Rethinking the New Keynesian Model

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Lucas-Modigliani Lectures, June 2026

The New Keynesian Model

Key Elements

- Monopolistic competition in goods and/or labor markets
- Price and/or wage rigidities $\Leftrightarrow$ "elastic markups"

$\Rightarrow$ key role for aggregate demand in determining output

Example: The Three Equation Model

The Three Equation Model

- Aggregate Supply Block: *New Keynesian Phillips Curve*

$$\pi_t = \beta \mathbb{E}_t\{\pi_{t+1}\} + \kappa(\widehat{y}_t - \widehat{y}_t^n)$$

- Aggregate Demand Block (I): *Dynamic IS Equation*

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}[i_t - \mathbb{E}_t\{\pi_{t+1}\} - \rho] + d_t$$

- Aggregate Demand Block (II): *Monetary Policy Rule*

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \widehat{y}_t + v_t$$

Rethinking the New Keynesian Model

- The purpose of macro models

- quantitative tools: simulations, forecasts $\Rightarrow$ estimated DSGE models
- tools to understand the mechanisms underlying economic fluctuations

- Three weaknesses of standard formulations of the NK model's AD block:

- focus on consumption Euler equation when modeling aggregate demand
- short-term nominal interest rate rule
- representative consumer assumption

- Present lectures: a proposal to reformulate/rethink the NK model's AD block

- focus on the consumption function
- focus on long-term real rate rules
- allowing for heterogeneity, while preserving tractability

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- Present lectures: a proposal to reformulate/rethink the NK model's AD block

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- allowing for heterogeneity, while preserving tractability

Outline of the Lectures

- Lecture 1: *The Dynamic IS Equation and its Discontents*
- Lecture 2: *Retinking Monetary Policy Rules*
- Lecture 3: *Heterogeneity*

Rethinking the New Keynesian Model (I)
The Dynamic IS Equation and its Discontents

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The Dynamic IS Equation and its Discontents

- Infinite-lived representative consumer
- Preferences: $E_0\{\sum_{t=0}^{\infty}\beta^t U(C_t, N_t; \Phi_t)\}$ with $U_{c,t} = C_t^{-\sigma}\Phi_t$
- Consumer's Euler equation

$$c_t = \mathbb{E}_t\{c_{t+1}\} - \frac{1}{\sigma}(\widehat{r}_t - z_t)$$

where $c_t \equiv \log C_t$, $r_t \equiv i_t - \mathbb{E}_t\{\pi_{t+1}\}$ and $z_t \equiv \log\Phi_t - \mathbb{E}_t\{\log\Phi_{t+1}\}$

- Goods market clearing (assuming $G = 0$ and well defined steady state $Y = C$)

$$\widehat{y}_t = \widehat{c}_t + g_t$$

where $y_t \equiv \log Y_t$, $g_t \equiv G_t/Y$ and $\widehat{x}_t = x_t - x$.

- Dynamic IS equation:

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}(\widehat{r}_t - z_t) + g_t - \mathbb{E}_t\{g_{t+1}\}$$

The Dynamic IS Equation and its Discontents

- Assumption: $\lim_{T\to\infty} \mathbb{E}_t\{\widehat{y}_{t+T}\} = \lim_{T\to\infty} \mathbb{E}_t\{\widehat{r}_{t+T}\} = 0$
- Assumption: real rate $\widehat{r}_t$ determined by the central bank
- Assumption: $z_t = \rho_z z_{t-1} + \varepsilon_t^z$
- Equilibrium (conditional on $\{\widehat{r}_{t+k}\}$):

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty} \mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{1}{\sigma(1-\rho_z)}\, z_t + g_t$$

$$\begin{aligned} \widehat{c}_t &= \widehat{y}_t - g_t \\ &= -\frac{1}{\sigma}\sum_{k=0}^{\infty} \mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{1}{\sigma(1-\rho_z)}\, z_t \end{aligned}$$

The Dynamic IS Equation and its Discontents

- Equilibrium (conditional on $\{\widehat{r}_{t+k}\}$):

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{1}{\sigma(1-\rho_z)}\, z_t + g_t$$

$$\widehat{c}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{1}{\sigma(1-\rho_z)}\, z_t$$

Some Unanswered Questions

- Why do tax changes have no effect on consumption and output?
- Where is the wealth effect on consumption from changes in government spending to be seen?
- How does the model capture the impact of a stock price "bubble"?
- Is there room for (irrational) waves of optimism/pessimism about future activity to affect current consumption and output?
- Why is there a "forward guidance" puzzle if consumers discount the future?

The Dynamic IS Equation and its Discontents

This lecture's goals:

- point out some limitations of the DIS for understanding the channels through which different shocks affect aggregate demand
- provide microfoundations for introducing additional shocks ("bubble" and "animal spirits")

Underlying problem: the Euler equation is an incomplete characterization of the consumption-savings decision
Proposed solution: back to the consumption function

Related Literature

- Consumption empirics: Campbell 1987, Campbell-Deaton 1989,...
- Models with imperfect information: Eusepi-Preston 2018, Angeletos-Lian 2018, Caballero-Simsek 2020, Roth-Wiederholt-Wohlfart 2024,...
- Models with heterogenous agents

- TANK: Galí et al. 2007, Bilbiie 2008,...
- HANK: Kaplan et al. 2018, Auclert 2019, Auclert-Straub-Rognlie 2024,...
- NK-OLG models: Galí 2021, Angeletos-Lian-Wolf 2024,...

A Basic NK Model with a Representative Consumer

The Consumption-Saving Problem

- Period budget constraint under complete markets

$$C_t + \mathbb{E}_t\{\Lambda_{t,t+1}\mathcal{A}_{t+1}\} = \mathcal{A}_t + W_t N_t$$

where $\mathcal{A}_t$ the (gross, real) payoff of portfolio of securities,

- Intertemporal budget constraint (C-IBC), given $\lim_{T\to\infty}\mathbb{E}_t\{\Lambda_{t,T}\mathcal{A}_{t+T}\} = 0$.

$$\sum_{k=0}^{\infty}\mathbb{E}_t\{\Lambda_{t,t+k}C_{t+k}\} = \mathcal{A}_t + \sum_{k=0}^{\infty}\mathbb{E}_t\{\Lambda_{t,t+k}W_{t+k}N_{t+k}\}$$

- Fundamental valuation of stocks:

$$Q_t^S = \sum_{k=0}^{\infty}\mathbb{E}_t\{\Lambda_{t,t+k}D_{t+k}\}$$

where $D_t \equiv Y_t - W_t N_t$ and Y_t is aggregate output.

- Alternative C-IBC representation

$$\begin{aligned}\sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} C_{t+k}\} &= \mathcal{A}_t - Q_t^S + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(W_{t+k}N_{t+k} + D_{t+k})\} \\ &= \mathcal{A}_t - Q_t^S + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} Y_{t+k}\}\end{aligned}$$

- Remark: in the absence of other assets in positive net supply, $\mathcal{A}_t - Q_t^S = 0$ *in equilibrium*, but this is not a constraint for the individual consumer.
- Log-linearizing around a steady state with $Y = C$ and $\mathcal{A} = Q^S$:

$$\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{c}_{t+k}\} = \widehat{f}_t + \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}$$

where $\widehat{f}_t \equiv (\mathcal{A}_t - Q_t^S)/Y$

- Intertemporal optimality condition:

$$Q_t = \beta \mathbb{E}_t\{(C_{t+1}/C_t)^{-\sigma}(\Phi_{t+1}/\Phi_t)(P_t/P_{t+1})\}$$

where $Q_t \equiv \exp\{-i_t\}$ is the price of a one-period nominal bond

- In log-deviations from steady state:

$$\begin{aligned}
\widehat{c}_t &= \mathbb{E}_t\{\widehat{c}_{t+1}\} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t\{\pi_{t+1}\} - \rho + \mathbb{E}_t\{\phi_{t+1}\} - \phi_t\right) \\
&= \mathbb{E}_t\{\widehat{c}_{t+1}\} - \frac{1}{\sigma}\left(\widehat{r}_t - z_t\right)
\end{aligned}$$

where $\widehat{r}_t \equiv i_t - \mathbb{E}_t\{\pi_{t+1}\} - \rho$ and $z_t \equiv \phi_t - \mathbb{E}_t\{\phi_{t+1}\}$

- Iterating forward k periods

$$\mathbb{E}_t\{\widehat{c}_{t+k}\} = \widehat{c}_t + \frac{1}{\sigma}\sum_{j=0}^{k-1}\mathbb{E}_t\{\widehat{r}_{t+j}\} - \frac{1}{\sigma}\sum_{j=0}^{k-1}\mathbb{E}_t\{z_{t+j}\}$$

- Combining C-IBC with optimality condition, and assuming $z_t \sim AR(1)$ we obtain the *consumption function*:

$$\widehat{c}_t = (1-\beta)\left(\widehat{f}_t + \sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}\right) - \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{\beta}{\sigma(1-\beta\rho_z)} z_t$$

Discussion

- static MPC: $1-\beta$
- explicit role for future income expectations
- changes in $\widehat{r}_t$: no income effect (given $F=0$ in steady state), only intertemporal substitution
- *direct* effect of monetary policy: $-\frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$ (no forward guidance puzzle)

Equilibrium

- Goods market clearing:

$$\begin{aligned}\widehat{y}_t &= \widehat{c}_t \\ &= (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} - \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k} - z_{t+k}\}\end{aligned}$$

where asset market clearing has been imposed ($\widehat{f}_t = 0$).

- Recursive representation:

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}(\widehat{r}_t - z_t)$$

$\Rightarrow$ standard dynamic IS equation (DIS)

- Equivalently, iterating forward

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{1}{\sigma(1-\rho_z)} z_t$$

- Note that this representation combines:

(i) consumption function (partial equilibrium)

(ii) static and dynamic multiplier effects (general equilibrium)

Closing the Model: A *Real* Rate Rule

- Under flexible prices: DIS determines $\widehat{r}_t$, given $\widehat{y}_t^n$

$$\widehat{r}_t^n = z_t + \sigma \mathbb{E}_t\{\Delta \widehat{y}_{t+1}^n\}$$

$$\Rightarrow \text{no role for MP}$$

- Under monopolistic competition and "elastic markups": demand-determined output

$$\Rightarrow \text{role for MP in the determination of } \widehat{r}_t \text{ and } \widehat{y}_t$$

- Standard assumption: a rule for the nominal rate i_t
- Proposed alternative: a rule for the *real* rate $\widehat{r}_t$
- Related literature: Romer 2000, Werning 2015, Debortoli-Galí 2024, Auclert-Straub-Rognlie 2024,...

Example

- A simple real rate rule

$$\widehat{r}_t = \phi_y \widehat{y}_t + \widehat{r}_t^x$$

where $\phi_y \geq 0$ and $\widehat{r}_t^x \sim AR(1)$

- Combined with DIS:

$$\widehat{y}_t = \frac{\sigma}{\sigma + \phi_y} \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma + \phi_y}(\widehat{r}_t^x - z_t)$$

- Unique bounded solution if $\phi_y > 0$

$$\widehat{y}_t = \frac{1}{\sigma(1-\rho_z) + \phi_y} z_t - \frac{1}{\sigma(1-\rho_r) + \phi_y} \widehat{r}_t^x$$

The Case for a Real Rate Rule:

- relevance
- simplicity
- robustness to alternative specifications of the price/wage block.

Application (I): Monetary Policy Transmission

- Exogenous monetary policy intervention (assuming $\phi_y \to 0$ for simplicity):

$$\widehat{r}_{t+k} = \rho_r^k$$

for $k = 0, 1, 2, ...$

- *Direct* effect on consumption

Using consumption function

$$\widehat{c}_t = (1-\beta)\left(\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}\right) - \frac{\beta}{\sigma}\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

$$\begin{aligned} \frac{\partial \widehat{c}_t}{\partial \widehat{r}_t} &= -\frac{\beta}{\sigma}\sum_{k=0}^{\infty}(\beta\rho_r)^k \\ &= -\frac{\beta}{\sigma(1-\beta\rho_r)} \end{aligned}$$

- *Total* effect on consumption and output

Using equilbrium condition

$$\widehat{c}_t = \widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty} \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

$$\begin{aligned}\frac{d\widehat{c}_t}{d\widehat{r}_t} &= -\frac{1}{\sigma}\sum_{k=0}^{\infty} \rho_r^k \\ &= -\frac{1}{\sigma(1-\rho_r)}\end{aligned}$$

- Ratio of direct effect to total effect:

$$\delta = \frac{\beta(1-\rho_r)}{1-\beta\rho_r} \in (0,\beta)$$

which is decreasing in ρ_r (and independent of ϕ_y)

- Direct effect dominant if low persistence ($\delta = \beta$ if $\rho_r = 0$).
- The more persistent is the shock the more important is the GE effect, due to the more persistent response of output and the forward-lookingness of consumption ($\delta \rightarrow 0$ when $\rho_r \rightarrow 1$)

Application (II): Fiscal Policy

Government

- Government period budget constraint:

$$G_t + B_t^G = \mathbb{E}_t\{\Lambda_{t,t+1} B_{t+1}^G\} + T_t$$

- Government intertemporal budget constraint (G-IBC):

$$B_t^G = \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(T_{t+k} - G_{t+k}\}$$

- Steady state assumptions: $G = 0,\ B^G > 0 \quad \Rightarrow T = (1-\beta)B^G$
- Log-linearization around the steady state:

$$\widehat{b}_t^G + \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{g}_{t+k}\} = \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{t}_{t+k}\} - \beta b^G \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

where $t_t \equiv T_t/Y$, $g_t \equiv G_t/Y$, and $b_t^G \equiv B_t^G/Y$.

- Income effect of interest rate changes: $-\beta b^G \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$

Consumers

- Consumer's period budget constraint:

$$C_t + \mathbb{E}_t\{\Lambda_{t,t+1}\mathcal{A}_{t+1}\} = \mathcal{A}_t + W_t N_t - T_t$$

- Consumer's intertemporal budget constraint (C-IBC)

$$\begin{aligned}
\sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} C_{t+k}\} &= \mathcal{A}_t + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(W_{t+k}N_{t+k} - T_t)\} \\
&= \mathcal{A}_t - Q_t^S + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(W_{t+k}N_{t+k} + D_{t+k} - T_t)\} \\
&= F_t + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(Y_{t+k} - T_{t+k})\}
\end{aligned}$$

where $F_t \equiv \mathcal{A}_t - Q_t^S$

- Log-linearizing the C-IBC around the steady state with $F = B^G$:

$$\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{c}_{t+k}\} = \widehat{f}_t + \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k} - \widehat{t}_{t+k}\} + \beta b^G \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

where $f_t \equiv (\mathcal{A}_t - Q_t^S)/Y$

- Income effect of interest rate changes: $\beta b^G \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$

- Combining C-IBC with the optimality condition yields the consumption function

$$\widehat{c}_t = (1-\beta)\left(\widehat{f}_t + \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k} - \widehat{t}_{t+k}\}\right) + \left[(1-\beta)b^G - \frac{1}{\sigma}\right] \beta \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}$$

- Substituting for $\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{t}_{t+k}\}$ using the G-IBC

$$\widehat{c}_t = (1-\beta)\left(\widehat{f}_t - \widehat{b}_t^G + \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k} - g_{t+k}\}\right) - \frac{\beta}{\sigma} \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

- Discussion

  - income effects of interest rate changes cancel out
  - Ricardian equivalence: irrelevance of timing of taxes $\{\widehat{t}_{t+k}\}$
  - shows negative wealth effect of $\{g_{t+k}\}$ (working through implied taxes).

    → *partial equilibrium perspective*

Equilibrium

- Asset market clearing: $\widehat{f}_t = \widehat{b}_t^G$
- Goods market clearing:

$$\begin{aligned}\widehat{y}_t &= \widehat{c}_t + g_t \\ &= (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{y}_{t+k} - g_{t+k}\} - \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\} + g_t\end{aligned}$$

- Recursive representation

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}\widehat{r}_t + g_t - \mathbb{E}_t\{g_{t+1}\}$$

- Iterating forward and assuming $\lim_{T\to\infty}\mathbb{E}_t\{g_{t+T}\} = \lim_{T\to\infty}\mathbb{E}_t\{\widehat{y}_{t+T}\} = \lim_{T\to\infty}\mathbb{E}_t\{\widehat{r}_{t+T}\} = 0:$

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + g_t$$

$$\begin{aligned}\widehat{c}_t &= \widehat{y}_t - g_t \\ &= -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\}\end{aligned}$$

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + g_t$$

$$\widehat{c}_t = \widehat{y}_t - g_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\}$$

Discussion

- Unit G-multiplier conditional on interest rate path, independent of persistence
- With *no* interest rate response, no impact on consumption. Intuition: negative wealth effect of higher anticipated taxes $(1-\beta)\sum_{k=0}^{\infty}\beta^k\mathbb{E}_t\{g_{t+k}\}$ is exactly offset by the positive wealth effect caused by higher anticipated income $(1-\beta)\sum_{k=0}^{\infty}\beta^k\mathbb{E}_t\{\widehat{y}_{t+k}\}$.
- Corollary: no effect of anticipated government spending on current output
- Contrast with the conventional approach focusing on the equilibrium condition

$$\widehat{c}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\}$$

which suggests *only* intertemporal substitution effects are at work (while mismeasuring them)

Application (III): Animal Spirits

- Consumption function

$$\widehat{c}_t = (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t^*\{\widehat{y}_{t+k}\} - \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t^*\{\widehat{r}_{t+k}\}$$

Equivalently:

$$\widehat{c}_t = (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} - \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\} + s_t$$

where

$$s_t \equiv (1-\beta)\sum_{k=1}^{\infty}\beta^k [\mathbb{E}_t^*\{\widehat{y}_{t+k}\} - \mathbb{E}_t\{\widehat{y}_{t+k}\}] - \frac{\beta}{\sigma}\sum_{k=1}^{\infty}\beta^k [\mathbb{E}_t^*\{\widehat{r}_{t+k}\} - \mathbb{E}_t\{\widehat{r}_{t+k}\}]$$

captures (irrational) waves of optimism or pessimism regarding future output and interest rates.

- Assumption: $s_t \sim AR(1)$
- Equilibrium:

$$\widehat{y}_t = (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} - \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\} + s_t$$

- Recursive representation (DIS)

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}\widehat{r}_t + (1-\beta\rho_s)s_t$$

- Iterating forward:

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + \left(\frac{1-\beta\rho_s}{1-\rho_s}\right)s_t$$

- Discussion

- fluctuations driven by animal spirits
- amplification increasing with persistence, due to effect of higher anticipated income.on consumption

Application (IV): (Irrational) Bubbles

- Stock valuation:

$$\begin{aligned} Q_t^S &= Q_t^F + Q_t^B \\ &= \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} D_{t+k}\} + Q_t^B \end{aligned}$$

- Implied C-IBC:

$$\begin{aligned} \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} C_{t+k}\} &= \mathcal{A}_t + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} W_{t+k} N_{t+k}\} \\ &= \mathcal{A}_t - Q_t^F + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(W_{t+k} N_{t+k} + D_{t+k})\} \\ &= F_t + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} Y_{t+k}\} \end{aligned}$$

- Consumption function (around a bubbleless steady state).

$$\widehat{c}_t = (1-\beta)\left(\widehat{f}_t + \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}\right) - \frac{\beta}{\sigma}\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

- Asset market clearing: $\mathcal{A}_t = Q_t^F + Q_t^B \quad \Rightarrow \widehat{f}_t = q_t^B \equiv Q_t^B / Y$
- Goods market clearing

$$\begin{aligned} \widehat{y}_t &= \widehat{c}_t \\ &= (1-\beta) q_t^B + (1-\beta)\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} - \frac{\beta}{\sigma}\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\} \end{aligned}$$

- Recursive representation (DIS)

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}\widehat{r}_t + (1-\beta)(q_t^B - \beta\mathbb{E}_t\{q_{t+1}^B\})$$

- Assumptions

$$q_t^B = \rho_b q_{t-1}^B + \varepsilon_t^B$$

- Equilibrium output:

$$\widehat{y}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{(1-\beta)(1-\beta\rho_b)}{1-\rho_b}q_t^B$$

$\Rightarrow$ bubble-driven fluctuations

Concluding Remarks

- Standard formulations/expositions of the AD block of the NK model:

(i) Dinamic IS equation: combines PE and GE, obscuring underlying mechanisms
(ii) Nominal rate rule: not the relevant interest rate

- Proposed reformulation:

(i) Back to the consumption function, and explicit PE/GE distinction
(ii) Real interest rate rule

- Proof of concept through several applications
- Unexpected outcome: NK model with *no reference to inflation* (nor money)!

$\Rightarrow$ *Real New Keynesian Model*

- Advantage: no need to take a stand on price/wage setting block
- Microfoundations for the textbook "Keynesian cross model"

- consistent with rational expectations
- immune to the Lucas critique

Rethinking The New Keynesian Model (II): Monetary Policy Rules

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Lucas-Modigliani Lectures, June 2026

Introduction

- Key element of the New Keynesian model: monetary policy rule
- Convential assumption: a "realistic" rule for the short-term nominal rate ("Taylor-type rule")
- In addition, the Taylor rule often used as a benchmark for monetary policy assessment
- Is it time to re-assess the usefulness of the Taylor rule?

Outline

- The Taylor rule: positive and normative aspects
- Pitfalls in the use of Taylor-type rules for monetary policy assessment
- The case for *long term real interest rate rules*

- Draws from my Jackson Hole discussion of Nakamura, Riblier and Steinsson's "Beyond the Taylor Rule"

The Taylor Rule

- The original Taylor rule (Taylor (1993)):

$$i_t = 4 + 1.5(\pi_t - 2) + 0.5\widehat{y}_t$$

The Original Taylor Rule

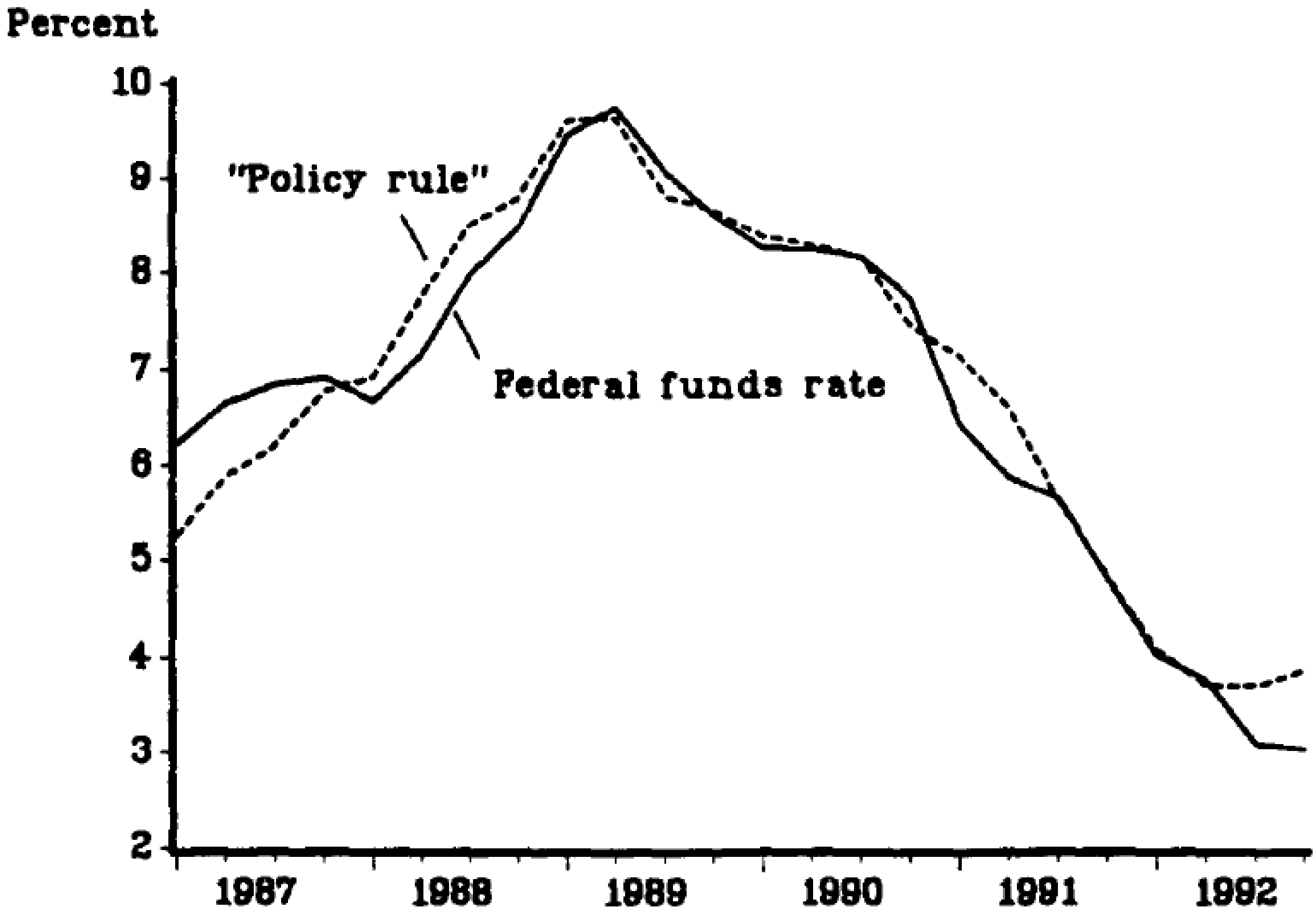


Figure 1. Federal funds rate and example policy rule.

Source: Taylor (1993)

The Taylor Rule

- The original Taylor rule (Taylor (1993)):

$$i_t = 4 + 1.5(\pi_t - 2) + 0.5\widehat{y}_t$$

- Baseline interest rate rule in NK models:

$$i_t = \phi_0 + \phi_\pi \pi_t + \phi_y \widehat{y}_t + v_t$$

- Positive vs normative dimensions of the Taylor rule

The Taylor Rule

- The original Taylor rule (Taylor (1993)):

$$i_t = 4 + 1.5(\pi_t - 2) + 0.5\widehat{y}_t$$

- Baseline interest rate rule in NK models:

$$i_t = \phi_0 + \phi_\pi \pi_t + \phi_y \widehat{y}_t + v_t$$

- Positive vs normative dimensions of the Taylor rule
- The Taylor principle

$$\phi_\pi + \frac{1-\beta}{\kappa}\phi_y > 1$$

- *Evidence*: U.S. Monetary Policy vs Taylor Rule (Nakamura et al. (2025))

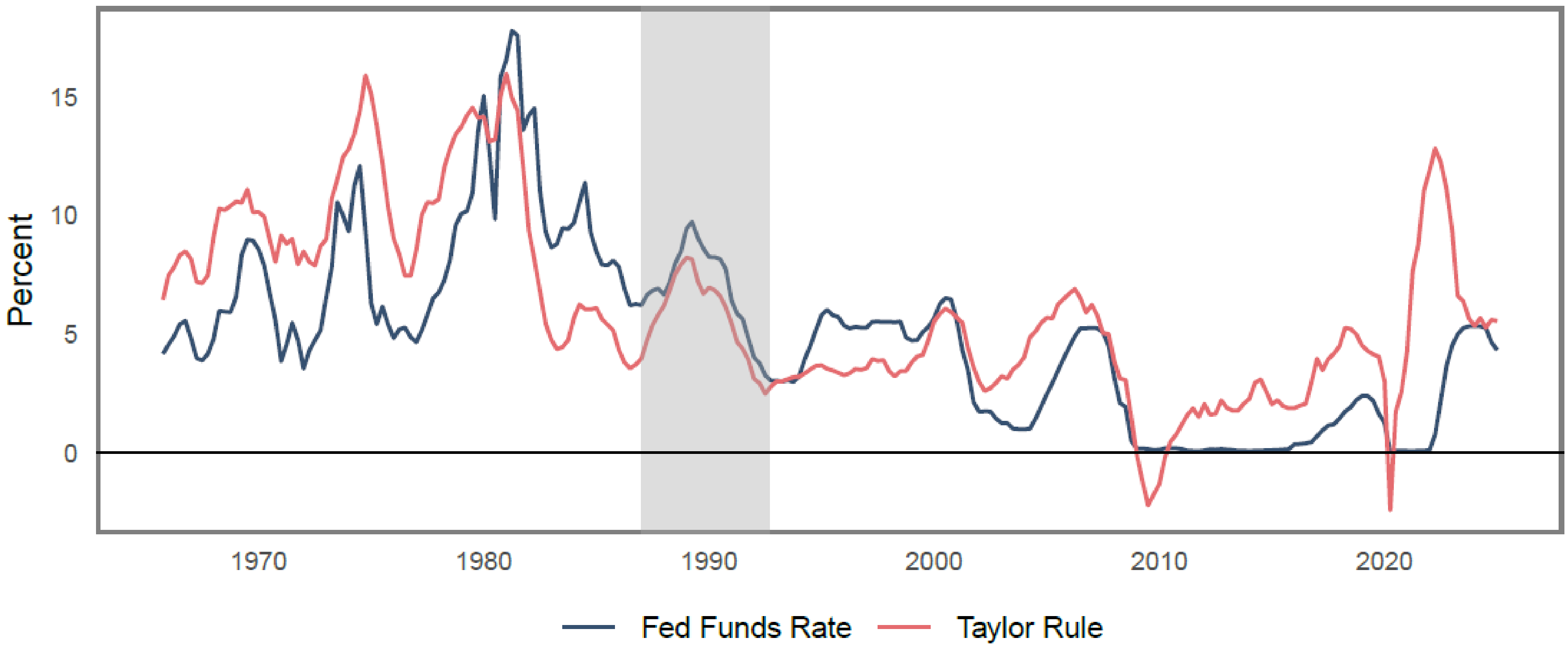


Figure 4: Original Taylor Rule with Retrospective Data

Note: The (light) red line shows the policy rate implied by the original Taylor rule—equation (1). We use retrospective data (i.e., the current data vintage) for the GDP deflator and the Greenbook's measure of the output gap (CBO output gap for last few years). The sample period is 1965Q4-2025Q1. The shaded area shows the sample period considered in Taylor (1993).

Source: Nakamura, Riblier and Steinsson (2025)

Pitfalls in the Use of Taylor Rules for Policy Assessment

Two Observations

1. Optimal monetary policy is not generally implementable by means of a simple Taylor rule
2. Optimal monetary policy's *observable outcomes* do not always satisfy the Taylor principle

$\Rightarrow$ Observed deviations from the Taylor rule or even from the Taylor principle should not be interpreted as *prima facie* evidence of "bad monetary policy"

Illustration (based on Nakamura et al. (2025)): Taylor rule-based assessment of monetary policy when the central bank follows an optimal policy (discretion and commitment):

$$\min \ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\pi_t^2 + \vartheta \widehat{y}_t^2 \right)$$

subject to:

$$\pi_t = \beta \mathbb{E}_t\{\pi_{t+1}\} + \kappa \widehat{y}_t + u_t \quad (1)$$

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}\left(\widehat{i}_t - \mathbb{E}_t\{\pi_{t+1}\} - z_t\right) \quad (2)$$

where $u_t = \rho_u u_{t-1} + \varepsilon_t$

Pitfalls in the Use of Taylor Rules for Policy Assessment

Optimal Monetary Policy: The Case of Discretion

- Equilibrium under the optimal policy (Galí 2015 ch.5):

$$\pi_t^* = \frac{\vartheta}{\kappa^2 + \vartheta(1-\beta\rho_u)}\; u_t \qquad ; \qquad \widehat{y}_t^* = \frac{\kappa}{\kappa^2 + \vartheta(1-\beta\rho_u)}\; u_t$$

$$\begin{aligned} i_t^* &= \rho + \frac{\vartheta\rho_u + \sigma\kappa(1-\rho_u)}{\kappa^2 + \vartheta(1-\beta\rho_u)} u_t + z_t \\ &= \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right] \pi_t^* + z_t \end{aligned}$$

- Implementation if $\frac{\sigma\kappa}{\vartheta} > 1$

$$i_t = \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right] \pi_t + z_t$$

- Implementation if $\frac{\sigma\kappa}{\vartheta} \leq 1$

$$\begin{aligned} i_t &= \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right] \pi_t + z_t + \varphi_\pi(\pi_t - \pi_t^*) \\ &= \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u) + \varphi_\pi\right] \pi_t + z_t - \frac{\vartheta\varphi_\pi}{\kappa^2 + \vartheta(1-\beta\rho_u)}\; u_t \end{aligned}$$

with $\varphi_\pi > \left(1 - \frac{\sigma\kappa}{\vartheta}\right)(1-\rho_u)$

Pitfalls in the Use of Taylor Rules for Policy Assessment

- Observed relation

$$i_t = \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right]\pi_t + z_t$$

- Estimated rule (using OLS):

$$i_t = \alpha + \phi_\pi \pi_t + v_t$$

Remarks

1. If $\frac{\sigma\kappa}{\vartheta} < 1$ the estimated Taylor rule will (misleadingly) suggest violation of the Taylor principle
2. The residual from the estimated rule should not be interpreted as an exogenous monetary policy shock
3. Questionable credibility since $\varphi_\pi(\pi_t - \pi_t^*)$ is never observed
4. Alternative: Implementation through forward-looking rule (Clarida-Galí-Gertler 1999):

$$i_t = \rho + \left[1 + \frac{\sigma\kappa}{\vartheta\rho_u}(1-\rho_u)\right]\mathbb{E}_t\{\pi_{t+1}\} + z_t$$

$\Rightarrow$ no misled assessment if $i_t = \alpha + \phi_\pi \mathbb{E}_t\{\pi_{t+1}\} + v_t$ is estimated.

Pitfalls in the Use of Taylor Rules for Policy Assessment

Optimal Monetary Policy: The Case of Commitment

- Equilibrium under the optimal policy

$$\widehat{p}_t^* = \delta \widehat{p}_{t-1}^* + \psi u_t \quad ; \quad \widehat{y}_t^* = \delta \widehat{y}_{t-1}^* - \frac{\kappa \psi}{\vartheta} u_t$$

where $\widehat{p}_t \equiv p_t - p_{-1}$ and with $\delta \in (0,1)$ and ψ a function of underlying parameters. Assuming $\rho_u = 0$:

$$i_t^* = \rho + \left(\frac{\sigma\kappa}{\vartheta} - 1 \right) (1-\delta) \widehat{p}_t^* + z_t$$

$\Rightarrow$ price level targeting rule

$\Rightarrow$ determinacy condition: positive price coefficient

- Implementation if $\frac{\sigma\kappa}{\vartheta} > 1$:

$$i_t = \rho + \left(\frac{\sigma\kappa}{\vartheta} - 1 \right) (1-\delta) \widehat{p}_t + z_t$$

- Implementation if $\frac{\sigma\kappa}{\vartheta} \leq 1$:

$$i_t = \rho + \left(\frac{\sigma\kappa}{\vartheta} - 1 \right) (1-\delta) \widehat{p}_t + z_t + \varphi_p (p_t - p_t^*)$$

with $\varphi_p > (1 - \frac{\sigma\kappa}{\vartheta})(1-\delta)$

Pitfalls in the Use of Taylor Rules for Policy Assessment

- Observed relation

$$i_t = \rho + \left(\frac{\sigma\kappa}{\vartheta} - 1\right)(1-\delta)\widehat{p}_t + z_t$$

- Estimated rule: $i_t = \alpha + \phi_\pi \pi_t + v_t$

$$\widehat{\phi}_\pi \Rightarrow \frac{1}{2}\left(\frac{\sigma\kappa}{\vartheta} - 1\right)(1-\delta)$$

$\Rightarrow$ misled assessment if $\frac{1}{2}\left(\frac{\sigma\kappa}{\vartheta} - 1\right)(1-\delta) < 1$

A Simple Interest Rate Rule: U.S. Evidence

$$i_t = \alpha + \phi_\pi \pi_t + v_t$$

Empirical Interest Rate Rules: U.S. Evidence
1991Q3-2024Q4

	CPI		Core PCE	
π_t	0.15^{***} (0.05)	0.33^{***} (0.09)	0.43^{***} (0.15)	0.68^{***} (0.17)
$\pi_t * ZLB_t$		-0.57^{***} (0.10)		-1.03^{***} (0.14)
R^2	0.28	0.41	0.29	0.49

The Case for Long Term Real Interest Rate Rules

Monetary Policy Transmission and the Long Real Rate

- Consumption

$$\widehat{c}_t = (1-\beta)\left(\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}\right) - \frac{\beta}{\sigma}\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\} + \frac{\beta}{\sigma(1-\beta\rho_z)} z_t$$

where $r_t \equiv i_t - \mathbb{E}_t\{\pi_{t+1}\}$.

- Real yield on a consol paying a constant real coupon:

$$\widehat{r}_t^L \equiv (1-\beta)\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

- Accordingly,

$$\widehat{c}_t = (1-\beta)\left(\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}\right) - \frac{\beta}{\sigma(1-\beta)}\widehat{r}_t^L + \frac{\beta}{\sigma(1-\beta\rho_z)} z_t$$

The Case for Long Term Real Interest Rate Rules

Monetary Policy Transmission and the Long Real Rate (cont)

- Investment under convex adjustment costs

$$\widehat{x}_t - \widehat{k}_t = \eta \widehat{q}_t$$

where

$$\widehat{q}_t = [1 - \beta(1-\delta)] \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}^K_{t+1+k}\} - \frac{1}{1-\beta}\widehat{r}^L_t$$

The Case for Long Term Real Interest Rate Rules

Monetary Policy Transmission and the Long Real Rate (cont)

- Investment under convex adjustment costs

$$\widehat{x}_t - \widehat{k}_t = \eta \widehat{q}_t$$

where

$$\widehat{q}_t = [1-\beta(1-\delta)] \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}^K_{t+1+k}\} - \frac{1}{1-\beta}\widehat{r}^L_t$$

Some Observations

- The long term real rate r_t^L is a *sufficient statistic* for the impact of monetary policy on aggregate demand.
- It is natural to think of policy in terms of its implications on the long real rate. This includes current and anticipated changes in the policy rate as well as unconventional interventions aimed at changing the term premium.
- *Corollary*: one may want to model monetary policy in terms of a rule for the long real rate, leaving implementation in the background.
- Empirical long rate rules allow for a better assessment of the adequacy of monetary policy. Illustrated by assuming optimal policy, evaluated by means of an estimated simple rule.

The Case for Long Term Real Interest Rate Rules

Equilibrium under a Long Real Rate Rule: An Example

- A simple long real rate rule

$$\widehat{r}_t^L = \phi_\pi \pi_t$$

where $\phi_\pi \geq 0$ and $\phi_y \geq 0$. Combined with

$$\widehat{r}_t^L = \beta \mathbb{E}_t\{\widehat{r}_{t+1}^L\} + (1-\beta)\widehat{r}_t$$

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}(\widehat{r}_t - z_t)$$

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

yields the difference equation for equilibrium output:

$$\widehat{y}_t = \frac{\sigma(1-\beta)}{\sigma(1-\beta)+\kappa\phi_\pi}\mathbb{E}_t\{\widehat{y}_{t+1}\} + \Psi_z z_t + \Psi_u u_t$$

- Necessary and sufficient condition for local uniqueness:

$$\phi_\pi > 0$$

- Interpretation through the lens of the Taylor Principle

The Case for Long Term Real Interest Rate Rules

Long Rate Rules for Monetary Policy Assessment

- *Optimal policy with discretion* can be implemented with the rule

$$r_t^L = \rho + \frac{\sigma\kappa(1-\beta)(1-\rho_u)}{\vartheta(1-\beta\rho_u)}\pi_t + \frac{1-\beta}{1-\beta\rho_z}z_t$$

- The inflation coefficient under the optimal policy is always positive
- The long real rate rule: $r_t^L = \alpha + \phi_\pi \pi_t + v_t$ can be estimated consistently using OLS

$\Rightarrow$ No misled inference on the adequacy of monetary policy
$\Rightarrow$ No unobserved off-equilibrium response required

The Case for Long Term Real Interest Rate Rules

Long Rate Rules for Monetary Policy Assessment

- *Optimal policy with commitment* can be implemented with the rule

$$r_t^L = \rho + \frac{\sigma\kappa}{\vartheta}\Omega[1-(\delta+\rho_u)+\beta\delta\rho_u]\ \widehat{p}_t + \frac{\sigma\kappa}{\vartheta}\Omega(1-\beta)\delta\rho_u\ \widehat{p}_{t-1} + \frac{1-\beta}{1-\beta\rho_z}z_t$$

where $\Omega \equiv \frac{1-\beta}{(1-\beta\rho_u)(1-\beta\rho_z)} > 0$

- Estimated simple rule: $r_t^L = \alpha + \phi_\pi \pi_t + v_t$
- But OLS estimates of ϕ_π converge to:

$$\widehat{\phi}_\pi \rightarrow \frac{\sigma\kappa}{2\vartheta}\Omega[1-(\delta+\rho_u)+\delta\rho_u(2\beta-1)]$$

which will be positive given $\beta \lesssim 1$ since $1-(\delta+\rho_u)+\delta\rho_u > 0$

A Simple Long Rate Rule: U.S. Evidence

$$r_t^L = \alpha + \phi_\pi \pi_t + v_t$$

r_t^L = 10 year Treasury Yield - 10 year SPF inflation forecast

A Simple Long Rate Rule: U.S. Evidence

$$r_t^L = \alpha + \phi_\pi \pi_t + v_t$$

r_t^L = 10 year Treasury Yield - 10 year SPF inflation forecast

Empirical Long Real Rate Rules: U.S. Evidence
1991Q3-2024Q4

	CPI		Core PCE	
π_t	0.07^{***} (0.02)	0.14^{***} (0.04)	0.19^{**} (0.07)	0.30^{***} (0.17)
$\pi_t * ZLB_t$		-0.25^{***} (0.10)		-0.46^{***} (0.06)
R^2	0.65	0.74	0.66	0.75

Why Not Long-Term Nominal Rate Rules?

- Nominal yield of a consol with constant nominal coupon:

$$\widehat{i}_t^L = (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{i}_{t+k}\}$$

- A simple long-term nominal rate rule

$$\widehat{i}_t^L = \phi_\pi \pi_t$$

where $\phi_\pi \geq 0$. Combined with

$$\widehat{i}_t^L = \beta \mathbb{E}_t\{\widehat{i}_{t+1}^L\} + (1-\beta)\widehat{i}_t$$

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}(\widehat{i}_t - \mathbb{E}_t\{\pi_{t+1}\} - z_t)$$

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

$\Rightarrow$ uniqueness condition:

$$\phi_\pi > 1$$

Why Not Long-Term Nominal Rate Rules?

Optimal Policy with Discretion

- Implementation:

$$i_t^L = \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right]\frac{1-\beta}{1-\beta\rho_u}\pi_t + \frac{1-\beta}{1-\beta\rho_z}z_t + \varphi_\pi(\pi_t - \pi_t^*)$$

with $\varphi_\pi > 1 - \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right]\frac{1-\beta}{1-\beta\rho_u}$

- Observed relation:

$$i_t^L = \rho + \left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right]\frac{1-\beta}{1-\beta\rho_u}\pi_t + \frac{1-\beta}{1-\beta\rho_z}z_t$$

- Estimated rule: $i_t^L = \alpha + \phi_\pi \pi_t + v_t$

$\Rightarrow$ estimated inflation coefficient less than one if $\left[\rho_u + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\right]\frac{1-\beta}{1-\beta\rho_u} < 1$
$\Rightarrow$ misled conclusion regarding indeterminacy
$\Rightarrow$ risk of no credibility since $\varphi_\pi(\pi_t - \pi_t^*)$ is never observed

Why Not Long-Term Nominal Rate Rules?

Optimal Policy with Commitment

- Implementation of *optimal policy with commitment* (assuming $\rho_u = 0$)

$$i_t^L = \rho + \left(\frac{\sigma\kappa}{\vartheta} - 1\right)(1-\delta)\widehat{p}_t + \frac{1-\beta}{1-\beta\rho_z} z_t + \varphi_p (p_t - p_t^*)$$

with $\varphi_p > \left(1 - \frac{\sigma\kappa}{\vartheta}\right)(1-\delta)$

- Observed relation:

$$i_t^L = \rho + \left(\frac{\sigma\kappa}{\vartheta} - 1\right)(1-\delta)\widehat{p}_t + \frac{1-\beta}{1-\beta\rho_z} z_t$$

- Estimated rule: $i_t^L = \alpha + \phi_\pi \pi_t + v_t$

$$\widehat{\phi}_\pi \Rightarrow \frac{1}{2}\left(\frac{\sigma\kappa}{\vartheta} - 1\right)(1-\delta) \lesseqgtr 1$$

$\Rightarrow$ risk of misled inference regarding indeterminacy
$\Rightarrow$ risk of no crediblity if $\frac{\sigma\kappa}{\vartheta} < 1$ since $\varphi_p(p_t - p_t^*)$ unobserved.

Why Not Short-Term Real Rate Rules?

- A simple short-term real rate rule

$$\widehat{r}_t = \phi_\pi \pi_t$$

where $\phi_\pi \geq 0$. Combined with

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{1}{\sigma}(\widehat{r}_t - \mathbb{E}_t\{\pi_{t+1}\} - z_t)$$

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

$\Rightarrow$ uniqueness condition:

$$\phi_\pi > 0$$

Why Not Short-Term Real Rate Rules?

- Optimal policy with discretion can be implemented by the rule

$$r_t = \rho + \frac{\sigma\kappa}{\vartheta}(1-\rho_u)\pi_t + z_t$$

with positive estimated inflation coefficient $\Rightarrow$ no misled assessment

- Optimal policy with commitment can be implemented by the rule

$$r_t = \rho + \frac{\sigma\kappa}{\vartheta}(1-\delta-\rho_u)\ \widehat{p}_t + \frac{\sigma\kappa}{\vartheta}\delta\rho_u\ \widehat{p}_{t-1} + z_t$$

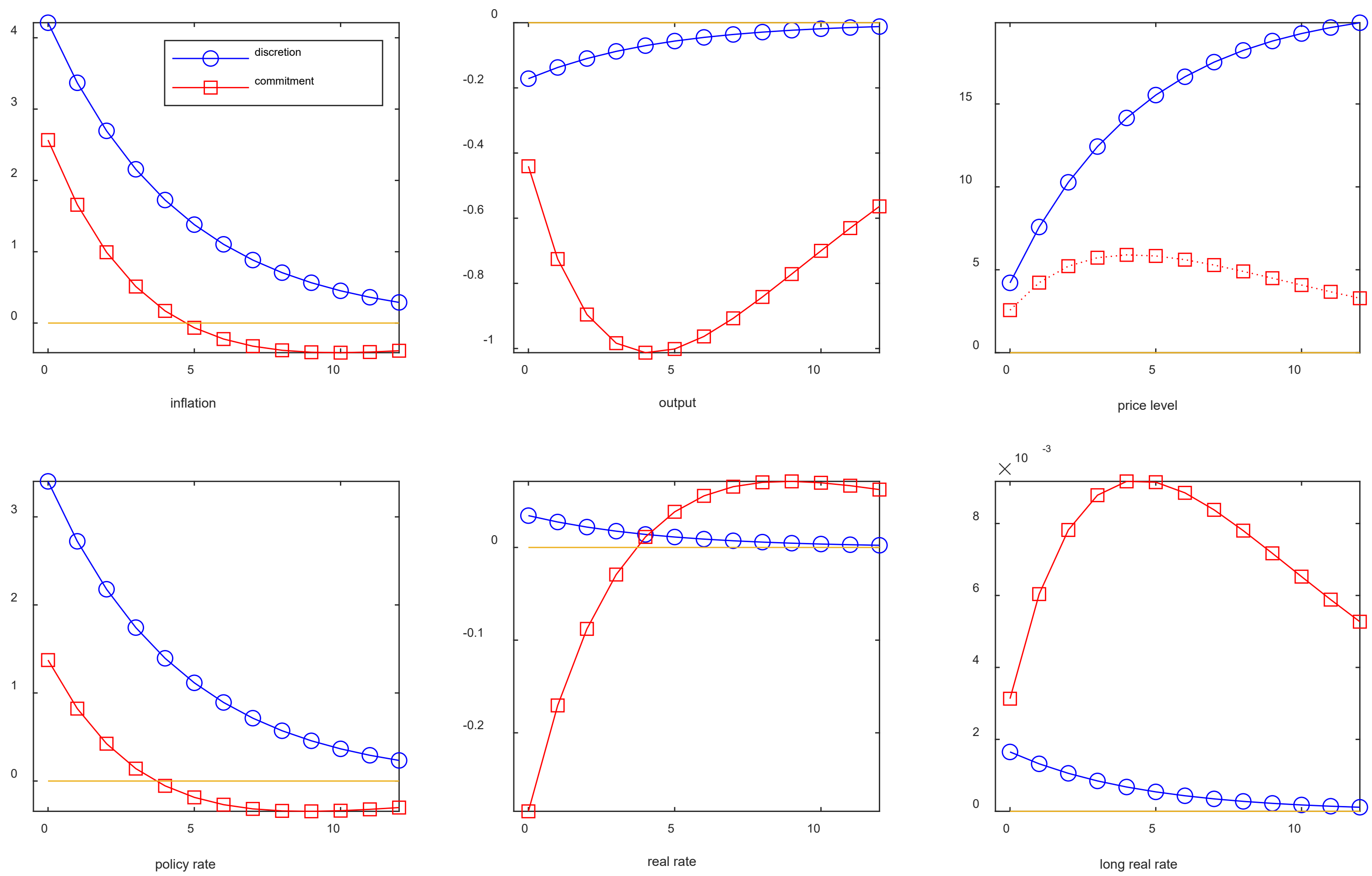
- Estimated (mis-specified) rule $r_t = \alpha + \phi_\pi \pi_t + v_t$ implying

$$\widehat{\phi}_\pi \rightarrow \frac{\sigma\kappa}{2\vartheta}(1-\delta-\rho_u-\delta\rho_u)$$

which is negative for $\rho_u > \frac{1-\delta}{1+\delta} \Rightarrow$ risk of misled assessment.

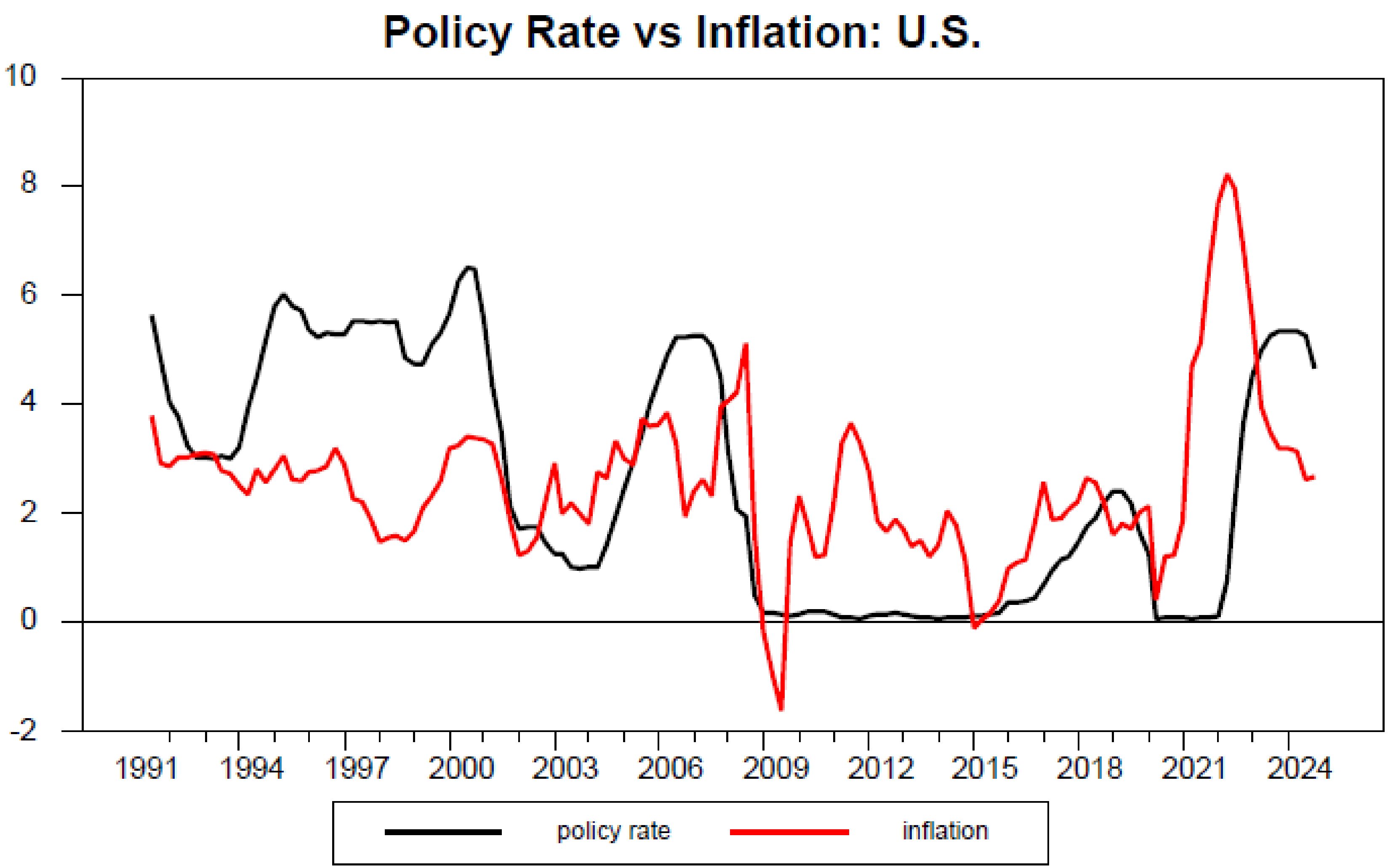
- Intuition for negative comovement: See simulations.

Optimal Monetary Policy: Discretion vs Commitment



Two Real World Illustrations

- The long real rate during the post-pandemic inflation surge
- Comparing U.S. vs Brazil monetary policy


Policy Rate vs Inflation: U.S.
10
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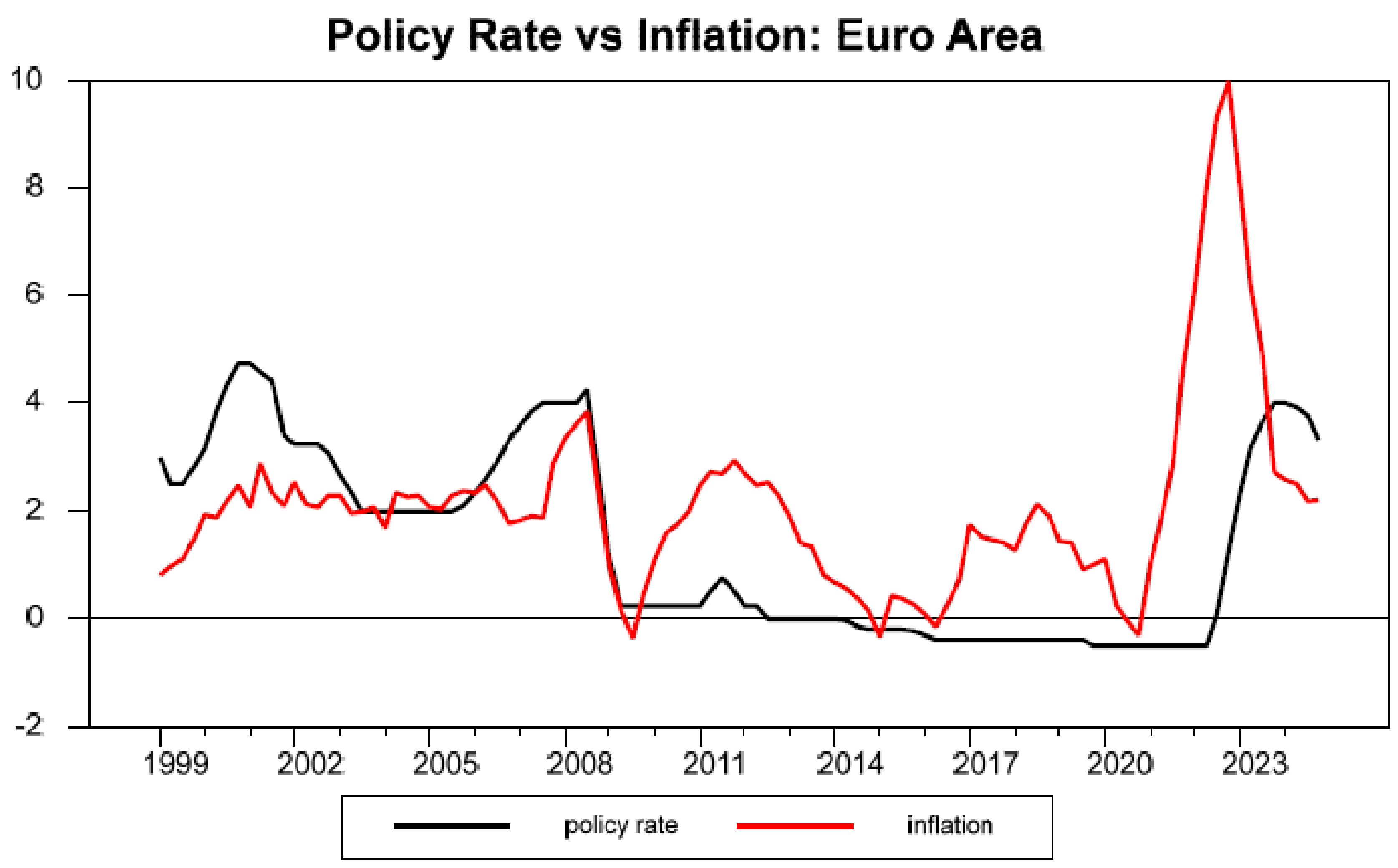
policy rate
inflation


Policy Rate vs Inflation: Euro Area
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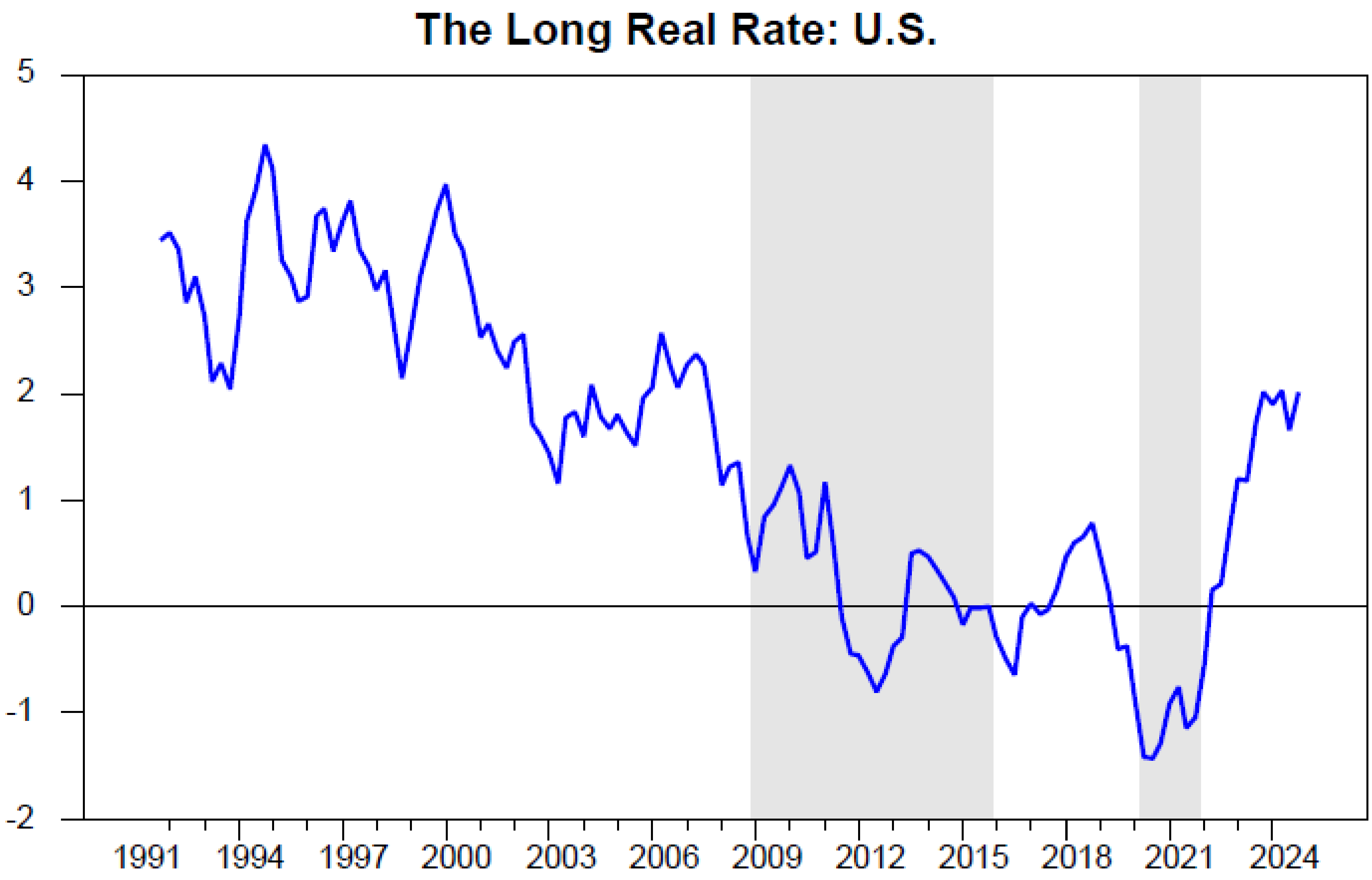
policy rate
inflation


The Long Real Rate: U.S.
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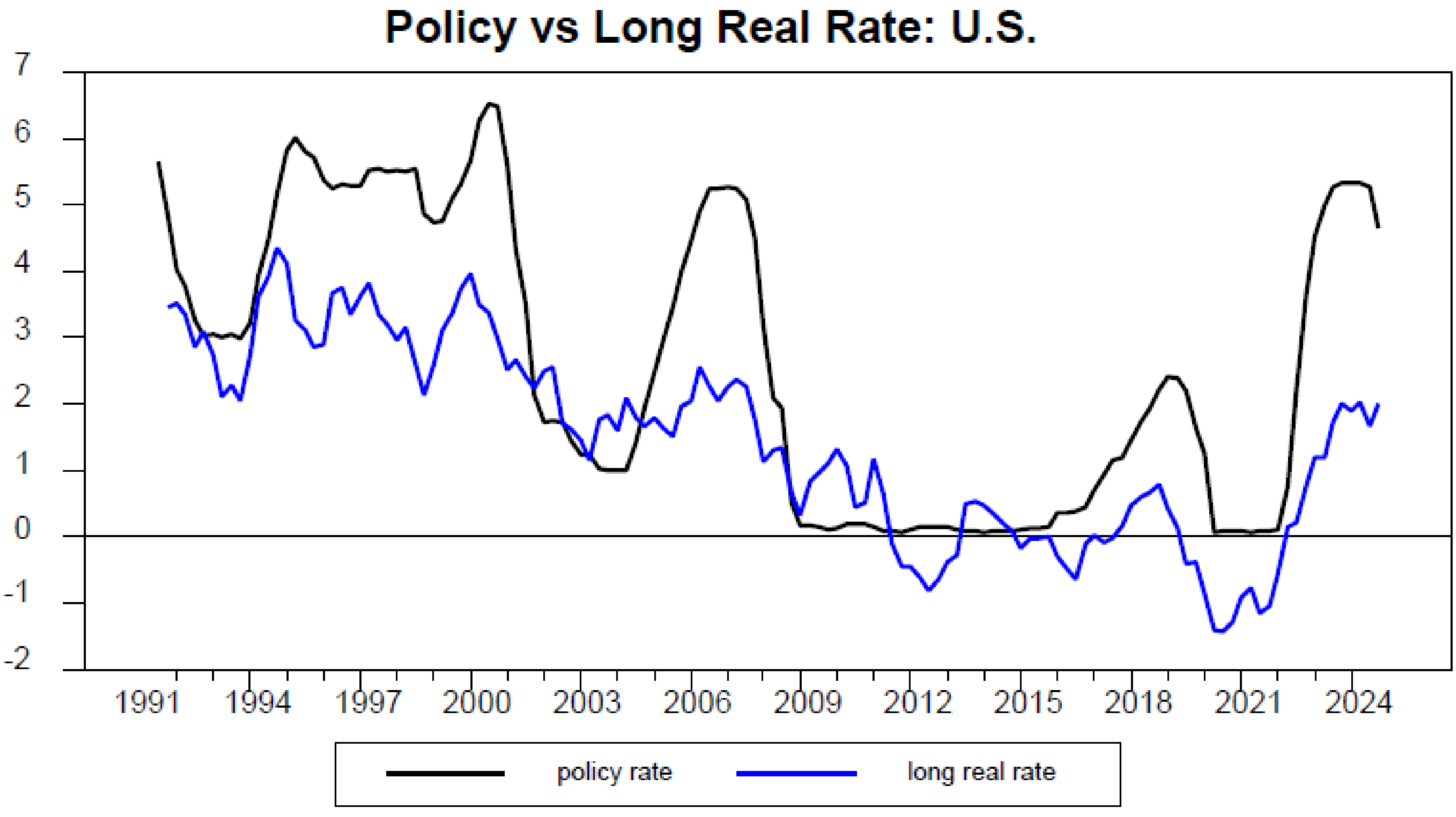

Policy vs Long Real Rate: U.S.
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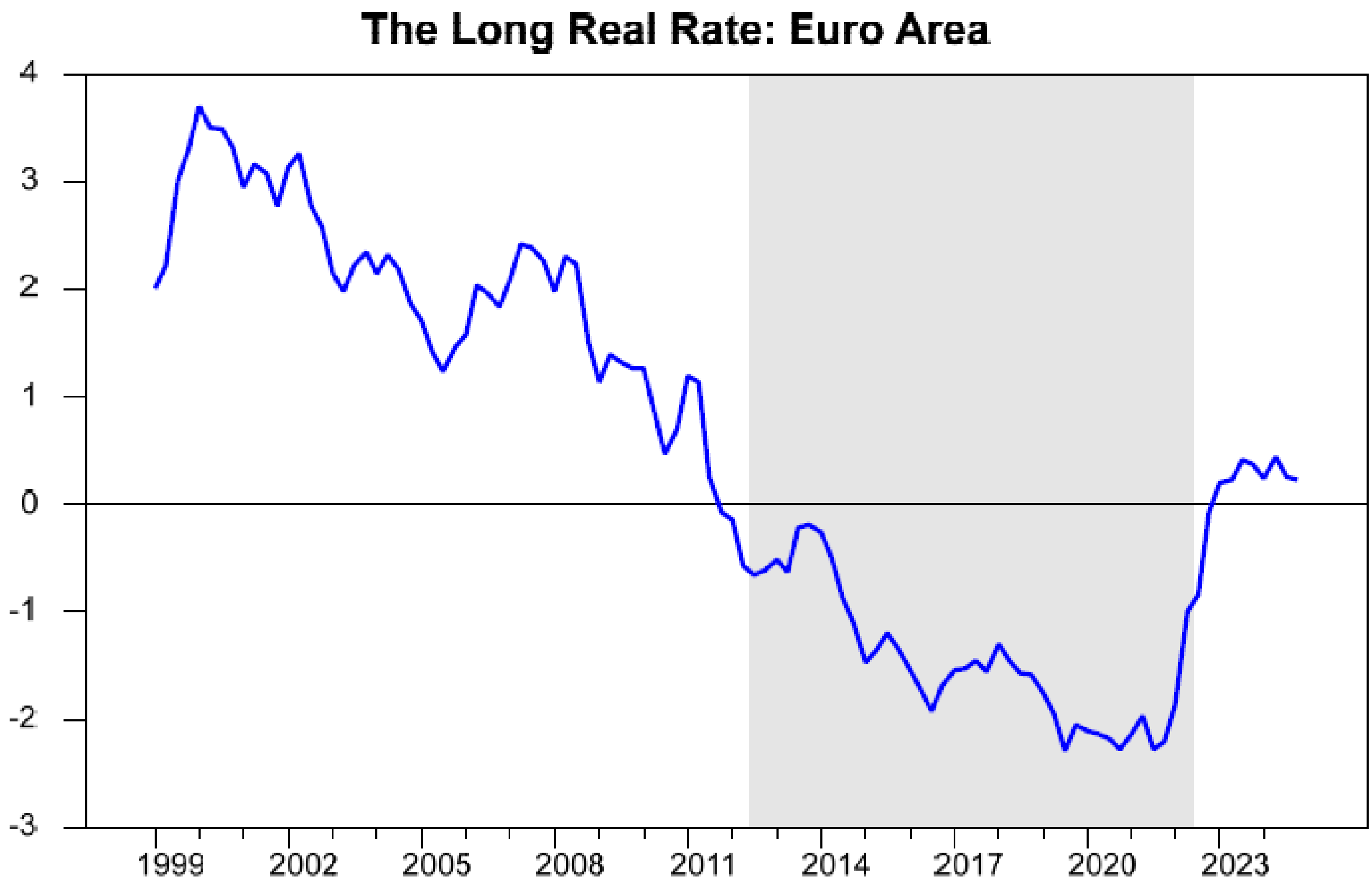
policy rate
long real rate


The Long Real Rate: Euro Area
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2002
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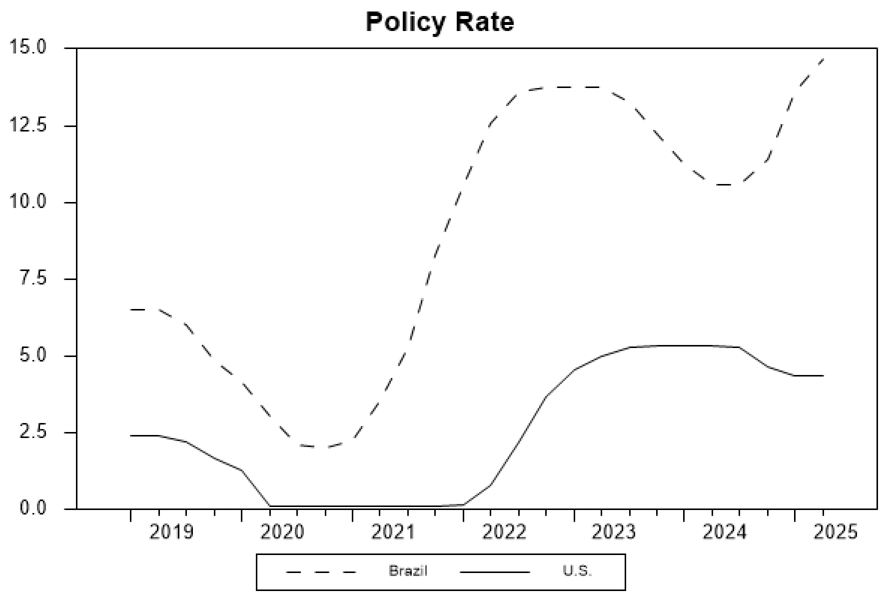
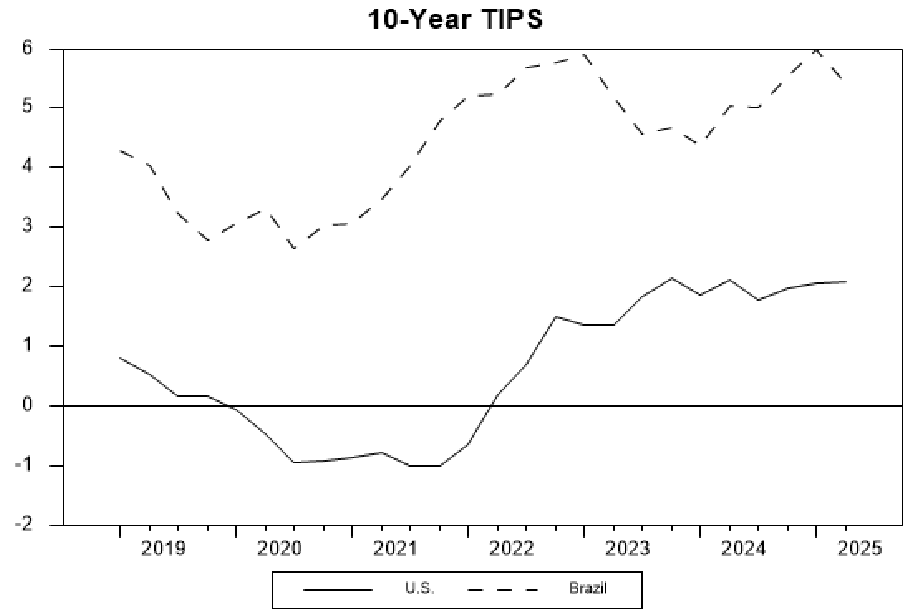
2023

Monetary Policy Responses to the Inflation Surge: U.S. vs Brazil





Main Takeaways

- Fitted Taylor-type rules may be misleading, unless the central bank literally follows a Taylor rule.
- Through the lens of the NK model, the long real rate is the best indicator of the monetary policy stance at any point in time.
- Simple long real rate rules may be embedded easily in a standard NK model
- Empirical long real rate rules may provide a better assessment of the adequacy of monetary policy.

Rethinking the New Keynesian Model (III): Heterogeneity

Jordi Galí

CREI, UPF and BSE

Lucas-Modigliani Lectures, June 2026

Background

- The long dominance of the representative agent (RA) paradigm in macro
- The HANK revolt (Kaplan-Moll-Violante, Auclert-Rognlie-Straub,...):

  - household heterogeneity, in the form of *idiosyncratic income shocks*
  - incomplete markets
  - borrowing constraints

    $\Rightarrow$ joint wealth and income distribution as state variable
    $\Rightarrow$ need for numerical solution methods, limited analytical results

- **This lecture**: a *simple, analytically tractable model* that sheds light on the *role of heterogeneity* in:

  (i) the determination of aggregate demand and output in response to shocks.
  (ii) the design of the optimal monetary policy

- Builds on Debortoli-Galí 2024

A New TANK Model

- Two consumer types: unconstrained and hand-to-mouth
- No heterogeneity within each group
- Identical preferences for all: $E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}-1}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right)$

Hand-to-Mouth Consumers

- Constant measure λ
- Consumption

$$C_t^H = Y_t^H - T_t^H + R_t^{-1}\Upsilon - \Upsilon$$

where

$$\begin{aligned} Y_t^H &= \Xi^H W_t N_t + \Theta^H D_t \\ &= \left[\Xi^H \frac{1-\alpha}{\mathcal{M}_t^p} + \Theta^H \left(1 - \frac{1-\alpha}{\mathcal{M}_t^p} \right) \right] Y_t \end{aligned}$$

where $N_t^H = N_t$ and a technology $Y_t = A_t N_t^{1-\alpha}$ is assumed. Borrowing limit Υ, assumed to be continuously binding.

- Standard TANK model (Galí et al 2007, Bilbiie 2008): $\Xi^H = 1$, $\Theta^H = 0$, $\Upsilon = 0$
- Debortoli-Galí 2024: generalization is needed to approximate channels at work in HANK models

- Log-linearization (under simplifying assumption $C^H = Y$):

$$\widehat{c}_t^H = \Omega^H \widehat{y}_t - \Sigma^H \widehat{\mu}_t^p - \upsilon\beta \widehat{r}_t - \widehat{t}_t^H$$

where $\Omega^H \equiv \frac{Y^H}{Y} = \Xi^H \frac{1-\alpha}{\mathcal{M}^p} + \Theta^H \left(1 - \frac{1-\alpha}{\mathcal{M}^p}\right)$, $\Sigma^H \equiv \frac{(1-\alpha)(\Xi^H - \Theta^H)}{\mathcal{M}^p}$, $\upsilon \equiv \frac{\Upsilon}{Y}$, and $t_t^H \equiv \frac{T_t^H}{Y}$.

- Two additional assumptions:

(i) wage schedule: $W_t = \mathcal{M}^w C_t^\sigma N_t^\varphi \quad \Rightarrow \quad \widehat{w}_t = \sigma \widehat{c}_t + \varphi \widehat{n}_t$
(ii) goods market clearing: $Y_t = C_t + G_t \quad \Rightarrow \quad \widehat{y}_t = \widehat{c}_t + g_t$

where $g_t \equiv G_t / Y$ and $G = 0$ is assumed.

- Implied markup function:

$$\begin{aligned} \widehat{\mu}_t^p &= [a_t - \alpha \widehat{n}_t] - \widehat{w}_t \\ &= -\left(\sigma + \frac{\varphi + \alpha}{1 - \alpha}\right) \widehat{y}_t + \mu_t^x \end{aligned}$$

where $\mu_t^x = \frac{1+\varphi}{1-\alpha} a_t + \sigma g_t$.

- Accordingly:

$$\widehat{c}_t^H = \chi^H \widehat{y}_t - \Sigma^H \mu_t^x - \upsilon\beta\widehat{r}_t - \widehat{t}_t^H$$

where $\chi^H \equiv \Omega^H + \Sigma^H \left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right) \gtrless 1$: MPC out of aggregate income for HtM consumers.

- Henceforth $\widehat{t}_t^H = \widehat{t}_t$ (uniform tax changes), for all t
- Implied consumption function for the HtM:

$$\widehat{c}_t^H = \chi^H \widehat{y}_t - \Sigma^H \mu_t^x - \upsilon\beta\widehat{r}_t - \widehat{t}_t$$

Unconstrained Consumers

- Constant measure $1 - \lambda$
- Period budget constraint:

$$C_t^U + \mathbb{E}_t\{\Lambda_{t,t+1}\mathcal{A}_{t+1}^U\} = \mathcal{A}_t^U + \Xi^U W_t N_t - T_t$$

- Intertemporal budget constraint

$$\sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} C_{t+k}^U\} = \mathcal{A}_t^U + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(\Xi^U W_{t+k} N_{t+k} - T_{t+k})\}$$

- Equilibrium with fundamental valuation of stocks:

$$\begin{aligned} \mathcal{A}_t^U &= B_{t-1}^U + \Theta^U Q_t^S \\ &= B_{t-1}^U + \Theta^U \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} D_{t+k}\} \end{aligned}$$

implying

$$\sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k} C_{t+k}^U\} = B_{t-1}^U + \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(Y_{t+k}^U - T_{t+k})\}$$

where

$$\begin{aligned} Y_t^U &\equiv \Xi^U W_t N_t + \Theta^U D_t \\ &= \left[\Xi^U \frac{1-\alpha}{\mathcal{M}_t^p} + \Theta^U \left(1 - \frac{1-\alpha}{\mathcal{M}_t^p}\right)\right] Y_t \end{aligned}$$

- Log-linearization of IBC combined with optimality condition implies

$$\widehat{c}_t^U = (1-\beta)\left(\widehat{b}_t^U + \sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\chi^U \widehat{y}_{t+k} - \Sigma^U \widehat{\mu}_{t+k}^x - \widehat{t}_{t+k}\}\right) + \left[(1-\beta)b^U - \frac{1}{\sigma}\right]\beta \sum_{k=0}^{\infty}\beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

where $\chi^U \equiv \Omega^U + \Sigma^U\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right)$, with $\Omega^U \equiv \Xi^U \frac{1-\alpha}{\mathcal{M}^p} + \Theta^U\left(1 - \frac{1-\alpha}{\mathcal{M}^p}\right)$ and $\Sigma^U \equiv \frac{(1-\alpha)(\Xi^U - \Theta^U)}{\mathcal{M}^p}$.

- Note that $(1-\beta)\chi^U$ is the MPC out of aggregate income for the unconstrained.
- Income and substitution effects of interest rate changes.

Government

- Period budget constraint:

$$G_t + B_t^G = \mathbb{E}_t\{\Lambda_{t,t+1} B_{t+1}^G\} + T_t$$

- Intertemporal budget constraint (G-IBC)

$$B_t^G = \sum_{k=0}^{\infty} \mathbb{E}_t\{\Lambda_{t,t+k}(T_{t+k} - G_{t+k}\}$$

- Log-linearized G-IBC around a steady state with $(1-\beta)B^G = T > 0$

$$\widehat{b}_t^G = \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{t}_{t+k} - g_{t+k}\} - b^G \beta \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

where $b_t^G \equiv B_t^G / Y$.

Aggregation

$$\begin{aligned}\widehat{c}_t &= \lambda \widehat{c}_t^H + (1-\lambda)\widehat{c}_t^U \\ &= \chi \widehat{y}_t - \lambda \widehat{t}_t + \lambda(1-\beta)\widehat{b}_t^G - \left[\frac{1-\lambda}{\sigma} + \lambda \upsilon \beta - \lambda(1-\beta)b^G\right]\beta \widehat{r}_t + \widehat{c}_t^F + \widehat{c}_t^X\end{aligned}$$

where $\chi \equiv \lambda \chi^H + (1-\lambda)(1-\beta)\chi^U$ and

$$\widehat{c}_t^F \equiv (1-\lambda)(1-\beta)\chi^U \sum_{k=1}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} - \left[\frac{1-\lambda}{\sigma} - \lambda(1-\beta)(\upsilon + b^G)\right]\beta \sum_{k=1}^{\infty} \beta^k \mathbb{E}_t\{\widehat{r}_{t+k}\}$$

$$\widehat{c}_t^X \equiv -(1-\lambda)(1-\beta)\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{g_{t+k}\} - \lambda \Sigma^H \left(\mu_t^x - (1-\beta)\sum_{k=0}^{\infty} \beta^k \mathbb{E}_t\{\mu_{t+k}^x\}\right)$$

- Role of heterogeneity (differences vs RANK)

- high MPC $\chi >> 1-\beta$
- "cash flow channel": proportional to $-\lambda \upsilon \widehat{r}_t$
- "income effect": proportional to $\lambda(1-\beta)b^G\widehat{r}_t$ (current) and $\lambda(1-\beta)(\upsilon + b^G)\widehat{r}_{t+k}$ (anticipated).
- "markup channel" if $\Sigma^H \neq 0$ (current vs anticipated)
- no Ricardian equivalence (captured by $-\lambda \widehat{t}_t + \lambda(1-\beta)\widehat{b}_t^G$)

- Missing channel relative to HANK: precautionary savings

Application (I): Monetary Policy Transmission

- Interest rate rule

$$\widehat{r}_t = \phi_y \widehat{y}_t + r_t^x$$

where $r_t^x \sim AR(1)$. Focus on limiting case of $\phi_y \to 0$. No other shocks, no fiscal block.

- Aggregate consumption function:

$$\widehat{c}_t = \chi \widehat{y}_t - \Psi_r r_t^x + (1-\lambda)(1-\beta)\chi^U \sum_{k=1}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}$$

where

$$\Psi_r = \lambda \upsilon \beta + \frac{\beta}{1-\beta\rho_r}\left[\frac{1-\lambda}{\sigma} - \lambda(1-\beta)\upsilon\right] > 0$$

measures the *direct* effect of MP on output

- Equilibrium:

$$\begin{aligned}\widehat{y}_t &= \widehat{c}_t \\ &= \chi \widehat{y}_t - \Psi_r r_t^x + (1-\lambda)(1-\beta)\chi^U \sum_{k=1}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\}\end{aligned}$$

- Recursive representation (DIS)

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \frac{\Psi_r(1-\beta\rho_r)}{\beta(1-\lambda\chi^H)} r_t^x$$

- *Total* effect of monetary policy (iterating forward):

$$\widehat{y}_t^{TANK} = -\frac{\Psi_r(1-\beta\rho_r)}{\beta(1-\lambda\chi^H)(1-\rho_r)} r_t^x$$

- Total effect in RANK

$$\widehat{y}_t^{RANK} = -\frac{1}{\sigma(1-\rho_r)} r_t^x$$

- Ratio of total effects: TANK over RANK

$$\frac{\widehat{y}_t^{TANK}}{\widehat{y}_t^{RANK}} = \frac{1+\lambda[\sigma\upsilon\beta(1-\rho_r)-1]}{1-\lambda\chi^H}$$

which is larger than one if and only if $\sigma\upsilon\beta(1-\rho_r)+\chi^H > 1$ (strong cash inflow channel, high HtM MPC, low IS)

- Decomposition:

$$\frac{\widehat{y}_t^{TANK}}{\widehat{y}_t^{RANK}} = \underbrace{1+\lambda[\sigma\upsilon\beta(1-\rho_r)-1]}_{DIRECT} \times \underbrace{\frac{1}{1-\lambda\chi^H}}_{GE}$$

$\Rightarrow$ GE effect increasing in λ

Application (II): Government Spending Multiplier

- Assumption #1: exogenous process for g_t

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g$$

- Assumption #2: tax rule

$$\widehat{t}_t = \phi_b \widehat{b}_t^G + \phi_g g_t$$

where $1-\beta < \phi_b < 1$ and $0 \leq \phi_g \leq 1$. Implied government debt dynamics:

$$\widehat{b}_{t+1}^G = \frac{1-\phi_b}{\beta}\widehat{b}_t^G + \frac{1-\phi_g}{\beta} g_t \tag{1}$$

- Assumption #3: $\widehat{r}_t = 0$ (no MP response)
- Aggregate consumption function

$$\begin{aligned}\widehat{c}_t \quad &= \quad \chi \widehat{y}_t - \lambda[\phi_b - (1-\beta)]\widehat{b}_t^G + (1-\lambda)(1-\beta)\chi^U \sum_{k=1}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} \\ &\quad - \left(\lambda \phi_g + \frac{\lambda\sigma\beta(1-\rho_g)\Sigma^H + (1-\lambda)(1-\beta)}{1-\beta\rho_g}\right) g_t\end{aligned}$$

- Counterpart in RANK:

$$\widehat{c}_t = (1-\beta)\widehat{y}_t + (1-\beta)\sum_{k=1}^{\infty}\beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} - \frac{1-\beta}{1-\beta\rho_g} g_t$$

- Goods market clearing

$$\begin{aligned}\widehat{y}_t &= \widehat{c}_t + g_t \\ &= \chi \widehat{y}_t - \lambda[\phi_b - (1-\beta)]\widehat{b}_t^G + (1-\lambda)(1-\beta)\chi^U \sum_{k=1}^{\infty} \beta^k \mathbb{E}_t\{\widehat{y}_{t+k}\} + \Psi_g g_t\end{aligned}$$

where $\Psi_g \equiv 1 - \left(\lambda\phi_g + \frac{\lambda\sigma\beta(1-\rho_g)\Sigma^H + (1-\lambda)(1-\beta)}{1-\beta\rho_g}\right)$

- Recursive representation (DIS)

$$\widehat{y}_t = \mathbb{E}_t\{\widehat{y}_{t+1}\} - \Phi_b \widehat{b}_t^G + \Phi_g g_t \qquad (2)$$

where $\Phi_b \equiv \frac{\lambda[\phi_b-(1-\beta)]\phi_b}{\beta(1-\lambda\chi^H)} > 0$ and $\Phi_g \equiv \frac{\beta(1-\rho_g)(1-\lambda\sigma\Sigma^H)+\lambda\phi_b-\lambda\phi_g[\beta(1-\rho_g)+\phi_b]}{\beta(1-\lambda\chi^H)}$ (> 0 if $\lambda\sigma\Sigma^H < 1$)

- State space representation of equilibrium:

$$\widehat{b}_{t+1}^G = \frac{1-\phi_b}{\beta}\widehat{b}_t^G + \frac{1-\phi_g}{\beta} g_t$$

$$\widehat{y}_t = -\frac{\lambda\phi_b}{1-\lambda\chi^H}\widehat{b}_t^G + \left[1 + \frac{\lambda(\Delta^H - \phi_g)}{1-\lambda\chi^H}\right] g_t$$

where $\Delta^H \equiv \Omega^H + \frac{\varphi}{1-\alpha}\Sigma^H$

- Impulse response:

$$\widehat{y}_t = \sum_{k=0}^{\infty} \theta_{t-k} \varepsilon_{t-k}^{g}$$

where

$$\theta_{t-k} \equiv \left[1 + \frac{\lambda}{1-\lambda\chi^H}\left(\Delta^H - \phi_g + \frac{\phi_b(1-\phi_g)}{1-\beta\rho_g - \phi_b}\right)\right]\rho_g^k - \frac{\lambda}{1-\lambda\chi^H}\left(\frac{\phi_b(1-\phi_g)}{1-\beta\rho_g-\phi_b}\right)\left(\frac{1-\phi_b}{\beta}\right)^k$$

- Impact multiplier:

$$\frac{d\widehat{y}_t}{d\varepsilon_t^g} = 1 + \frac{\lambda(\Delta^H - \phi_g)}{1-\lambda\chi^H}$$

- Larger with more deficit financing (low ϕ_g).
- Larger than one (and increasing in λ) if and only if $\Delta^H \equiv \Omega^H + \frac{\varphi}{1-\alpha}\Sigma^H > \phi_g$ /rationalized GLV 2007 evidence)
- Independent of ϕ_b

- Cumulative multiplier

$$\frac{\sum_{k=0}^{\infty}\beta^k(d\widehat{y}_{t+k}/d\varepsilon_t^g)}{\sum_{k=0}^{\infty}\beta^k(dg_{t+k}/d\varepsilon_t^g)} = 1 + \frac{\lambda(\Delta^H - 1)}{1-\lambda\chi^H}$$

- Independent of (ϕ_g, ϕ_b)

Optimal Monetary Policy in the New TANK Model

- Assumptions: $\Xi^H = \Xi^N = 1$ and $1 + s = \mathcal{M}^p \mathcal{M}^w - 1 \quad \Rightarrow \quad Y_t^n = Y_t^e$
- Steady state redistribution so that $C^H = C^U$.
- Staggered price setting à la Calvo:

$$\pi_t = \beta \mathbb{E}_t\{\pi_{t+1}\} + \kappa x_t \tag{3}$$

where $x_t \equiv y_t - y_t^e$ is the output gap $\Rightarrow$ "Divine Coincidence"
- Implied welfare-based loss function (around efficient steady state).

$$\mathbb{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\pi_t^2 + \vartheta_x x_t^2 + \vartheta_h h_t^2\right) \tag{4}$$

where $h_t \equiv c_t^U - c_t^H$ is the "consumption gap", with $\vartheta_x \equiv \frac{\kappa}{\epsilon}$ and $\vartheta_h \equiv \frac{\lambda(1-\lambda)\sigma(1-\alpha)}{\sigma(1-\alpha)+\alpha+\varphi}\vartheta_x$.
- RANK ($\lambda = 0$): $\vartheta_h = 0 \Longrightarrow$ strict inflation targeting is optimal
- Standard TANK model (Bilbiie 2008): $h_t = k x_t \Rightarrow$ "Super Divine Coincidence" $\Rightarrow$ strict inflation targeting remains optimal
- More generally, trade-off between (i) stabilization of inflation and the output gap vs (ii) stabilization of the consumption gap.

The Optimal Monetary Policy Problem under Discretion

$$\min_{\widehat{r}_t} \pi_t^2 + \vartheta_x x_t^2 + \vartheta_h h_t^2$$

subject to:

$$\pi_t = \beta \mathbb{E}_t\{\pi_{t+1}\} + \kappa x_t \quad (5)$$

$$(1-\lambda) h_t = -\Upsilon_x x_t + \Upsilon_a a_t + \upsilon \beta \widehat{r}_t \quad (6)$$

$$x_t = \mathbb{E}_t\{x_{t+1}\} - \Psi_a a_t + \frac{1-\lambda}{\sigma(1-\lambda\chi^H)} z_t - \Sigma_r \widehat{r}_t + \frac{\lambda \upsilon \beta}{1-\lambda\chi^H} \mathbb{E}_t\{\widehat{r}_{t+1}\} \quad (7)$$

where

$$\Upsilon_x \equiv \chi^H - 1 = (1-\Theta^H)\left(\mathcal{M}^w\left[\sigma(1-\alpha)+1+\varphi\right]-1\right) > 0$$

$$\Upsilon_a \equiv \frac{(1-\Theta^H)[1-\mathcal{M}^w(1-\alpha)](1+\varphi)}{\sigma(1-\alpha)+\alpha+\varphi} > 0$$

$$\Psi_a \equiv (1+\varphi)(1-\rho_a)\left[\frac{1}{\sigma(1-\alpha)+\alpha+\varphi} + \frac{\lambda\mathcal{M}^w(1-\Theta^H)}{1-\lambda\chi^H}\right] > 0$$

$$\Sigma_r \equiv \frac{1}{1-\lambda\chi^H}\left(\lambda\upsilon\beta + \frac{1-\lambda}{\sigma}\right) > 0$$

and taking expectations as well as exogenous variables (a_t, z_t) as given.

- Remark: $\Upsilon_x \equiv \chi^H - 1 > 0$ implies that an increase in output lowers the consumption gap.
- Optimality condition ("optimal targeting rule"):

$$x_t = -\frac{\kappa}{\vartheta_x}\pi_t + \frac{\vartheta_h}{1-\lambda}\left(\frac{\upsilon\beta}{\Sigma_r} + \Upsilon_x\right) h_t \quad (8)$$

- Combined with (5)-(7) yields a system of difference equations for $(x_t, \pi_t, h_t, \widehat{r}_t)$

Equilibrium under the Optimal Policy: Demand Shocks

- Assuming $\rho_z = 0$

$$\widehat{r}_t = \frac{1}{\Delta}\ (1-\lambda)[\vartheta_x + \kappa^2(1-\Psi_h \Upsilon_x)]\ z_t$$

$$\pi_t = \frac{1}{\Delta}\ \upsilon\beta\Psi_h(1-\lambda)\vartheta_x\kappa\ z_t$$

$$h_t = \frac{1}{\Delta}\ \upsilon\beta(1-\Psi_h\Upsilon_x)(\vartheta_x+\kappa^2)\ z_t$$

where

$$\Psi_h \equiv \frac{\vartheta_h\left(\frac{\upsilon\beta}{\Sigma_r}+\Upsilon_x\right)}{(1-\lambda)^2+\vartheta_h\Upsilon_x\left(\frac{\upsilon\beta}{\Sigma_r}+\Upsilon_x\right)} > 0$$

$$\Delta \equiv [\lambda\upsilon\beta\sigma + 1 - \lambda]\,[\vartheta_x + \kappa^2(1-\Psi_h\Upsilon_x)] + \Psi_h\upsilon\beta\vartheta_x\sigma(1-\lambda\chi^H) > 0$$

- Response to a positive demand shock ($z_t > 0$):

(i) If $\lambda = 0 \Rightarrow \vartheta_h = \Psi_h = 0$ $\quad\Rightarrow\quad \pi_t = x_t = 0$ and $\widehat{r}_t = z_t$
(ii) If $\lambda > 0$ and $\upsilon = 0$ $\quad\Rightarrow\quad \pi_t = x_t = 0$ and $\widehat{r}_t = z_t$
(iii) If $\lambda > 0$ and $\vartheta_h = 0$ $\quad\Rightarrow\quad \pi_t = x_t = 0$ and $\widehat{r}_t = \frac{1-\lambda}{\lambda\upsilon\beta\sigma+1-\lambda}\ z_t$
(iv) If $\lambda > 0$, $\vartheta_h > 0$ and $\upsilon > 0$
- increase in consumption gap
- increase in inflation and the output gap (to dampen the increase in the consumption gap)
- increase in $\widehat{r}_t$, but less than z_t (and less than in (iii))

Equilibrium under the Optimal Policy: Technology Shocks

- Assuming $\rho_a = 0$

$$\widehat{r}_t = -\frac{1}{\Delta} \left\{ \Psi_a \sigma (1-\lambda\chi^H)[\vartheta_x + \kappa^2(1-\Psi_h \Upsilon_x)] + \Psi_h \Upsilon_a \vartheta_x \sigma(1-\lambda\chi^H) \right\} a_t \equiv -d_r \ a_t$$

$$\pi_t = \frac{\Psi_h \vartheta_x \kappa \left(\Upsilon_a - d_r \upsilon\beta\right)}{\vartheta_x + \kappa^2(1-\Psi_h \Upsilon_x)} \ a_t \equiv d_\pi \ a_t$$

$$h_t = \frac{\left(\Upsilon_a - \upsilon\beta d_r\right)\left(1-\Psi_h \Upsilon_x\right)(\vartheta_x + \kappa^2)}{(1-\lambda)[\vartheta_x + \kappa^2(1-\Psi_h \Upsilon_x)]} \ a_t$$

- Response to a positive technology shock ($a_t > 0$):

(i) If $\lambda = 0 \Rightarrow \vartheta_h = \Psi_h = 0$ $\quad\Rightarrow\quad \pi_t = x_t = 0$ and $\widehat{r}_t = -\sigma\Psi_a a_t$
(ii) If $\lambda > 0$ and $\vartheta_h = 0$ $\quad\Rightarrow\quad \pi_t = x_t = 0$ and $\widehat{r}_t = -\frac{\sigma\Psi_a}{\lambda\upsilon\beta\sigma + 1 - \lambda} a_t$
(iii) If $\lambda > 0$, $\vartheta_h > 0$
- if $\Upsilon_a - d_r\upsilon\beta > 0$, increase in consumption gap, positive inflation to tame it
- if $\Upsilon_a - d_r\upsilon\beta < 0$ reduction in consumption gap, negative inflation to tame it

Intuition: $a_t > 0$ increases markup and consumption gap, while required lower $\widehat{r}_t$ reduces it.

Concluding Remarks

- Central lesson from HANK literature: heterogeneity activates several channels/mechanisms that are potentially relevant for economic fluctuations

(i) differences in wealth generate differences in MPCs across consumers ⇒ redistribution of resources across consumers affect aggregate demand
(ii) large multiplier effects from high MPCs (hand-to-mouth behavior)
(iii) failure of Ricardian equivalence
(iv) utilitarian policy maker should care about consumption inequality ⇒ impact on optimal policy

- Limitation of existing HANK models: complex, no analytical results, need to draw on numerical solutions
- Standard TANK model: fails to capture some of the channels found in HANK models, limited policy implications.
- The New TANK model (Debortoli-Galí 2024):

- designed to capture the main channels at work in HANK models
- analytically tractable
- non-trivial implications for the optimal design of monetary policy.

- The road ahead: supply-side effects of heterogeneity