Monetary Policy under Uncertain Expectations in an Emerging Economy

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Korean Society for Macroeconomic Dynamics
June 5, 2026

Motivation

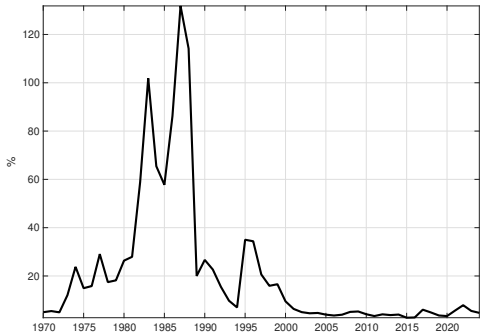
- Anchoring inflation expectations is a core task of monetary policy
- Emerging economies (EMEs) face this challenge with high-inflation legacies and post-crisis regime shifts
  (Mexico 1994, Thailand 1997, Russia 1998, Brazil 1999, Argentina 2002)
- Even after credibility-enhancing reforms, an EME central bank may not be fully confident that private expectations have adjusted to the new regime
- Empirically, IT central banks with high-inflation legacies respond more aggressively to inflation expectation gaps — even as credibility improves (Jacome et al. 2025)
- $\Rightarrow$ How should monetary policy be conducted when the central bank is uncertain about how private-sector expectations form?

This Paper

- Explain monetary policy in an EME during regime transition through the lens of robustly optimal monetary policy under uncertain private-sector expectations
- **Framework:** Small open economy New Keynesian (SOE-NK) model with a hybrid Phillips curve
- **Expectations:** Private agents may form near-rational expectations (NRE) — perturbations of rational expectations (RE) à la Woodford (2010)
- **Central-bank (CB) uncertainty:** The CB treats this perturbation as ambiguous (Knightian; Gilboa and Schmeidler, 1989), formalized by multiplier preferences (Hansen and Sargent, 2001, 2012)
- Estimate the model using Mexican data (1998:I-2007:IV); out-of-sample policy-rate validation; mechanism decomposition via RE benchmark and RE-counterfactual (RC)

Mexico as a Canonical Case Study

Annual Inflation Rate, Mexico: 1970–2024



Source: IMF IFS.

- Prolonged high inflation from the 1970s through the mid-1990s — peaking at 131.8% in 1987
- 1994 Peso Crisis forced abandonment of the exchange-rate band, triggering a regime shift built on the 1993 central-bank-independence reform
- **Post-crisis transition:** shift to monetary dominance and inflation targeting in 2001 (Meza, 2019) — the regime transition our framework studies

Main Findings

1. **Strong concern for robustness.** The NRE estimation yields a large posterior estimate for degree of concern for robustness, implying substantial ambiguity aversion about private-sector expectations

2. **External validation.** The NRE model matches Mexico's actual policy-rate dynamics: 63% RMSE reduction relative to the RE benchmark

3. **Mechanism.** Three coordinated signatures, all of which arise from the robustness channel:
   - hawkish inflation stabilization *(level)*
   - endogenous inflation persistence without backward-looking price-setting *(dynamics)*
   - cost-push attribution of inflation & depreciation fluctuations *(common driver)*

Related Literature

- **This paper.** The first quantitative analysis of robustly optimal monetary policy under *Type III ambiguity* (Hansen and Sargent, 2012) in a small open economy — applied to a regime transition in an EME

- **Robust optimal policy by ambiguity type:**

  - *Ambiguity about the model/shocks* (Types 0–II): Walsh (2004), Hansen and Sargent (2001, 2008), Leitemo and Söderström (2008a,b), Dennis et al. (2009), Dennis (2010), Levine and Pearlman (2010), Karantounias (2013, 2023)
  - Ambiguity about private beliefs (Type III): Woodford (2010), Adam and Woodford (2012, 2021), Kwon and Miao (2019) — *this paper extends to SOE and provides first empirical implementation*

- **Belief distortions in dynamic macro models:** Ilut and Schneider (2014), Gust et al. (2020), Bhandari et al. (2023), L'Huillier et al. (2023), Bianchi et al. (2023), Na and Xie (2025), Na and Yoo (2025)

- **SOE / EME monetary policy:** Gali and Monacelli (2005), Na et al. (2018), Devereux et al. (2019), Meza (2019), Jacome et al. (2025)

Roadmap

1. **The Model** — Robustly optimal monetary policy in a SOE-NK framework under private agents' NRE
2. **Estimation & Validation** — Bayesian estimation on Mexican data; out-of-sample policy-rate forecast
3. **Inspecting the Mechanism** — The role of robustness

The Model

SOE-NK (Aggregate Demand)

- Aggregate demand

$$x_t = \hat{\mathbb{E}}_t x_{t+1} - \frac{1}{\tau}\left(i_t - \hat{\mathbb{E}}_t \pi_{H,t+1} - \bar{rr}_t\right),$$

  where x_t: output gap; $\pi_{H,t}$: domestic inflation; i_t: nominal interest rate; $\bar{rr}_t$: natural real interest rate

- $\hat{\mathbb{E}}_t[\,\cdot\,]$ denotes private agents' *potentially distorted* expectations under near-rational expectations (NRE)

SOE-NK (Aggregate Supply, Open-Economy Links)

- Aggregate supply (hybrid NKPC with backward-looking firms):

$$\pi_{H,t} = \tilde{\beta}\,\hat{\mathbb{E}}_t \pi_{H,t+1} + \eta \pi_{H,t-1} + \kappa x_t + u_t$$

where $\tilde{\beta}, \eta, \kappa$ depend on $\delta \in [0,1]$ (fraction of backward-looking pricing; $\delta = 0$ purely forward-looking, $\delta = 1$ purely backward-looking)
u_t: cost-push shock

- Open-economy links: terms of trade (ToT) s_t and nominal depreciation Δe_t:

$$\begin{aligned} s_t &= \tau(x_t + \tilde{y}_t - y_t^*) && \text{(risk sharing)} \\ \Delta e_t &= \pi_{H,t} + \Delta s_t - \pi_t^* && \text{(identity)} \end{aligned}$$

where $\tilde{y}_t$: flex-price output; y_t^*, π_t^*: foreign output and inflation

Shock Processes

- Three structural shocks follow AR(1) processes:

$$\begin{aligned} u_{t+1} &= \rho_u u_t + \sigma_u \varepsilon^u_{t+1} && \text{(cost-push)} \\ a_{t+1} &= \rho_a a_t + \sigma_a \varepsilon^a_{t+1} && \text{(productivity)} \\ y^*_{t+1} &= \rho_{y^*} y^*_t + \sigma_{y^*} \varepsilon^{y^*}_{t+1} && \text{(world output)} \end{aligned}$$

  with $\varepsilon^i_{t+1} \sim \mathcal{N}(0,1)$, $i \in \{u, a, y^*\}$, mutually independent and i.i.d. over time

- Productivity and world output shocks enter the natural real rate:

$$\bar{rr}_t = \bar{r} + \Lambda_{r,a}\, a_t + \Lambda_{r,y^*}\, y^*_t$$

  where $\bar{r}$: steady-state real rate; $\Lambda_{r,a}, \Lambda_{r,y^*}$: loadings derived from preferences and technology

Belief Distortion and Relative Entropy

- Setup (Hansen and Sargent, 2008): uncertainty driven by $\boldsymbol{\varepsilon}_t \equiv [\varepsilon_t^u, \varepsilon_t^a, \varepsilon_t^{y^*}]'$, history $\boldsymbol{\varepsilon}^t$; reference measure $\mathcal{P}$ (RE), distorted measure $\hat{\mathcal{P}}$ (NRE); $\hat{\mathcal{P}} \ll \mathcal{P}$.
- Likelihood ratio (Radon-Nikodym derivative):

$$m_{t+1} = \frac{\hat{p}(\boldsymbol{\varepsilon}_{t+1} \mid \boldsymbol{\varepsilon}^t)}{p(\boldsymbol{\varepsilon})}, \qquad \mathbb{E}_t[m_{t+1}] = 1$$

- Distorted expectation:

$$\hat{\mathbb{E}}_t X_{t+1} = \mathbb{E}_t[m_{t+1} X_{t+1}]$$

- Relative entropy (KL divergence) — measures distance $\hat{\mathcal{P}}$ from $\mathcal{P}$:

$$\mathcal{R}_t \equiv \mathbb{E}_t[m_{t+1} \ln m_{t+1}] \geq 0$$

Robustly Optimal Monetary Policy (Min-Max)

- **Paternalistic welfare** (Woodford, 2010): the central bank evaluates welfare under its own reference measure $\mathcal{P}$, even though private agents form expectations under $\hat{\mathcal{P}}$

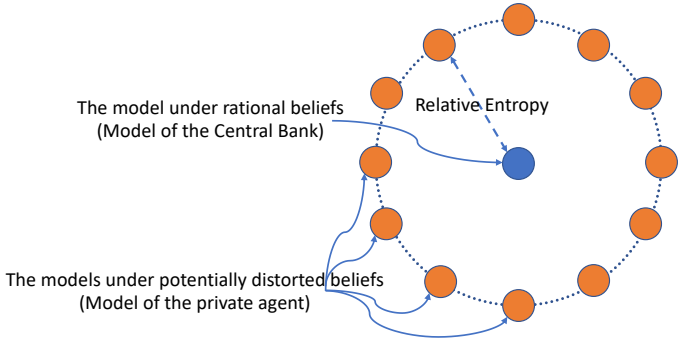
Definition (Robustly Optimal Monetary Policy)

$$\min_{\{\pi_{H,t},x_t,i_t\}} \max_{\{m_{t+1}\}} \underbrace{\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left(\pi_{H,t}^2 + \lambda_x \left(x_t - \bar{x} \right)^2 \right)}_{\text{welfare loss under RE}} - \underbrace{\theta \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t m_{t+1} \ln m_{t+1}}_{\text{concern for robustness}}$$

subject to equilibrium conditions and $\mathbb{E}_t[m_{t+1}] = 1$; $\bar{x}$ is the target output gap

- θ: penalty on belief distortions; *smaller* $\theta \Rightarrow$ *stronger* concern for robustness
  $\theta \to \infty$: RE benchmark

Entropy Diagram: Set of Admissible Beliefs under Type III Ambiguity



- Entropy ball: admissible distorted beliefs $\hat{\mathcal{P}}$ within a relative-entropy budget around the reference $\mathcal{P}$ (radius $\propto 1/\theta$)
- Worst-case: the belief on the boundary that *maximizes the planner's loss* — the most damaging belief the central bank (CB) guards against
- Smaller $\theta \Rightarrow$ larger ball $\Rightarrow$ broader range of distortions considered

The Robust Optimal Policy Problem: What is Going on?

- *(next 3 slides):* simple closed-economy NKPC to build intuition
- Robustly optimal monetary policy problem:

$$\min_{x_t,\pi_t} \max_{m_{t+1}\geq 0} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \tfrac{1}{2}\big(\pi_t^2 + \lambda(x_t - x^*)^2\big) - \theta\, \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t\, m_{t+1} \ln m_{t+1}$$

  subject to $\pi_t = \kappa x_t + \beta\, \mathbb{E}_t m_{t+1}\pi_{t+1} + u_t,\ \ \mathbb{E}_t m_{t+1} = 1$

- Nature's best response (worst-case beliefs):

$$m_{t+1}^* = \frac{\exp\big(\beta\mu_t\pi_{t+1}/\theta\big)}{\mathbb{E}_t\big[\exp\big(\beta\mu_t\pi_{t+1}/\theta\big)\big]} \quad \text{(exponential tilting of } \pi_{t+1}\text{)}$$

  where μ_t = Lagrange multiplier on the NKPC

Worst-Case Beliefs *Tighten* the Constraint

- Recall worst-case (prev. slide):

$$m^*_{t+1} = \frac{\exp\big(\beta\mu_t\pi_{t+1}/\theta\big)}{\mathbb{E}_t\big[\exp\big(\beta\mu_t\pi_{t+1}/\theta\big)\big]}$$

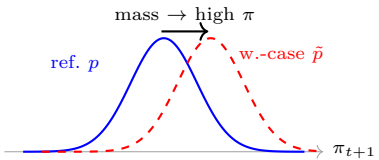
- FOC w.r.t. x_t:

$$-\lambda(x_t - x^*) = \kappa\mu_t \;\Rightarrow\; \mu_t > 0 \iff x_t < x^*$$

- FOC w.r.t. π_t:

$$\pi_t - \mu_t + m^*_t\,\mu_{t-1} = 0$$

- Either way, the worst-case moves the intercept $\beta\,\mathbb{E}_t m\,\pi_{t+1}$ in the direction the planner would *not* want $\Rightarrow$ a less favorable inflation–output trade-off



Case $\mu_t > 0$ (fighting inflation, $x_t < x^*$): nature shifts probability mass toward high inflation, pushing the intercept up — exactly the direction the planner did *not* want.

Robustly Optimal Policy Response

- Whatever pressure the economy faces, worst-case expectations amplify it. With $\mu_{-1} = 0$, the impact period gives $\mu_0 = \pi_0$:
  - positive cost-push $\Rightarrow \pi_0 > 0,\ \mu_0 > 0$ (fighting inflation) $\Rightarrow$ worst case: expectations drift up
  - negative cost-push $\Rightarrow \pi_0 < 0,\ \mu_0 < 0$ (fighting deflation) $\Rightarrow$ worst case: expectations drift down
- The distortion's bite grows with inflation *volatility* $\left(m^* \propto e^{\beta \mu_t \pi_{t+1}/\theta}\right)$: more inflation variability $\Rightarrow$ more room for nature to distort beliefs damagingly
- Implications: Hawkishness + Amplified history dependence
  - hawkishness: stabilize inflation more aggressively — this denies nature the room to create harmful expectation distortions
  - history dependence: the m_t^* factor on μ_{t-1} in $\pi_t - \mu_t + m_t^* \mu_{t-1} = 0$ amplifies the history dependence $\Rightarrow$ stronger endogenous inflation persistence

Commitment in a Timeless Perspective

- m^* is nonlinear in endogenous variables $\Rightarrow$ no closed-form solution
- Follow Woodford (2010): restrict to conditionally-linear policies, then impose self-consistency
- Initial commitment (linear form):

$$\begin{bmatrix} \pi_{H,0} \\ x_0 \end{bmatrix} = \mathbf{\Phi}_{-1} + \mathbf{\Gamma}_{-1}\boldsymbol{\varepsilon}_0$$

- Conditionally-linear rule for $t \geq 0$:

$$\begin{bmatrix} \pi_{H,t+1} \\ x_{t+1} \end{bmatrix} = \mathbf{\Phi}_t + \mathbf{\Gamma}_t\boldsymbol{\varepsilon}_{t+1}$$

- Self-consistency (the *timeless* part):

$$\mathbf{\Phi}_{-1} \overset{d}{=} \mathbf{\Phi}_t \text{ (equal in distribution)}, \qquad \mathbf{\Gamma}_{-1} = \mathbf{\Gamma}_t \equiv \mathbf{\Gamma}$$

- $\Rightarrow$ Time-invariant linear policy under self-consistent commitment

Solution Method: Linear State Space (Kwon and Miao, 2019)

- Linearized equilibrium system:

$$\begin{bmatrix} \boldsymbol{X}_{t+1} \\ \hat{\mathbb{E}}_t \boldsymbol{Y}_{t+1} \end{bmatrix} = \boldsymbol{A} \begin{bmatrix} \boldsymbol{X}_t \\ \boldsymbol{Y}_t \end{bmatrix} + \boldsymbol{B} i_t + \boldsymbol{C} \boldsymbol{\varepsilon}_{t+1}$$

  where $\boldsymbol{X}_t \equiv [1, \pi_{H,t-1}, u_t, a_t, y_t^*]'$, $\boldsymbol{Y}_t \equiv [\pi_{H,t}, x_t]'$

- State-space law of motion:

$$\begin{bmatrix} \boldsymbol{\varepsilon}_{t+1} \\ \boldsymbol{X}_{t+1} \\ \boldsymbol{\Phi}_t \end{bmatrix} = \boldsymbol{H} \begin{bmatrix} \boldsymbol{\varepsilon}_t \\ \boldsymbol{X}_t \\ \boldsymbol{\Phi}_{t-1} \end{bmatrix} + \begin{bmatrix} \boldsymbol{I} \\ \boldsymbol{C}_X \\ \boldsymbol{0} \end{bmatrix} \boldsymbol{\varepsilon}_{t+1}$$

- Policy rules:

$$\begin{bmatrix} i_t \\ \boldsymbol{\mu}_{Y,t} \\ \boldsymbol{\mu}_{X,t} \\ \mathbb{E}_t \boldsymbol{\mu}_{X,t+1} \end{bmatrix} = \boldsymbol{G} \begin{bmatrix} \boldsymbol{\varepsilon}_t \\ \boldsymbol{X}_t \\ \boldsymbol{\Phi}_{t-1} \end{bmatrix}$$

  where $\boldsymbol{\mu}_{X,t}, \boldsymbol{\mu}_{Y,t}$ are Lagrange multipliers in the CB's problem

- $\boldsymbol{\Gamma}$ is solved as a self-consistent fixed point via iteration over the planner's FOCs

Worst-case Beliefs and Relative Entropy

- Reparameterization: use $\tilde{\theta} \equiv 1/\theta$
  - *higher* $\tilde{\theta} \Rightarrow$ *stronger* concern for robustness
  - $\tilde{\theta} = 0$: RE benchmark; $\tilde{\theta} \to \infty$: maximal robustness
  - this is the parameterization used in estimation

- Worst-case belief distortion measure:

$$m_{t+1} = \exp\left(-\tfrac{1}{2}\tilde{\theta}^2 \boldsymbol{\mu}'_{Y,t}\boldsymbol{\Gamma}\boldsymbol{\Gamma}'\boldsymbol{\mu}_{Y,t} + \tilde{\theta}\,\boldsymbol{\mu}'_{Y,t}\boldsymbol{\Gamma}\,\boldsymbol{\varepsilon}_{t+1}\right)$$

- Distorted mean of forward-looking variables:

$$\mathbb{E}_t[m_{t+1}\boldsymbol{Y}_{t+1}] = \boldsymbol{\Phi}_t + \tilde{\theta}\,\boldsymbol{\Gamma}\boldsymbol{\Gamma}'\boldsymbol{\mu}_{Y,t}$$

- Relative entropy:

$$\mathbb{E}_t[m_{t+1}\ln m_{t+1}] = \tfrac{1}{2}\tilde{\theta}^2 \boldsymbol{\mu}'_{Y,t}\boldsymbol{\Gamma}\boldsymbol{\Gamma}'\boldsymbol{\mu}_{Y,t}$$

Estimation & Validation

Estimation

- Observables: 1998Q1–2007Q4
  - CPI inflation π_t
  - nominal exchange-rate depreciation vis-à-vis USD: Δe_t
- Policy rate is *not* used for estimation; used for external validity check
- Bayesian estimation of $\mathbf{\Theta} = [\tilde{\theta}, \delta, \omega, \varphi, \rho_u, \sigma_u, \rho_a, \sigma_a]'$ and measurement-error s.d.'s
- Random-walk Metropolis–Hastings: 1 million MCMC draws, 25% acceptance rate

Estimation: Linear State Space (Measurement/Transition)

- Measurement equation:

$$\begin{bmatrix} \pi_t \\ \Delta e_t \end{bmatrix} = \tilde{\boldsymbol{G}} \begin{bmatrix} \boldsymbol{\xi}_t \\ \boldsymbol{\xi}_{t-1} \end{bmatrix} + \begin{bmatrix} \sigma_{\pi}^{me} & 0 \\ 0 & \sigma_{\Delta e}^{me} \end{bmatrix} \begin{bmatrix} \epsilon_t^{me,\pi} \\ \epsilon_t^{me,\Delta e} \end{bmatrix}$$

- Transition equation:

$$\begin{bmatrix} \boldsymbol{\xi}_{t+1} \\ \boldsymbol{\xi}_t \end{bmatrix} = \tilde{\boldsymbol{H}} \begin{bmatrix} \boldsymbol{\xi}_t \\ \boldsymbol{\xi}_{t-1} \end{bmatrix} + \boldsymbol{\nu}_{t+1}$$

- State vector $\boldsymbol{\xi}_t = [\boldsymbol{\varepsilon}_t', \boldsymbol{X}_t', \boldsymbol{\Phi}_{t-1}']'$ — innovations, predetermined states, lagged policy parameters
- Likelihood evaluated via Kalman filter; Posterior via RW-MH sampler

Why Does the SOE Structure Identify $\tilde{\theta}$?

- In our SOE with complete markets, Δe_t carries essentially the similar information as the open-economy output gap (via the risk-sharing condition + depreciation identity)
- Observing Δe_t allows the aggregate-demand equation to bind estimation alongside the aggregate-supply (NKPC)
- For closed-economy estimation (only π_t): only NKPC binds; Euler is not identified; *both* NRE and RE fail to track the actual policy rate
- For SOE estimation (π_t and Δe_t): both equations bind; $\tilde{\theta}$ identified via forward-looking expectations on *both*
- Openness contributes empirically by allowing both equilibrium equations to constrain $\tilde{\theta}$ — not through a new robust-policy mechanism

Pre-Set Parameters

Parameter	Description	Value
σ	IES	1
ζ	Calvo-Yun price stickiness	0.75
ρ_{y^*}	Persistence (world output)	0.84
$\sigma_{y^*} \times 100$	s.d. (world output)	0.45
β	Quarterly discount factor	0.975
α	1-Home bias (import share)	0.279

Prior Distributions

Parameter	Description	Support	Distribution	Para(1)	Para(2)	[mean, std]
$\tilde{\theta}$	Robustness	$[0, 10^4]$	Uniform	0	10^4	$[5\times10^3, 2.88\times10^3]$
δ	Backward-looking	$[0, 1]$	Beta	2.0	3.0	[0.4, 0.2]
ω	Expenditure swit.	$\mathbb{R}^+$	Gamma	2.0	2.0	[4.0, 2.82]
φ	Inverse Frisch	$\mathbb{R}^+$	Gamma	2.0	2.0	[4.0, 2.82]
ρ_u	Persistence (cost-push)	$[0, 1)$	Beta	2.0	3.0	[0.4, 0.2]
ρ_a	Persistence (TFP)	$[0, 1)$	Beta	2.0	3.0	[0.4, 0.2]
$\sigma_u\times100$	s.d. (cost-push)	$\mathbb{R}^+$	Gamma	0.25	2.0	[0.5, 1.0]
$\sigma_a\times100$	s.d. (TFP)	$\mathbb{R}^+$	Gamma	0.25	2.0	[0.5, 1.0]

Posterior Distributions

	NRE		RE		NRE_0		RE_0	
Parameters	Mean	[5%, 95%]	Mean	[5%, 95%]	Mean	[5%, 95%]	Mean	[5%, 95%]
$\tilde{\theta}$	**1807**	[896, 3190]	–	–	**1594**	[831, 2708]	–	–
δ	0.10	[0.023, 0.21]	0.49	[0.14, 0.78]	–	–	–	–
ω	8.27	[6.16, 11.3]	4.31	[1.17, 7.62]	8.11	[5.99, 11.1]	6.47	[4.46, 9.14]
φ	1.97	[0.48, 4.80]	2.95	[0.33, 7.94]	1.35	[0.31, 3.44]	0.66	[0.10, 1.68]
ρ_u	0.32	[0.09, 0.59]	0.60	[0.12, 0.92]	0.38	[0.15, 0.62]	0.86	[0.75, 0.95]
σ_u	0.030	[0.016, 0.057]	0.013	[0.008, 0.023]	0.029	[0.016, 0.056]	0.013	[0.008, 0.022]
ρ_a	0.88	[0.77, 0.96]	0.88	[0.78, 0.96]	0.88	[0.77, 0.96]	0.87	[0.73, 0.96]
σ_a	0.031	[0.018, 0.049]	0.044	[0.027, 0.066]	0.027	[0.015, 0.044]	0.043	[0.029, 0.064]
Log MDD	**209.57**		192.07		**212.82**		192.00	

NRE: baseline; RE: imposes $\tilde{\theta}=0$; NRE_0, RE_0: same with $\delta=0$ (no backward-looking pricing).

- **Substantial concern for robustness**: posterior $\tilde{\theta}_{\text{NRE}} = 1807$ (CI $[896, 3190]$); bounded away from RE ($\tilde{\theta} = 0$); same for NRE_0
- **Strong in-sample fit**: NRE has higher log MDD than RE (209.57 vs. 192.07); gap strengthens when backward-looking pricing is removed

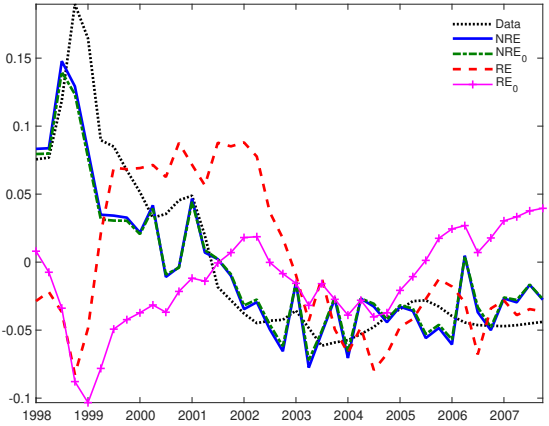
Implied Parameters Shaping Aggregate Demand/Supply

- Derived from estimated deep parameters $(\delta, \omega, \varphi)$:

	NRE	RE	NRE_0	RE_0
η *(backward weight)*	0.11	0.38	0	0
$\tilde{\beta}$ *(effective discount)*	0.86	0.60	0.975	0.975
κ *(NKPC slope)*	0.16	0.08	0.15	0.09
τ *(inverse IS slope)*	0.36	0.60	0.37	0.43

- NRE implies a much more forward-looking aggregate supply (η low, $\tilde{\beta}$ high) — robustness substitutes for backward-looking pricing
- NRE also delivers a steeper aggregate supply (κ twice as large) — inflation more responsive to output gap fluctuations

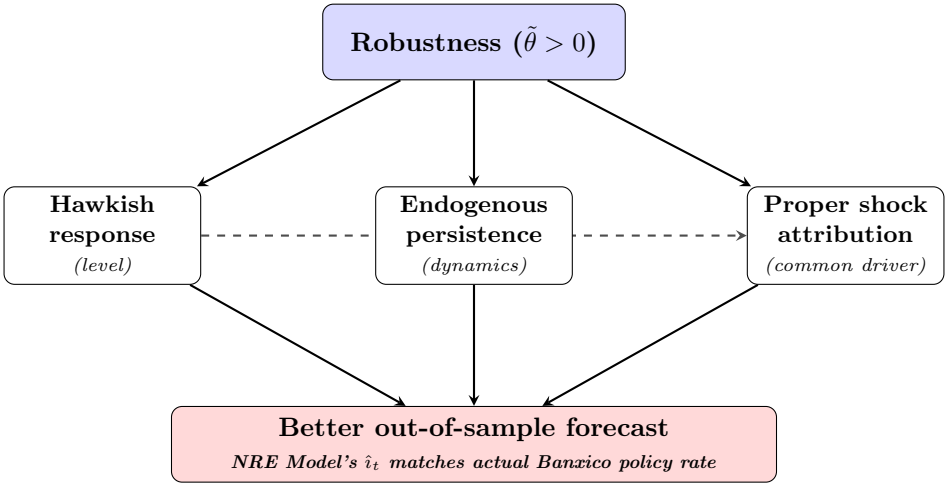
Model-Predicted Monetary Policy Rates



- **RMSE:** NRE 0.0295 vs RE 0.0788 $\Rightarrow$ 63% reduction; NRE_0 0.0301 vs RE_0 0.0910 $\Rightarrow$ 67% reduction
- NRE captures the level, persistence, and timing of Mexico's actual policy rate; RE does not

Inspecting the Mechanism

Inspecting the Mechanism: Overview



Inspecting the Mechanism: Normative Structure

Lemma

For *any* $\tilde{\theta} \in \mathbb{R}_+$, the robustly optimal policy achieves zero domestic inflation and zero output gap in response to TFP shocks a_t and world-output shocks y_t^*:

$$\Gamma_{\pi_H,a} = \Gamma_{x,a} = \Gamma_{\pi_H,y^*} = \Gamma_{x,y^*} = 0$$

- Divine coincidence: TFP/world shocks are fully offset by optimal policy — no inflation–output trade-off
- Cost-push is the only shock that drives $(\pi_{H,t}, x_t)$ under optimal policy
- Yet, TFP/world shocks still affect terms-of-trade, exchange rate, and policy rate — this is why the exchange rate observable identifies $\tilde{\theta}$

Optimal Policy Coefficients

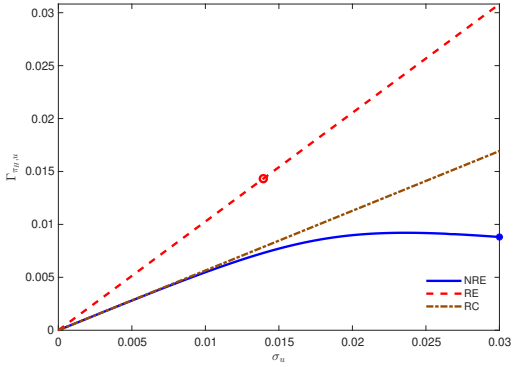
- Following the Lemma, the only nonzero policy coefficients are responses to cost-push shocks:

	NRE	RE	NRE_0	RE_0
$\Gamma_{\pi_H,u}$ *(inflation response)*	0.0088	0.0143	0.0087	0.0141
$\Gamma_{x,u}$ *(output gap response)*	-0.1152	-0.0493	-0.1138	-0.0541

- Under NRE, the central bank is more hawkish: $\sim$40% smaller inflation response, $\sim$2.3$\times$ larger output-gap tolerance
- Exchange-rate amplification: since $\Delta e_t = \pi_{H,t} + \tau \Delta x_t - \pi_t^*$, the larger $|\Gamma_{x,u}|$ directly amplifies the exchange-rate response to cost-push shocks
- Same pattern in NRE_0 vs RE_0 — the contrast is *not* driven by backward-looking pricing

Certainty Equivalence vs. Robustness

Optimal Policy Coefficient $\Gamma_{\pi_H,u}$



RE-counterfactual (RC): holds NRE-estimated parameters fixed but imposes $\tilde{\theta} = 0$

- RE (certainty equivalence): policy coefficient $\Gamma_{\pi_H,u}$ is proportional to σ_u
- NRE (robustness): $\Gamma_{\pi_H,u}$ is *concave* w.r.t. σ_u — larger shocks $\Rightarrow$ more hawkish

Endogenous Inflation Persistence

Proposition

Let $\delta = 0$ (no backward-looking pricing). In equilibrium with robustly optimal policy, domestic inflation satisfies

$$\pi_{H,t} = \rho_{\pi_H}\, \pi_{H,t-1} + \Gamma_{\pi_H,u}\, \varepsilon^u_t - \rho_{\pi_H}(1-\rho_u)\sigma_u \sum_{j=0}^{\infty} \rho_u^j\, \varepsilon^u_{t-j-1},$$

where $\rho_{\pi_H} \in (0,1)$ *increases* as $\tilde{\theta}$ increases.

- Higher $\tilde{\theta} \Rightarrow$ stronger $\rho_{\pi_H} \Rightarrow$ greater history dependence and endogenous inflation inertia
- Robustness alone (no indexation) generates persistence

Second Moments: Data and Models

Moments	Data	**NRE**	RE	NRE_0	RE_0
$\sigma(\pi_t)$	1.09	0.81	1.23	0.83	1.22
$\sigma(\Delta e_t)$	3.12	3.30	3.10	3.28	2.94
$\rho(\pi_t, \Delta e_t)$	0.28	0.23	0.31	0.26	0.39
$\rho(\pi_t, \pi_{t-1})$	**0.92**	**0.65**	0.37	0.69	0.23
$\rho(\pi_t, \pi_{t-2})$	**0.80**	**0.44**	0.09	0.49	0.07
$\rho(\Delta e_t, \Delta e_{t-1})$	0.13	-0.09	0.05	-0.06	-0.02
$\rho(\Delta e_t, \Delta e_{t-2})$	0.07	-0.10	-0.03	-0.08	-0.03

- **Inflation persistence**: NRE captures observed $\rho(\pi_t, \pi_{t-1})$ *much better* than RE
- NRE achieves this with $\delta \approx 0.10$; RE requires $\delta \approx 0.49$ — robustness *substitutes* for indexation
- Standard deviations (incl. $\sigma(\Delta e_t)$) and cross-correlation: both models broadly match
- Depreciation autocorrelation: a common weakness of both models (observed AR(1) coefficient small; models near zero)

Shock Decompositions

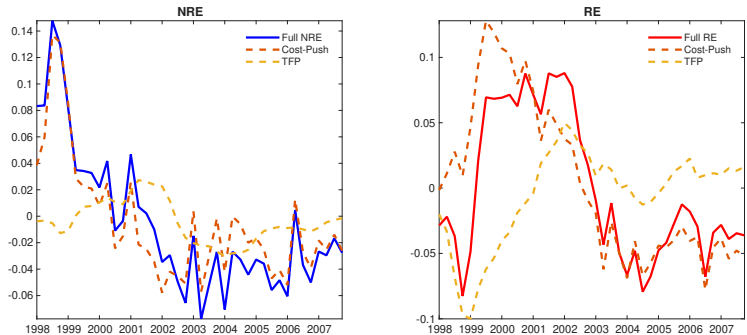
Unconditional Variance Decomposition

Model	**NRE**			RE			NRE_0			RE_0		
Series/shock	Cost	TFP	World	Cost	TFP	World	Cost	TFP	World	Cost	TFP	World
CPI Inflation	**75.4**	21.7	0.45	62.1	36.1	0.38	77.3	19.7	0.52	58.0	40.2	0.43
Depreciation Rate	**78.7**	16.7	0.34	24.1	**72.5**	0.77	79.4	15.9	0.42	7.90	88.7	0.94

- NRE: cost-push shocks dominate $\geq$ **75%** of *both* inflation and depreciation
- RE: splits the explanation — 62% of inflation from cost-push, but 72% of depreciation attributed to TFP
- NRE's larger $|\Gamma_{x,u}|$ amplifies the exchange-rate response $\Rightarrow$ cost-push drives joint dynamics of π and Δe
- Result is *not* driven by backward-looking pricing (same pattern in NRE_0 vs RE_0)

Shock Decompositions (cont.)

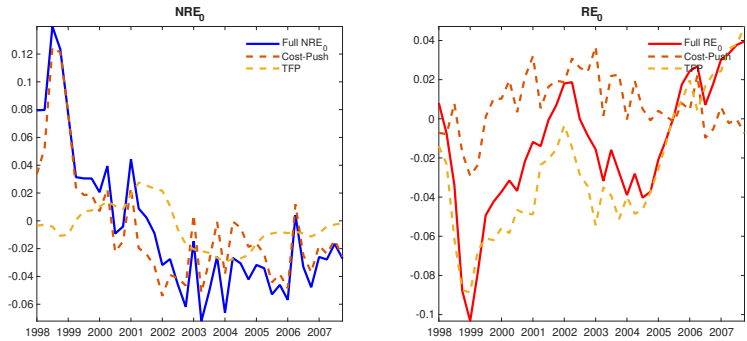
Monetary Policy Rates in the Models, Conditional on Shocks



- NRE: policy rate primarily driven by cost-push shocks — consistent with Mexico's post-crisis disinflation dynamics
- RE: policy movements attributed to productivity shocks — fails to match the data

Shock Decompositions: (cont., $\delta = 0$)

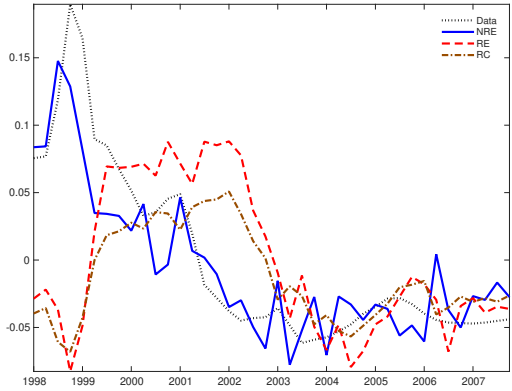
Monetary Policy Rates in the Models, Conditional on Shocks ($\delta = 0$)



- Removing backward-looking pricing ($\delta = 0$): NRE results essentially unchanged; RE performance further deteriorates
- NRE's success comes from robustness, not from backward-looking pricing

External Validity: Is It Really From $\tilde{\theta}$?

Monetary Policy Rates: RE-Counterfactual (RC)



- **RC**: hold NRE-estimated parameters fixed, but impose $\tilde{\theta} = 0$
- RC makes the implied policy rate collapse back to RE-like failure
- $\Rightarrow$ External validity is driven by robustness, not other parameter changes

Robustness Checks and Advanced Economy Benchmark

- **Alternative samples** closer to the Peso Crisis (1996Q1 / 1997Q1 starts): results remain robust — high $\tilde{\theta}$, minimal δ under NRE, strong external validity 96Q1 97Q1
- **Closed-economy specification fails** to replicate Mexico's actual policy-rate path Closed-Economy Failure
- **Advanced economy benchmark** (Canada, 1991Q2–2007Q4): NRE implies *low* $\tilde{\theta}$; NRE and RE yield similar estimates and policy-rate performance Canada

Why No Financial Wedge?

- We abstract from international financial wedges to isolate belief distortions and the CB's concern for robustness:
  - sovereign default risk (e.g. Na et al. (2018))
  - sudden stops and external financing constraints (e.g. Braggion et al. (2009); Devereux et al. (2019))
  - currency risk premia (e.g. Itskhoki and Mukhin (2023))
- We acknowledge the importance of financial wedges; we show that belief distortions alone can account for key features of post-crisis monetary policy behavior
- Embedding ambiguity in the canonical SOE-NK ensures mechanisms are not driven by reduced-form wedges or semi-structural shocks ⇒ clean identification & comparison with RE benchmark
- Sample (1998–2007) spans the post-Peso Crisis, pre-GFC period, when financial frictions were less likely to dominate short-run policy dynamics

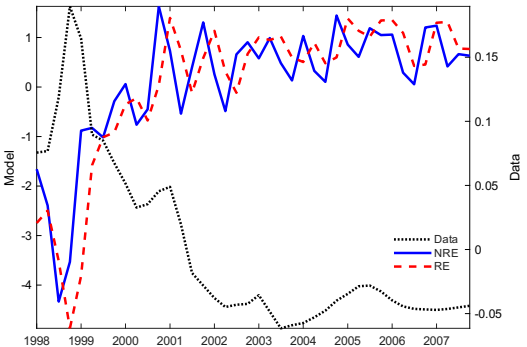
Conclusion

- Robustly optimal monetary policy in a SOE-NK model with CB uncertainty about private agents' forward-looking expectations (Type III ambiguity)
- Optimal policy departs from RE: more hawkish on inflation, larger output-gap and exchange-rate adjustments; amplified history dependence generates persistent inflation without backward-looking pricing
- Estimated on Mexican post-Peso Crisis data: NRE implies substantial robustness and matches the observed policy rate (63% RMSE reduction vs. RE), despite i_t being excluded from estimation
- Central role of robustness $\times$ cost-push in shaping inflation, exchange-rate, and policy-rate dynamics
- Observed inflation persistence in post-crisis environments may reflect deliberate policy choices under ambiguity, not intrinsic structural rigidities — promising framework for regime transitions in EMEs

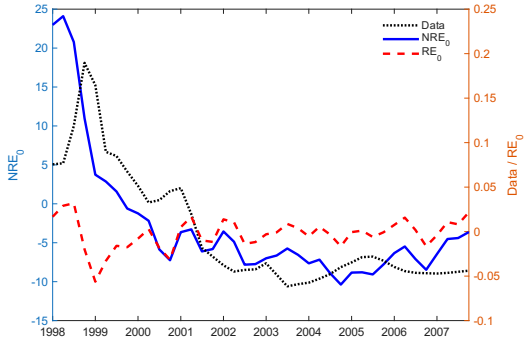
Backup Slides

Closed Economy Predictions (Aggregate Supply Only)

(a) With Price Indexation



(b) Without Price Indexation



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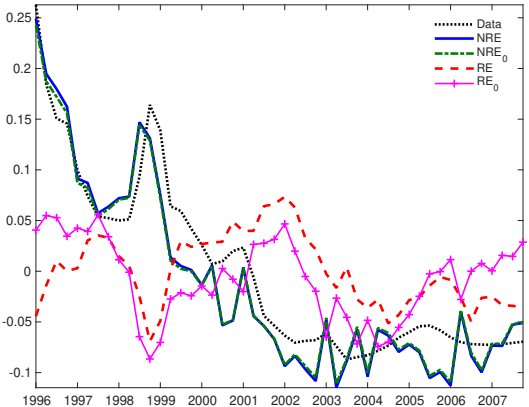
Data and Model Predictions on Monetary Policy Rates: 1Q 1996–4Q 2007



NRE: $\tilde{\theta} = 1035$, $\delta = 0.06$; NRE_0: $\tilde{\theta} = 959$; RE: $\delta = 0.54$

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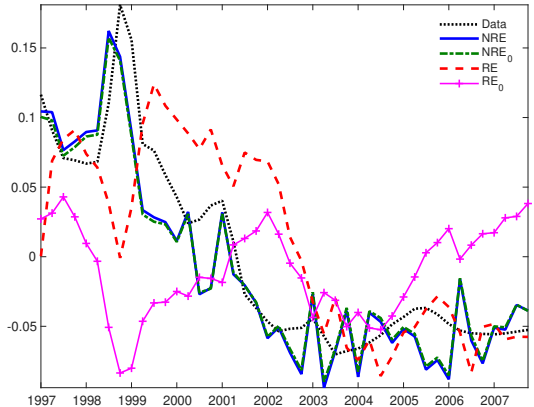
Data and Model Predictions on Monetary Policy Rates: 1Q 1997–4Q 2007



NRE: $\tilde{\theta} = 1868$, $\delta = 0.08$; NRE_0: $\tilde{\theta} = 1685$; RE: $\delta = 0.73$

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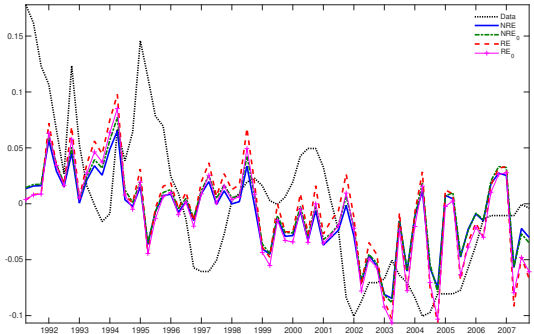
Data and Model Predictions on Monetary Policy Rates: Canada



NRE: $\tilde{\theta} = 46.9$, $\delta = 0.05$; NRE_0: $\tilde{\theta} = 36.2$; RE: $\delta = 0.07$

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