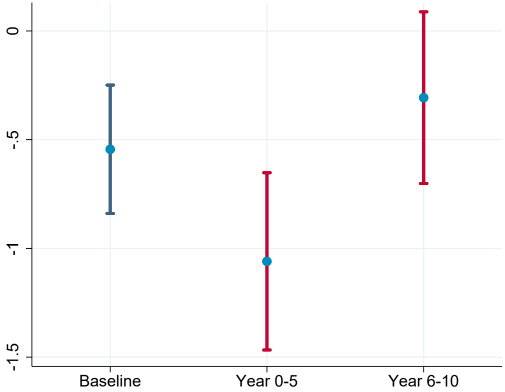
- Differently from previous years, **marked reduction in sensitivity [3-5] years out**

Estimating ψ_π across sub-samples, Long-run horizon

- **Long-run sensitivity** ([6-10] years out) more **"anchored"**

Pre vs. post 2020

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



- Significant reduction in interest rate sensitivity, stronger for shorter maturities

Results consistent with FRB communications/actions

- Strategy review (August 2020) and adoption of Flexible Average Inflation Targeting

  "[...] the Committee seeks to achieve inflation that averages 2 percent over time, and therefore judges that, following periods when inflation has been running persistently be- low 2 percent, appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time."

  FOMC press releases between **September 2020** and **December 2021**

  “[...] the Committee will aim to achieve inflation moderately above 2 percent for some time so that inflation averages 2 percent over time and longer-term inflation expectations remain well anchored at 2 percent.”

Results consistent with FRB communications/actions

- Strategy Review (August 2020) and adoption of Flexible Average Inflation Targeting

- As inflation starts to rise, the Fed makes it explicit that it sees these increases as **temporary** and hence in line with its objective. Between **April 2020** to **November 2021** FOMC press releases state

  "Inflation has risen, largely reflecting transitory factors."

- Davig and Foerster (2022) show that communicating a delay of the return to the target is equivalent to a decrease in ψ_π in the canonical Taylor rule

Outline

Robustness

1. Presence of output gap leads to biased estimates of ψ_π
   - Fed may seem more Dovish in 2020, but it was just responding to different shocks relative to the past (supply shocks)
   - We repeat the analysis conditioning on the **same type of shock** before and after 2020 (**monetary shock**)
   - We obtain comparable results

2. Risk premia and liquidity premia/convenience yields ▸ Details
   - Take out risk premium on treasuries and TIPS
   - Risk-neutral expectations recovered from Swaps

3. At the zero lower bound, interest rates less responsive to inflation ▸ Details
   - We control explicitly for the ZLB constraint and find comparable results

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

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

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

- OLS does not identify ψ_π but

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

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)

Detecting a structural break in the policy rule

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- 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 ψ_{π} **conditioning on the same type of shock**
  - Forecasts updates around "monetary events". Regress $\Delta \mathbb{E}_{t}^{m}[\,\bar{i}_{k} - \rho \bar{i}_{k-1}]$ on $\Delta \mathbb{E}_{t}^{m}[(1-\rho_{i})\bar{\pi}_{k}]$ and test for a structural break in ψ_{π} 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 κ is the slope of the Phillips curve, β is the rate of time preference and ρ_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 (κ, σ, β) are constant
- A reduction in $\hat{\psi}_{\pi}^{\text{OLS,m}}$ across the two sub-samples indicates a reduction in ψ_{π} (ρ_y not sensitive to ψ_{π} in standard calibrations)

Results

$$\Delta\mathbb{E}_t[\,\bar{i}_k - \rho_i \bar{i}_{k-1}\,] = a + \psi_\pi\ \Delta\mathbb{E}_t[(1-\rho_i)\bar{\pi}_k] + d\ \left(\Delta\mathbb{E}_t[(1-\rho_i)\bar{\pi}_k] \times D_{2020:M8}\right) + \eta_t$$

	(1) Baseline	(2) Monetary events
d (10 year avg)	$-0.54^{\star\star\star}$	$-0.88^{\star\star}$
	(0.11)	(0.43)
d (5 year avg, 1-5)	$-1.05^{\star\star\star}$	$-1.94^{\star\star\star}$
	(0.15)	(0.50)
d (5 year avg, 6-10)	-0.13	-0.26
	(0.10)	(0.30)
N. obs.	4019	455

- Results hold even when conditioning on the same type of "shock"

▸ Risk premia ▸ ZLB

Outline

Taking stock

- Document sizable and robust reduction in interest rate sensitivity to inflation
- To what extent did this policy shift contribute to the rise in US inflation after 2020?
- We answer this question within a standard 3-equations NK economy with Markov switching regimes in the monetary policy rule (Historical vs. FAIT)
  - Estimate most of the parameters in a pre-sample
  - **Estimate parameters of FAIT regime to fit high-frequency evidence**
- Belief counterfactual (Bianchi, 2013)
  - Filter sequence of shocks that rationalizes data on nominal rates, inflation and output
  - Given filtered shocks, ask how the economy would have behaved under historical regime

Environment

- 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, $\frac{\phi}{2} \left(\frac{P_{i,t}}{P_{i,t-1}} \frac{1}{1+\bar{\pi}} - 1 \right)^2$

Environment

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

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  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 $\bar{\pi}_t=\frac{1}{N}\sum_{j=0}^{N}\pi_{t-j}$

Equilibrium conditions and model parameters

- Shocks: μ_t, θ_t, $\varepsilon_{m,t}$ and ξ_t; Endogenous variables: c_t, y_t, π_t, i_t

$$
\begin{aligned}
1 &= (1+i_t)\beta\mathbb{E}_t\left[\exp\{\hat{\theta}_{t+1}\}\left(\frac{c_t}{c_{t+1}}\right)^{\sigma}\frac{1}{1+\pi_{t+1}}\right] \\
\tilde{\pi}_t &= \frac{1}{\phi(\exp\{\hat{\mu}_t\}-1)}y_t\left[\exp\{\hat{\mu}_t\}\chi c_t^{\sigma}y_t^{\nu}-1\right]+\beta\mathbb{E}_t[\exp\{\hat{\theta}_{t+1}\}\tilde{\pi}_{t+1}] \\
1+i_t &= (1+i_{t-1})^{\rho_i}\left\{\bar{i}\left[\frac{1+d(\xi_t)\pi_t+[1-d(\xi_t)]\bar{\pi}_t}{1+\pi^{\star}}\right]^{\psi_\pi(\xi_t)}\left(\frac{y_t}{\bar{y}_t}\right)^{\psi_y}\right\}^{1-\rho_i}\exp\{\sigma_m\varepsilon_{m,t}\} \\
y_t &= c_t+\frac{\phi}{2}\left(\frac{\pi_t-\bar{\pi}}{1+\bar{\pi}}\right)^2 \\
\hat{\theta}_t &= \rho_\theta\hat{\theta}_{t-1}+\sigma_\theta\varepsilon_{\theta,t} \\
\hat{\mu}_t &= (1-\rho_\mu)\bar{\mu}+\rho_\mu\hat{\mu}_{t-1}+\sigma_\mu\varepsilon_{\mu,t}
\end{aligned}
$$

- Parameters: preferences, $[\sigma,\nu,\chi,\beta]$; policy, $[\pi^{\star},\rho_i,N,\psi_\pi(H),\psi_\pi(D),\psi_y,P_{HH},P_{DD}]$; shocks, $[\bar{\mu},\rho_\mu,\sigma_\mu,\rho_\theta,\sigma_\theta,\sigma_m]$

Estimation

We fix $\{\sigma, \nu, \chi, \bar{\mu}, \pi^\star, \beta\}$ at conventional values and proceed in two steps

1. Fit the single regime model on 1984:Q1-2019:Q4 sample to estimate structural shocks' process and $\{\phi, \rho_i, \psi_\pi(H), \psi_y\}$
   - Data: (de-trended) Employment, CPI inflation and Federal funds rate
   - Model fit the data reasonably well
   - Parameter estimates consistent with previous studies
2. Fix $P_{HH} = 0.994$ and $N = 12$. Choose $\{\psi_\pi(D), P_{DD}\}$ to fit the high frequency evidence
   - Obtain $\mathbb{E}_t^m[\,\tilde{\bar{i}}_k - \rho_i \tilde{\bar{i}}_{k-1}|\xi]$ and $\mathbb{E}_t^m[\,(1-\rho_i)\tilde{\bar{\pi}}_k|\xi]$ and compute

$$\psi_\pi^k(\zeta) = \frac{\mathbb{E}_t^m[\,\tilde{\bar{i}}_k - \rho_i \tilde{\bar{i}}_{k-1}|\xi]}{\mathbb{E}_t^m[\,(1-\rho_i)\tilde{\bar{\pi}}_k|\xi]}$$

   - Then match $d^k = \psi_\pi^k(\zeta = D) - \psi_\pi^k(\zeta = H)$ with empirical estimates

Parameters

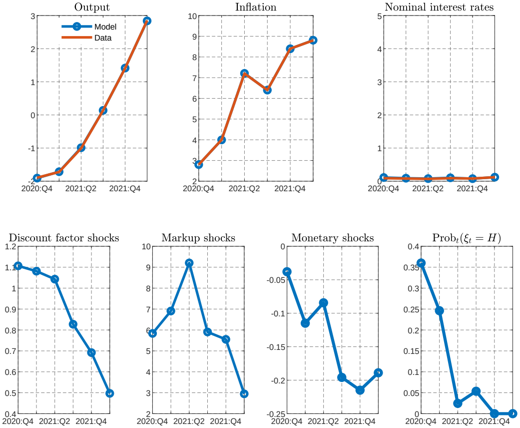
Panel A: **Fixed parameters**		
	Value	Notes
σ	1.000	Intertemporal elasticity of substitution of 1
ν	1.000	Frish elasticity of 1
χ	0.833	Normalize output to 1 in steady state
$\overline{\mu}$	1.200	20% markup in steady state
$\pi^\star$	0.005	Inflation target of 2%
β	0.995	Annualized real interest rate 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.
ϕ	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
ψ_y	0.29	[0.18,0.39]	Normal	1.50	0.50
ρ_i	0.90	[0.87,0.92]	Beta	0.50	0.29
ρ_μ	0.83	[0.73,0.93]	Beta	0.50	0.29
ρ_θ	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

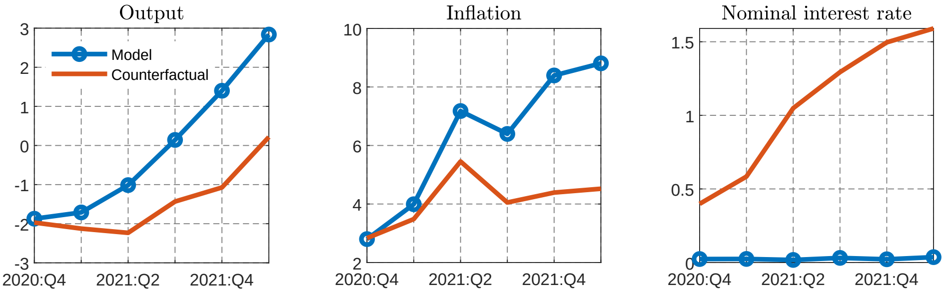
What realization of shocks do we need to fit the data post covid (2020:Q4-2022:Q1)?



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

Counterfactual

What was the role of monetary policy shift in propagating inflation?



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

Why is the change in the monetary rule so consequential?

Iterating forward the Phillips curve and the Euler equation, we have

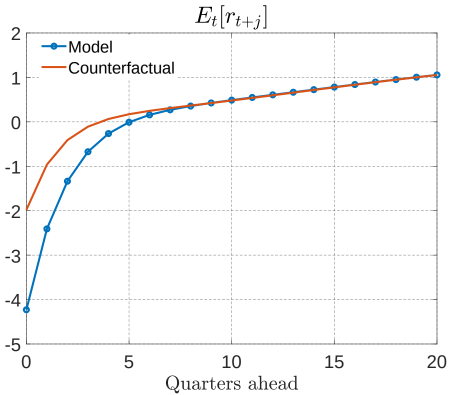
$$\begin{aligned} \hat{\pi}_t &= \kappa \sum_{j=0}^{\infty} \beta^j \mathbb{E}_t[\hat{y}_{t+j}] + \kappa \sum_{j=0}^{\infty} \beta^j \mathbb{E}_t[\hat{\mu}_{t+j}] \\ \hat{y}_t &= -\frac{1}{\sigma} \sum_{j=0}^{\infty} \mathbb{E}_t[\hat{r}_{t+j}] - \frac{1}{\sigma} \sum_{j=0}^{\infty} \mathbb{E}_t[\hat{\theta}_{t+1+j}]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

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

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

Sensitivity of π_t to $\mathbb{E}_t[\hat{r}_{t+j}]$ **increasing** in j. Due to "forward guidance puzzle" *and* the forward-looking nature of inflation

Why is the change in the monetary rule so consequential?



- Difference in real rates across regimes not empirically implausible (comparable to the change in TIPS after the lift-off in March 2022)
- Large effects on inflation due to "forward guidance puzzle"

Conclusion

- Novel approach to test for perceived shifts in the monetary policy rule
- Robust evidence of a shift to a more Dovish regime shortly after the pandemic
- When coupled with the baseline NK model, this change in the policy regime has quantitatively important implications for the dynamics of inflation over this episode

Conclusion

- Novel approach to test for perceived shifts in the monetary policy rule

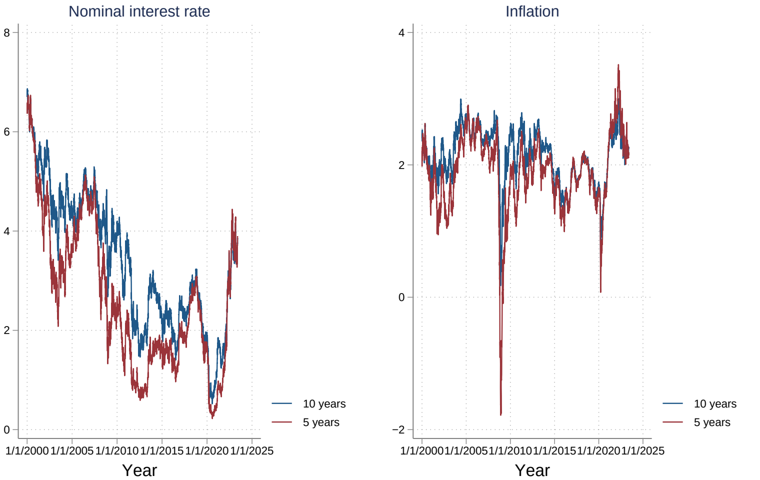
- Robust evidence of a shift to a more Dovish regime shortly after the pandemic

- When coupled with the baseline NK model, this change in the policy regime has quantitatively important implications for the dynamics of inflation over this episode

- Shift in expectation for 0-5 horizon but long-run sensitivity anchored
  Work in progress:
    - Different in emerging markets like Brazil and Turkey
    - More Dovish stance in short-run leads to expectations of more Dovish stance in long-run
    - Reputation model to account for cross-countries differences

Additional Slides

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

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

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

Results

$$\Delta\mathbb{E}_t[\,\bar{i}_k - \rho_i \bar{i}_{k-1}\,] = a + \psi_\pi \, \Delta\mathbb{E}_t[(1-\rho_i)\bar{\pi}_k] + d \; (\Delta\mathbb{E}_t[(1-\rho_i)\bar{\pi}_k] \times D_{2020:M8}) + \eta_t$$

	(1) Baseline	(2) Monetary events	(3) Risk premia	(4) ZLB
d (10 year avg)	$-0.54^{\star\star\star}$	$-0.88^{\star\star}$	-0.27	-0.35^{*}
	(0.11)	(0.43)	(0.19)	(0.20)
d (5 year avg, 1-5)	$-1.05^{\star\star\star}$	$-1.94^{\star\star\star}$	$-1.05^{\star\star\star}$	$-1.25^{\star\star\star}$
	(0.15)	(0.50)	(0.12)	(0.27)
d (5 year avg, 6-10)	-0.13	-0.26	$0.16^{\star\star\star}$	0.19
	(0.10)	(0.30)	(0.04)	(0.14)
N. obs.	4019	455	4019	4019

- Results hold even when conditioning on the same type of "shock"

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 β'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 $\{\mathbb{E}_t[\bar{i}_k], \mathbb{E}_t[\bar{\pi}_k]\}$.

Results

$$\Delta \mathbb{E}_t[\,\bar{i}_k - \rho_i \bar{i}_{k-1}\,] = a + \psi_\pi \, \Delta \mathbb{E}_t[(1-\rho_i)\bar{\pi}_k] + d \, \left(\Delta \mathbb{E}_t[(1-\rho_i)\bar{\pi}_k] \times D_{2020:M8}\right) + \eta_t$$

	(1) Baseline	(2) Monetary events	(3) Risk premia	(4) ZLB
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N. obs.	4019	455	4019	4019

- Results hold even when conditioning on the same type of "shock"

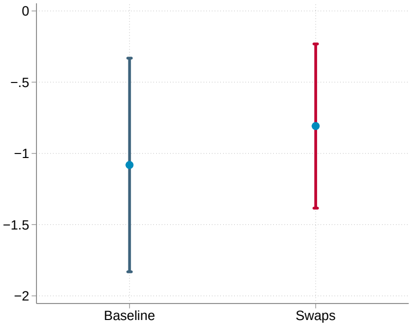
Return

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



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