Monetary Policy with Supply Regimes

Galo Nuño[1] Simon Scheidegger[2] Philipp Renner[3]

[1]Bank of Spain, CEPR, and CEMFI[1]

[2]Department of Economics, University of Lausanne, and Grantham Institute, London School of Economics

[3]Department of Economics, Lancaster University

IMF

September, 2025

[1]The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the Banco de España, or the Eurosystem.

Introducing supply regimes

→ This paper studies monetary policy in a New Keynesian model with supply regimes, that is, sustained increases in production costs due to:

- Wars.
- Geopolitical fragmentation.
- Tariffs.

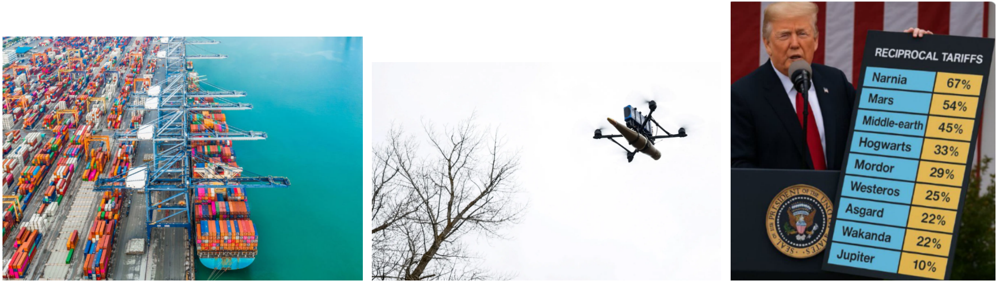


Figure: Examples of supply shocks: COVID, War, Tariffs.

What are the implications for monetary policy?

- We introduce a standard New Keynesian model with temporary shocks and supply regimes.
- Supply regimes are modeled as a Markov chain.
  - Normal and bad times depending on the mean of cost-push shocks.
- We analyze optimal policy under commitment and discretion.
- Technical contribution $\rightarrow$ deep learning-based method to analyze globally optimal policy in Markov switching models.

Supply regimes alter the standard prescriptions

Findings:

1. Regime-switching natural interest rate driven by precautionary savings behavior.
2. Optimal policy under commitment: "bygones are bygones."
3. Optimal monetary policy under discretion displays an inflationary bias in bad times.
4. Traditional Taylor rules fail to stabilize inflation in normal and bad times (not today).

A New Keynesian model with supply regimes

Households

- Households consume goods c_t, and supply labor h_t to firms:

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma} - \frac{h_t^{1+\omega}}{1+\omega} \right],$$

where $c_t = \left[\int_0^1 c_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}$ and subject to:

$$p_t c_t + B_t \leq p_t w_t h_t + (1 + i_t) B_{t-1} + T_t.$$

  - B_t are holdings of a nominal bond.
  - $1 + i_t$ is the nominal interest.
  - w_t is the real wage.
  - p_t is the price level.
  - T_t are the profits from monopolistic producers.

Firms

- Continuum of monopolistic firms with technology

$$y_t\left(j\right) = A_t h_t\left(j\right).$$

  - A_t is the stochastic total factor productivity.

- Firms face temporary ξ_t and persistent η_t cost-push shocks.

- Total costs are $\Psi\left(y_{t+k}(j)\right) \equiv \left(1+\tau_{y+k}\right) w_t \left(\frac{y_{t+k}(j)}{A_t}\right)$ where the labor wedge is

$$\left(1+\tau_t\right) \equiv \left(1-\bar{\tau}+\xi_t+\eta_t\right).$$

  - Labor subsidy $\bar{\tau} = \frac{1}{\epsilon}$.

- We assume price stickiness *à la* Calvo with a parameter θ.
- Firms maximize the stream of expected profits:

$$\max_{P_t^*(j)} \mathbb{E}_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[\frac{P_t^*(j)}{p_{t+k}} y_{t+k}(j) - \Psi\left(y_{t+k}, (j)\right) \right],$$

  - $\Lambda_{t,t+k}$ is the stochastic discount factor.

Market clearing

- Goods:

$$y_t = c_t + g_t.$$

  - Government spending $g_t = \bar{g}\tilde{g}_t$ where $\tilde{g}$ is a shock.

- Price level

$$1 = \theta\left(1+\pi_t\right)^{\epsilon-1} + (1-\theta)\left(\frac{P_t^*}{p_t}\right)^{1-\epsilon}.$$

- Aggregate production

$$y_t = A_t h_t \Delta_t^{-1},$$

  - Price dispersion $\Delta_t \equiv \int \left(\frac{p_t(j)}{p_t}\right)^{-\epsilon} dj = \theta\left(1+\pi_t\right)^{\epsilon}\Delta_{t-1} + (1-\theta)\left(\frac{P_t^*}{p_t}\right)^{-\epsilon}.$

Shocks

- TFP:

$$\log\left(A_t\right) = \left(1-\rho^A\right)\left(-\frac{\left(\sigma^A\right)^2}{2}\right) + \rho^A \log\left(A_{t-1}\right) + \varepsilon_t^A,$$

- Government spending

$$\log\left(\tilde{g}_t\right) = \left(1-\rho^g\right)\left(-\frac{\left(\sigma^g\right)^2}{2}\right) + \rho^g \log\left(\tilde{g}_{t-1}\right) + \varepsilon_t^g,$$

- (Temporary) cost push shock

$$\xi_t = \rho^\tau \xi_{t-1} + \varepsilon_t^\tau,$$

- The permanent cost-push shock follows a two-state Markov chain:
  - Normal times ($\eta_t = 0$) and bad times ($\eta_t = \bar{\eta} = \frac{1}{\varepsilon}$).
  - Transition probabilities $p_{12} = \mathbb{P}\left(\eta_t = \bar{\eta} \mid \eta_{t-1} = 0\right)$ and $p_{21} = \mathbb{P}\left(\eta_t = 0 \mid \eta_{t-1} = \bar{\eta}\right)$.

Summary of the model

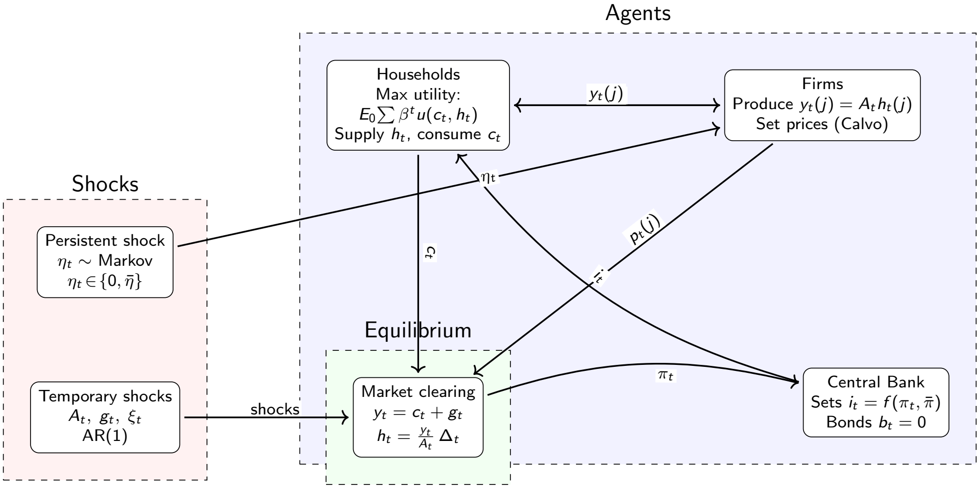


Figure: Schematic of agents, equilibrium conditions, and shocks.

Regime-based natural rates

Efficient allocation

- The allocation produced by a social planner maximizing household welfare subject to technological constraints.
- The efficient allocation equates the MRS between consumption and labor, $\hat{h}_t^{\omega}\hat{c}_t^{\gamma}$, to the marginal rate of transformation, A_t.
- Efficient consumption $\hat{c}_t$ satisfies

$$\left(\frac{\hat{c}_t+\hat{g}_t}{A_t}\right)^{\omega}=A_t\hat{c}_t^{-\gamma}.$$

Flexible-price allocation

- Counterfactual equilibrium with flexible prices, $\theta = 0$.
- Mark-up $\mathcal{M} = \frac{\epsilon}{\epsilon-1}$ now varies with the labor wedge $\mathcal{M}(1+\tau_t) = \mathcal{M}(1-\bar{\tau}+\xi_t+\eta_t)$; this drives regime-dependent natural rates and two distinct stochastic steady states.
- Now consumption satisfies

$$\left(\frac{c_t^* + g_t}{A_t}\right)^{\omega} = \frac{A_t c_t^{*-\gamma}}{\mathcal{M}(1+\tau_t)}. \tag{1}$$

- The cost-push shock affects consumption.

Natural rate

- The natural rate is the real interest rate in the stochastic steady state of the flex-price economy

$$1 = \beta E_t \left[\frac{{c_t^*}^\gamma}{{c_{t+1}^*}^\gamma} \right] (1 + r_t^*) \, .$$

- If the economy is in regime 1, this equation implies

$$\frac{1}{\beta (1 + r_t^*)} = {c_{1,t}^*}^\gamma \left(p_{12} E_t \left[\frac{1}{{c_{2,t}^*}^\gamma} \right] + (1 - p_{12}) \, E_t \left[\frac{1}{{c_{1,t}^*}^\gamma} \right] \right) ,$$

where the notation $z_{n,t}$ denotes variable z at time t and regime $n = \{1, 2\}$.

Calibration and solution method

Calibration

Parameter		Value
Long-run productivity level	A	1
Inverse Frisch elasticity	ω	1
Inverse of intertemporal elasticity of substitution	γ	2
Discount factor	β	0.9975
Elasticity of substitution among varieties	ϵ	7
Government spending constant	$\bar{g}$	0.2
Calvo constant	θ	0.75
Taylor rule slope	ψ	2
Inflation target	$\bar{\pi}$	0
Labor subsidy	$\bar{\tau}$	$\frac{1}{\epsilon}$

Table: Key parameters of the model I.

Parameter		Value
Mean of cost-push shock during persistent supply shock	$\bar{\eta}$	$\frac{1}{\varepsilon}$
Transition probability from normal to negative supply times	p_{12}	$1/48$
Transition probability from negative supply to normal times	p_{21}	$1/24$
Persistence of TFP shock	ρ^A	0.99
Persistence of cost-push shock	ρ^τ	0.90
Persistence of government spending shock	ρ^g	0.97
Standard deviation of TFP shock	σ^A	0.009
Standard deviation of cost-push shock	σ^τ	0.0014
Standard deviation of government spending shock	σ^g	0.0052

Table: Key parameters of the model II.

Deep equilibrium nets

- A global solution to our model is crucial .
- Dimensionality is too high for standard methods.
- We extend the Deep equilibrium method of Azinovic et al. (2022).

Optimal monetary policy

Optimal policy under discretion

The central Bank maximizes household welfare under discretion (i.e., cannot commit to future policy paths).

$$V\left(\Delta_{t-1}, A_t, \tau_t, g_t, n_t\right) = \max_{c_t, h_t, w_t, \pi_t, p_t^*, \Delta_t} \frac{c_t^{1-\gamma}}{1-\gamma} - \frac{h_t^{1+\omega}}{1+\omega} + \beta \mathbb{E}_t\left[V\left(\Delta_t, A_{t+1}, \tau_{t+1}, g_{t+1}\right)\right]$$

subject to the equilibrium conditions:

$$c_t^{-\gamma} = h_t^{\omega} / w_t, \tag{2}$$

$$1 = \theta\left(1+\pi_t\right)^{\epsilon-1} + (1-\theta)\left(p_t^*\right)^{1-\epsilon}, \tag{3}$$

$$\Delta_t = \theta\left(1+\pi_t\right)^{\epsilon} \Delta_{t-1} + (1-\theta)\left(p_t^*\right)^{-\epsilon}, \tag{4}$$

$$y_t = A_t h_t \left(\Delta_t\right)^{-1}, \tag{5}$$

$$y_t = c_t + g_t. \tag{6}$$

$$p_t^* = \mathcal{M} \frac{y_t w_t \left(1+\tau_t\right)\left(A_t\right)^{-1} + \mathbb{E}_t\left[\theta \Lambda_{t,t+1}\left(1+\pi_{t+1}\right)^{\epsilon} \Xi_{t+1}^N\right]}{y_t + \mathbb{E}_t\left[\theta \Lambda_{t,t+1}\left(1+\pi_{t+1}\right)^{\epsilon-1} \Xi_{t+1}^D\right]}. \tag{7}$$

Optimal policy under commitment

The central bank maximizes household welfare under commitment (i.e., Ramsey problem).

$$\max_{\{c_t, h_t, w_t, \pi_t, p_t^*, \Delta_t\}_{t\geq 0}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\gamma}}{1-\gamma} - \frac{\left(\frac{(c_t+g_t)\Delta_t}{A_t} \right)^{1+\omega}}{1+\omega} \right],$$

subject to the equilibrium conditions (2)-(6) and the constraints:

$$\begin{aligned}
p_t^* \Xi_t^D &= \mathcal{M} \Xi_t^N, \\
\Xi_t^N &= (c_t + g_t)^{1+\omega} \left(\frac{\Delta_t}{A_t} \right)^{\omega} c_t^{\gamma} (1+\tau_t) (A_t)^{-1} + \mathbb{E}_t \left[\beta\theta c_t^{\gamma} c_{t+1}^{-\gamma} (1+\pi_{t+1})^{\epsilon} \Xi_{t+1}^N \right], \\
\Xi_t^D &= (c_t + g_t) + \mathbb{E}_t \left[\beta\theta c_t^{\gamma} c_{t+1}^{-\gamma} (1+\pi_{t+1})^{\epsilon-1} \Xi_{t+1}^D \right].
\end{aligned}$$

Ergodic distribution: Commitment

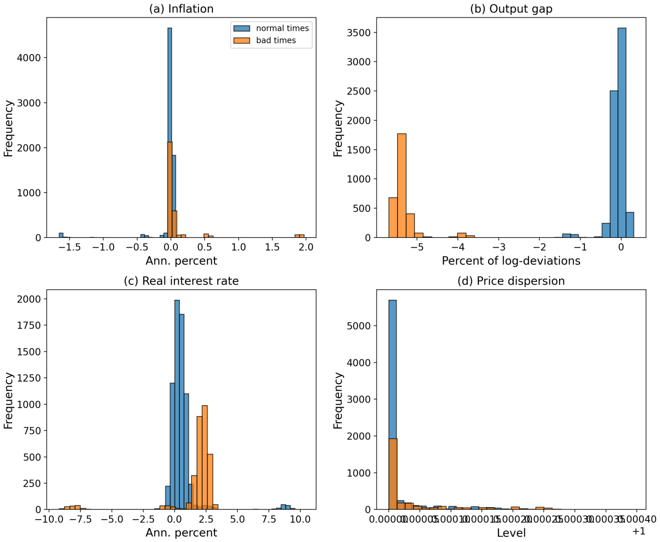


Figure: Ergodic distribution: commitment.

Ergodic distribution: Discretion

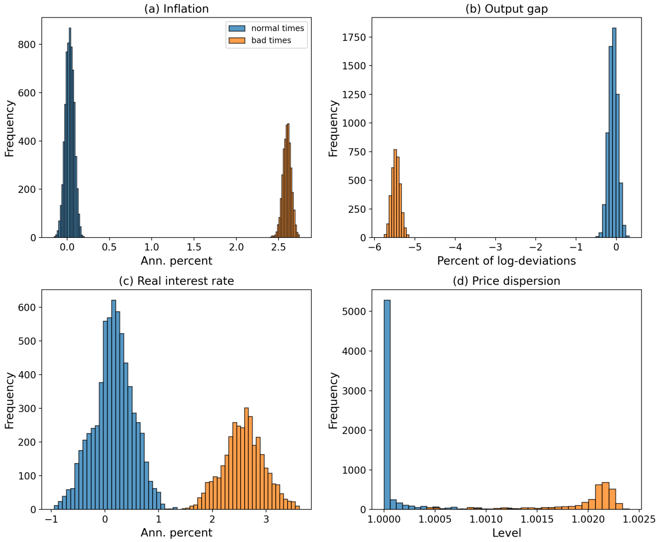


Figure: Ergodic distribution: discretion.

Regime switch: commitment vs. discretion

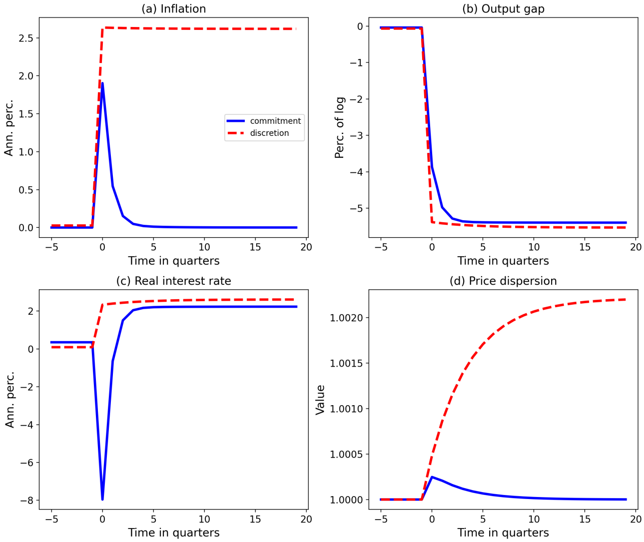


Figure: Response to a regime change.

Note: solid blue = commitment; dashed red = discretion.

Bygones are bygones

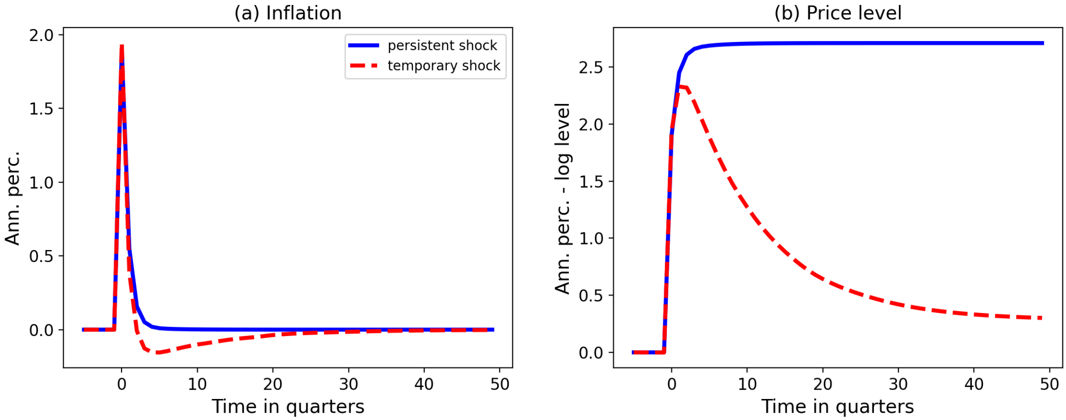


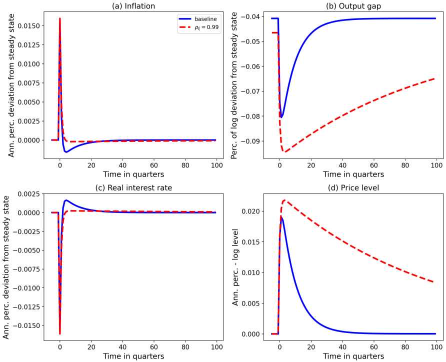
Figure: Comparison between a persistent (Markov switching) and temporary shocks.
Note: Transition from a normal times regime to a bad times regime in the case of the optimal policy under commitment in the baseline (solid blue line) and a temporary cost-push shock calibrated to produce the same level of inflation on impact as the permanent shock (dashed red line).

Intuition from LQ (local) model

- Optimal response under commitment is given by:

$$\pi_t = -\frac{1}{\epsilon}\left(x_t - x_{t-1}\right).$$

- In the limit, x_t jumps down on impact by $-\Delta$ and then remains constant, which implies that inflation increases on impact $\frac{\Delta}{\epsilon}$ and then remains constant at zero.



Note: solid blue $=\rho^{\tau} = 0.90$; dashed red $=\rho^{\tau} = 0.99$.

Are regimes necessary?

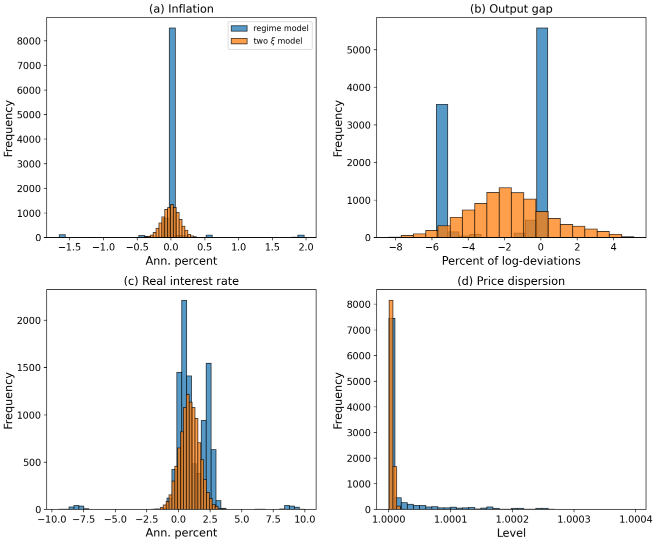


Figure: Histograms of two temporary $(1 - \bar{\tau} + \xi_1 + \xi_2)$ autoregressive shocks (orange) calibrated to match expectation and variance of the Markov shock, compared to the baseline model (blue).

Questions?