Time-Consistent Fiscal Policy and Business-Cycle Amplification in Emerging Markets

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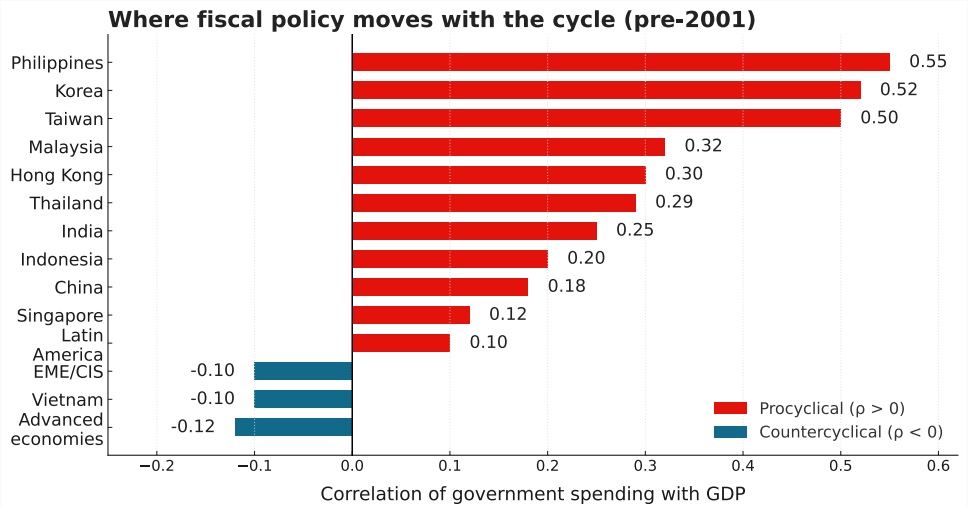
Roadmap

- Motivation and facts on procyclical government spending in Emerging Markets
- Model: time-consistent fiscal policy in a small open economy
- Calibration and solution strategy
- Results: mechanisms, moments, counterfactuals
- Policy implications and limits

Motivation

Procyclicality in Emerging Markets



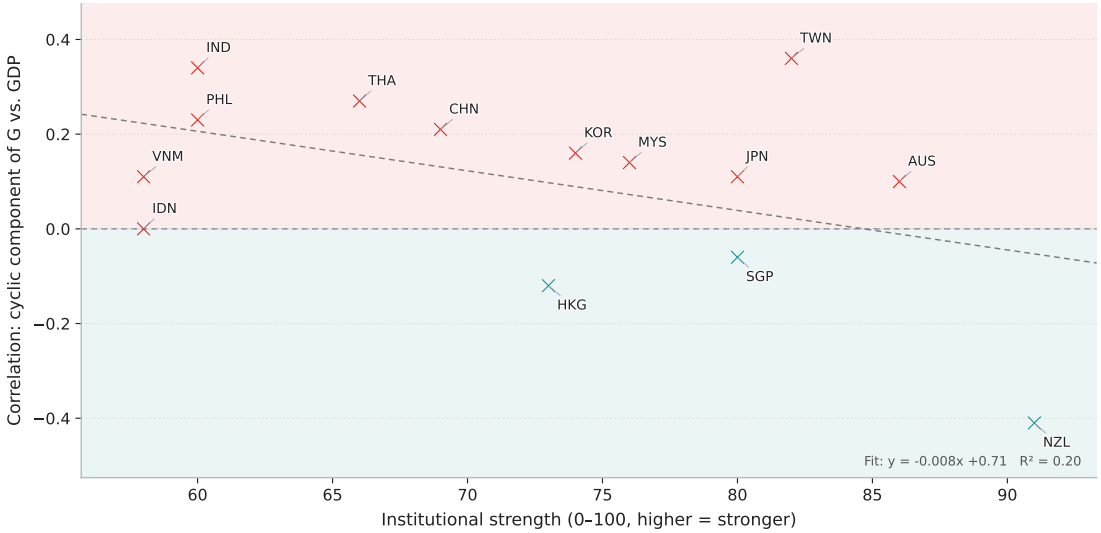
Source: IMF. Positive = procyclical; negative = countercyclical.

Why it matters

- **Procyclical** G: spend more in booms, cut in recessions $\Rightarrow$ amplifies fluctuations and erodes fiscal space when it is needed.
- **Stylized fact:** Emerging Market Economies often have $\mathrm{corr}(G, Y) > 0$ (about 0.3–0.6); many Advanced Economies are near zero or mildly countercyclical. (Frankel et al., 2013; Ilzetzki and Végh, 2008; Kaminsky et al., 2005).
- **Example—Philippines:** historically procyclical G with volatile growth; fiscal tightening during 1997–98 and 2008–09 constrained stabilization.
- **Why study:** amplification $\Rightarrow$ larger output swings, crowding-out of private buffers, crisis risk, and distributional losses.

We bring a **structural, quantitative** lens to explain *why* procyclicality arises endogenously and *how large* the costs are for EMs.

Procyclicality and Institutional Strength



1980–2011 • Country codes labeled • Zero line separates pro- and countercyclical

Fiscal Cyclicality by Region

Region	2000–2008	2009–2016	Interpretation
Developing Asia (East, South & Pacific)	−0.07	−0.02	Countercyclical on average; little change from early 2000s to 2010s.
Latin America & Caribbean	0.20	0.09	Procyclical, but much less so in the 2010s (moved toward neutrality).
Europe & Central Asia	0.48	0.05	Strongly procyclical in early 2000s; roughly acyclical by 2009–2016.
Middle East & North Africa	−0.23	0.12	Flipped from countercyclical to procyclical (deterioration).

Source: World Bank staff analysis of 116 developing countries (Herrera et al., 2019). Correlations are between cyclical components of real government expenditure and GDP.

What we do?

- **Question:** Why does procyclicality emerge under limited commitment and capital mobility, and what are the macro/welfare costs?
- **Approach:** globally solved small open-economy model with a **time-consistent** (Markov-perfect) fiscal authority.
- **Outputs:** quantify amplification, saving responses, and trade-offs across alternative cyclical stances for G within the same environment.

Key ingredients (policy and constraints)

- **Limited commitment:** fiscal policy is Markov-perfect (re-optimized each period).
- **Feasibility caps:** constant government debt stock and government expenditure cap.
- **Adjustment frictions:** convex cost on ΔG discourages abrupt changes.
- **External environment:** small open economy with capital mobility; fundamentals can be anticipated via **news**.

Calibration and measurement

- **Target: Philippines** as a representative EM with data-rich, typical moments. EM business-cycle benchmarks: Aguiar and Gopinath, 2007.
- **Fit objects:** moments for G, Y, and saving; persistence; and $\mathrm{corr}(G, Y)$.
- **Evaluation:** model-implied amplification, crowding-out of private buffers, and policy trade-offs across different G cyclicality settings.

The model delivers an endogenous procyclicality mechanism and a disciplined map from policy frictions to macro and welfare impacts.

Research Question & Contributions

Research question

- **Puzzle.** Benevolent governments sometimes cut G in recessions (deepening downturns), contrary to Keynesian advice (Gavin and Perotti, 1997; Tornell and Lane, 1999).
- **Setting.** No commitment and feasibility caps; the Markov rule $G(s_t)$ determines **volatility** and **welfare**.
- **Object.** Solve the **time-consistent** (MPE) allocation and vary the **cyclicality of** G *within* limited commitment.

Limited commitment, caps, adjustment frictions, and news can rationalize **procyclical** G as optimal discretion.

Contributions - What is new?

- **Endogenous procyclicality from limited commitment.** With a constant debt stock, an expenditure cap, and a convex cost on ΔG, the Markov-perfect rule tilts G with the cycle—without political-economy forces or a debt-elastic interest-rate premium.
- **Forward-looking fiscal channel.** One-period-ahead news about (z_{t+1}, r^*_{t+1}) shifts today's G_t before realizations, generating anticipatory spending movements testable in the data.
- **Policy-relevant parsimony.** The frictions correspond to real fiscal institutions (debt ceiling, expenditure cap) and a standard adjustment penalty, so model objects map directly to implementable rules.
- **Global, fully non-linear solution.** We solve the MPE on states with grids $\times$ (baseline) and $\times$ (publication), capturing occasionally binding constraints and cycle asymmetries.

Contributions - What the model matches and reveals?

- **Cyclicality and persistence match EM facts.** $\mathrm{corr}(G, Y) \approx 0.37$ and $\mathrm{AR}(1)\{G\} \approx 0.64$.
- **How much of G is cyclical.** Running $\log G$ on $\log Y$ yields $R^2 \approx 0.18$, quantifying the cycle-driven share of spending variation.
- **Crowding-out is modest.** $+1\%$ in $G_t \Rightarrow\approx -1.17\%$ in A_{t+1}; sensitivity of the rule to private assets ≈ 0.0005 (near zero).
- **Anatomy of the policy rule.** Most fiscal movement comes from *state-contingent level shifts* rather than strong feedback on private asset holdings.

Contributions - What it implies for policy?

- **Welfare gains without commitment.** In the same limited-commitment MPE, making G smoother or less procyclical reduces amplification and raises welfare—no extra commitment technology assumed.
- **De-prioritize private-asset targeting.** The rule is nearly flat in A ($\partial G/\partial A \approx 0$), so trying to steer household balances has little effect relative to tuning spending rules.

Benchmark EM cycle evidence: Aguiar and Gopinath, 2007.

Why the Philippines & External Validity?

Why the Philippines & external validity

- **Representative EM:** near medians on income, trade openness, and external positions.
- **Institutional match:** debt anchors/deficit ceilings; no structural-balance rule $\Rightarrow$ procyclical bias.
- **Data standards & comparability:** IMF **GFSM 2014** (Government Finance Statistics Manual) + IMF **SDDS** (Special Data Dissemination Standard) $\Rightarrow$ consistent fiscal mapping, transparent releases/metadata, replicable moments.

Generalizes to EMs with similar market access, institutions, and standards; not to Advanced Economies with strong commitment and large fiscal space.

2000–2020: Philippine government spending cyclicality at a glance

Evidence — corr(G, Y) on cycle components

Subperiod	**HP** (λ=6.25)	**Hamilton** (h=1, p=1)
2000–2005	$+0.11$	-0.79
2006–2010	≈ 0.00	-1.00
2011–2015	-0.67	-0.99
2016–2020	$+0.98$	$+0.95$

Notes: Annual logs; cycles via HP (Ravn–Uhlig) and Hamilton filters. Magnitudes are small-T sensitive; **signs are robust**. (Hamilton, 2018; Ravn and Uhlig, 2002)

Model

Key model features & assumptions

- **Time-consistent** government: no commitment to future G (Markov-perfect equilibrium). (Bachmann and Bai, 2013a; Fernández-Villaverde et al., 2015; Klein et al., 2008)
- **Borrowing & spending limits**: debt-to-GDP ceiling and spending cap always respected (constrain G in busts/booms).
- **Open economy**: households trade assets internationally at r^* (perfect capital mobility) (Corsetti and Müller, 2013; Mendoza, 1991; Obstfeld and Rogoff, 1996).
- **Shocks & news**: productivity (z) and world interest rate (r^*) shocks each period, plus one-period-ahead news signals (advance information) (Beaudry and Portier, 2006; Jaimovich and Rebelo, 2009).
- **Adjustment cost**: convex cost $\frac{\Omega}{2}(G_{t+1} - G_t)^2$ on changing G (smooths fiscal policy changes) (Bachmann and Bai, 2013b).

Households — preferences & budget

Equations

$$u(C_t, G_t) = \theta_t \log C_t + (1 - \theta_t) \log G_t \tag{1}$$

$$C_t + A_{t+1} = (1 - \tau_{\ell,t})\, w_t L + \left[1 + (1 - \tau_A) r_t^*\right] A_t \tag{2}$$

Intuition

- (1): intratemporal trade-off between private C_t and public G_t via taste weight θ_t.
- (2): disposable resources = after-tax labor income $(1 - \tau_{\ell,t}) w_t L$ + after-tax return on assets $[1 + (1 - \tau_A) r_t^*] A_t$.
- Perfect capital mobility pins the intertemporal margin at the world rate r_t^*.

Symbols: C_t private consumption; G_t public good; A_t household foreign assets; w_t real wage; L inelastic labor supply; θ_t taste weight on C_t (time-varying); $\tau_{\ell,t}$ labor-income tax; τ_A asset-income tax; r_t^* world interest rate.

Firms & SOE closure — technology & factor prices

Equations

$$Y_t = z_t K_t^{\alpha} L^{1-\alpha}, \qquad \alpha \in (0,1) \tag{3}$$

$$r_{k,t} = \alpha z_t \left(\frac{K_t}{L}\right)^{\alpha-1}, \quad w_t = (1-\alpha) z_t \left(\frac{K_t}{L}\right)^{\alpha} \tag{4}$$

Intuition

- Cobb–Douglas technology $\Rightarrow$ factor prices equal marginal products.
- Higher z_t raises both $r_{k,t}$ and w_t via the capital–labor ratio K_t/L.

Symbols: z_t total factor productivity; K_t private capital; L inelastic labor supply; α capital share; $r_{k,t}$ rental price of capital (MPK); w_t real wage.

Firms & SOE closure — user cost & capital demand (current)

Equations (from (4))

$$r_{k,t} = r_t^* + \delta \tag{5}$$

$$K_t = L\left(\frac{\alpha z_t}{r_t^* + \delta}\right)^{\frac{1}{1-\alpha}} \tag{6}$$

Intuition

- SOE closure equates the user cost $r_t^* + \delta$ with MPK: combine (4) and (5).
- Given (z_t, r_t^*), (6) pins down the equilibrium K_t/L and hence w_t.

Symbols: δ depreciation rate; r_t^* world interest rate.

Firms & SOE closure — news & investment

Equations

$$K_{t+1} = L\left(\frac{\alpha z_{t+1}}{r^*_{t+1} + \delta}\right)^{\frac{1}{1-\alpha}} \tag{7}$$

$$I_t = K_{t+1} - (1-\delta)K_t \tag{8}$$

Intuition

- News at t about (z_{t+1}, r^*_{t+1}) fixes desired next-period capital via (7).
- Investment adjusts according to (8); $\partial K_{t+1}/\partial z_{t+1} > 0$, $\partial K_{t+1}/\partial r^*_{t+1} < 0$.

Symbols: I_t gross investment.

Government — budget & financing (I)

Equations

$$B_{t+1} = (1 + r_{b,t})\, B_t + G_t + AC_t - T_t \tag{9}$$

$$T_t = \tau_{\ell,t}\, w_t L + \tau_a\, r_{b,t}\, A_t \tag{10}$$

$$r_{b,t} = r_t^* \quad \text{(SOE closure)} \tag{11}$$

Intuition

- (9) links debt dynamics to spending, adjustment costs, and taxes.
- (11) pins the borrowing rate to the world rate in an SOE.

Symbols: B_t public debt; $r_{b,t}$ gov. borrowing rate; G_t purchases; AC_t adjustment cost of changing G; T_t taxes; $\tau_{\ell,t}$ labor-tax rate; τ_a asset-income tax ($\tau_a \equiv \tau_A$ on HH slide); w_t wage; L inelastic labor; A_t private foreign assets; r_t^* world rate.

Government — constant-debt rule & implied taxes (II)

Equations (from (9) & (11))

$$B_{t+1} = B_t \equiv \bar{B} \tag{12}$$

$$T_t = G_t + AC_t + r_{b,t}\,\bar{B} \tag{13}$$

$$\tau_{\ell,t} = \frac{G_t + AC_t + r_{b,t}\,\bar{B} - \tau_a\, r_{b,t}\, A_t}{w_t\, L} \tag{14}$$

$$0 \le \tau_{\ell,t} \le \bar{\tau}_\ell < 1$$

Intuition

- Using (9) with (12) gives (13): the primary surplus must cover interest $r_{b,t}\bar{B}$.
- Given prices and (G_t, AC_t), (14) is the endogenous labor tax needed to implement the rule.

Symbols: $\bar{B}$ constant debt target; $\bar{\tau}_\ell$ labor-tax cap.

Government — feasibility caps & adjustment costs (III)

Equations

$$AC_t = \frac{\Omega}{2}\left(G_{t+1} - G_t\right)^2, \qquad \Omega > 0 \tag{15}$$

$$G_{t+1} \leq \bar{g} \cdot Y_{t+1}, \qquad \bar{g} \in (0,1) \tag{16}$$

$$Y_t = C_t + I_t + G_t + AC_t + TB_t \tag{17}$$

Intuition

- (15): changing G uses resources (not utility), appearing in both budget and goods market.
- With news, parts of Y_{t+1} are known at t, so (16) constrains G_{t+1} at choice time.
- (17) closes the goods market with the trade balance TB_t.

Symbols: Ω adjustment-cost parameter; $\bar{g}$ spending-to-output cap; Y_t output; C_t private consumption; I_t investment; TB_t trade balance (exports minus imports).

Market clearing — absorption & investment

Equations

$$Y_t = C_t + I_t + G_t + AC_t + TB_t \tag{18}$$

$$I_t = K_{t+1} - (1 - \delta) K_t \tag{19}$$

Intuition

- Absorption identity: output goes to private absorption ($C_t + I_t$), public purchases G_t, fiscal adjustment costs AC_t, and the trade balance TB_t.
- AC_t is a resource use (appears in the government budget and goods market), not a utility term.
- Given a choice of K_{t+1}, investment follows from capital accumulation (19).

Symbols: Y_t output; C_t consumption; I_t investment; G_t government purchases; AC_t adjustment cost of changing G; TB_t trade balance (exports minus imports); K_t capital; δ depreciation rate.

Balance of payments — external adjustment

Equations (consistent with (18))

$$TB_t = Y_t - \big(C_t + I_t + G_t + AC_t\big) \tag{20}$$

$$\tag{21}$$

Intuition

- Goods-market clearing implies the trade balance (20) as the residual.
- A surplus $TB_t > 0$ increases A_{t+1}; a deficit reduces it. Domestic taxes are internal transfers and do not alter this external identity.

Symbols: A_t net foreign assets; r_t^* world interest rate.

Markov-Perfect Equilibrium (MPE): components

Public consumption is chosen to maximize the contemporaneous utility of the household (both private consumption and public goods), **subject to adjustment costs on changes in G and tax-collapse constraints**.

Objects

- **State vector:** $\mathbf{s} = (A, G, r^*, z, \varepsilon_r, \varepsilon_z, \theta)$
- **Government policy function:** $G' = \Psi(\mathbf{s})$
- **Aggregate asset transition:** $A' = H(\mathbf{s}, G')$
- **Tax function (implements constant debt):** $\tau_\ell = \tau_\ell(\mathbf{s}; H)$
- **Value function:** $v(a, \mathbf{s}; \Psi, H)$
- **Best-response value:** $J(a, \mathbf{s}, G'; \Psi, H)$
- **Household asset rule:** $a' = h(a, \mathbf{s}, G'; \Psi, H)$

MPE — household best response & budget (I)

Household best response (given G' and (Ψ, H))

$$J(a, \mathbf{s}, G'; \Psi, H) = \max_{c,\, a' \geq \underline{a}} \left\{ \theta \log c + (1-\theta) \log G + \beta\, \mathbb{E}\big[v(a', \mathbf{s}'; \Psi, H) \big] \right\} \tag{22}$$

$$\text{s.t.} \quad c + a' = (1 - \tau_\ell)\, w(r^*, z)\, L + \big[1 + (1 - \tau_A)\, r^* \big]\, a \tag{23}$$

Intuition

- (22): one-period utility plus discounted continuation value given policy rule Ψ and aggregator H.
- (23): disposable resources are after-tax labor income and after-tax world return on assets.

Symbols: J current-period objective with continuation; v value function; a private assets; $\mathbf{s}$ Markov state (see next slide); Ψ government policy rule; H aggregator for aggregates; $\underline{a}$ borrowing limit. $w(r^*, z)$ comes from firm pricing (see (4)); τ_A asset-income tax.

MPE — constraints, aggregation & transitions (II)

Restrictions & laws of motion

$$c \geq 0, \qquad a' \geq \underline{a} \tag{24}$$

$$A' = H(\mathbf{s}, G') \tag{25}$$

$$\tau_\ell = \tau_\ell(\mathbf{s}; H) \quad \text{(implements gov't financing, see (14))} \tag{26}$$

$$w = w(r^*, z) \quad \text{(factor pricing, see (4))} \tag{27}$$

$$\mathbf{s}' \sim \mathcal{P}(\cdot \,|\, \mathbf{s}, G', \varepsilon_r, \varepsilon_z) \quad \text{with } r^{*'} \text{ and } z' \text{ determined by news } (\varepsilon_r, \varepsilon_z) \tag{28}$$

State vector

A convenient choice is $\mathbf{s} = (a, A, r^*, z, \theta, G)$, where A are aggregate (external) assets and G is current public spending.

Notes: (25) aggregates private choices into next-period aggregates (e.g., A'). (26) ties the labor tax to the financing rule (e.g., constant-debt) via (14). (28) summarizes exogenous transitions with news that partially reveal $r^{*'}$ and z' at time t.

MPE — government policy & fixed point (III)

Government problem (limited commitment / Markov-perfect)

$$\Psi(\mathbf{s}) = \arg\max_{G'} \; J(a, \mathbf{s}, G'; \Psi, H) \tag{29}$$

s.t. financing & caps: (12), (13), (15), (16) and goods market (18).

Markov-perfect equilibrium (definition)

A pair (Ψ, H) is an MPE if:
(i) Ψ solves (29) taking (Ψ, H) as given;
(ii) given Ψ, households' best responses solve (22)–(23) subject to (24)–(28);
(iii) H is consistent with aggregation of best responses (e.g., (25)).

Symbols: Ψ policy function $G' = \Psi(\mathbf{s})$; $\mathcal{P}$ transition kernel for $\mathbf{s}$; $(\varepsilon_r, \varepsilon_z)$ news shocks determining $r^{*'}$ and z'.

Calibration & Solution

Calibration — at a glance (annual)

Targets & primitives

- Ratios: $G/Y = 0.15,\ K/Y \approx 2.36,\ I/Y \approx 0.236,\ \mathbb{E}[A] = 0.$
- Preferences/tech: $\beta = 0.96,\ \alpha = 0.33,\ \delta = 0.10,\ r^* = 0.04,\ \bar{\theta} = 0.75.$
- Fiscal frictions: adjustment cost $\Omega = 0.01$; spending cap $\bar{g} = 0.35$; asset-income tax $\tau_a = 0.15$.

Closure & steady state (intuition)

- SOE closure: $r_b = r^*$; stationarity via constant domestic debt $\bar{B} = 0.5$ (no DEIR).
- User cost pins capital: $MPK = r^* + \delta \Rightarrow K/Y = \alpha/(r^* + \delta) \approx 2.36.$
- Goods market: $I/Y = \delta(K/Y) \approx 0.236$, so $C/Y \approx 1 - 0.15 - 0.236 = 0.614.$

All values annual; targets anchor levels and co-movements rather than over-fitting moments.

Solution & validation — essentials

How we solve

- Global MPE: EGM for households; VFI for government; parametric policy updates with damping/acceleration.
- Financing/caps enforced each iteration (constant-debt rule, Ω, $\bar{g}$, goods market).

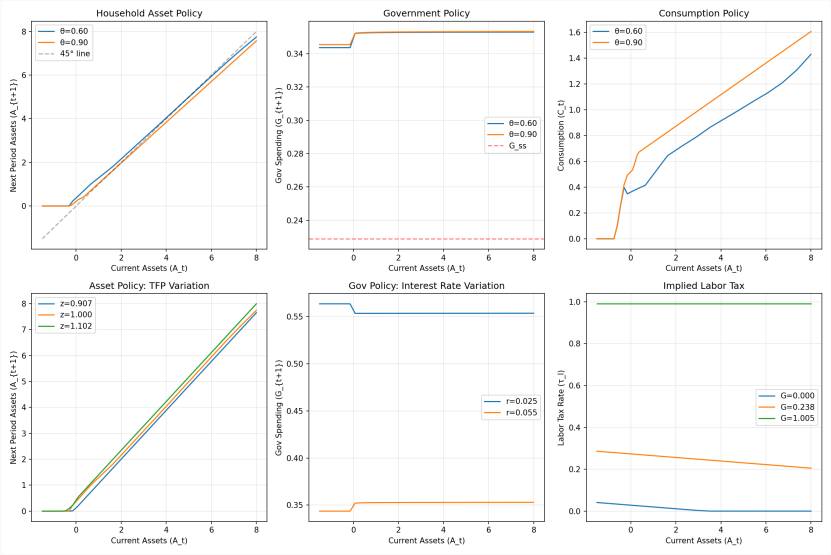
What fits (headline moments)

- Procyclicality: $\mathrm{corr}(G, Y) \approx 0.366$; persistence: $\rho_G \approx 0.638$.
- Macro share: $R^2(\log G \mid \log Y) \approx 0.134$.
- Mechanism: near-zero wealth slope in G; crowding-out $+1\%$ in $G_t \Rightarrow\approx -1.69\%$ in A_{t+1}.

Robustness: zero grid-bound hits; grid refinements shift moments by $< 2\%$.

Results & Discussion

Equilibrium policy functions (MPE, simulated)



Policy functions — key takeaways

- **Procyclicality & persistence.** $\mathrm{corr}(G, Y) \approx 0.366$; $AR(1)$ of $G \approx 0.638$.
- **Macro share of $\mathrm{Var}(G)$.** $R^2(\log G \sim \log Y) \approx 0.134$ — the cycle explains a meaningful share of G variation.
- **Crowding out (mechanism).** $+1\%$ in $G_t \Rightarrow\approx -1.69\%$ in A_{t+1} (mean elasticity).
- **Near-zero wealth slope.** Slope of G w.r.t. private assets ≈ 0.000042 — state-contingent intercepts drive policy.

Notes: MPE with news on (z_{t+1}, r^*_{t+1}); fitted log-quadratic rules over the state grid.

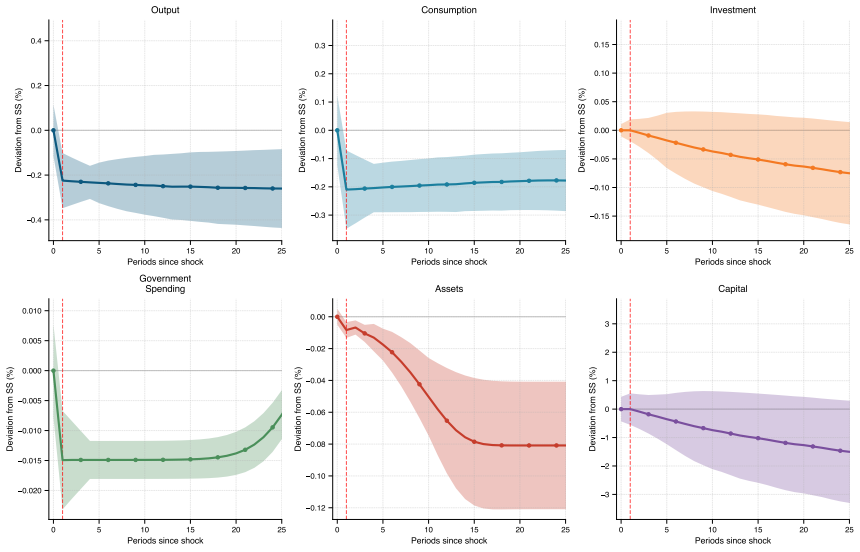
Mechanism

- **SOE user cost pins capital:** $MPK_t = r_t^* + \delta \Rightarrow$ fast K adjustment to news about r^*, z.
- **Policy is intercept-driven:** government shifts G mostly via state-dependent intercepts, not via A_t feedback.
- **Crowding out:** higher G_t reduces saving ($A_{t+1} \downarrow$) as households internalize future fiscal pressure and world-rate returns.

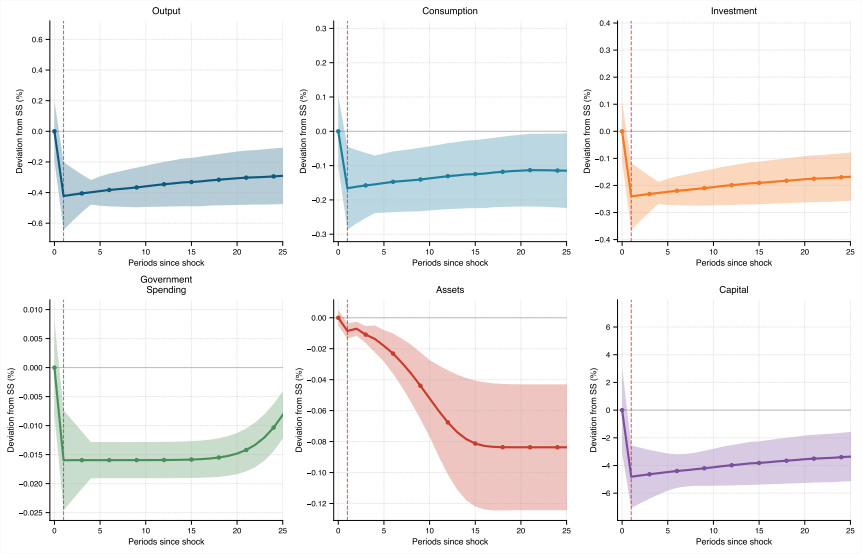
Business-cycle properties — headline moments

- **Output–consumption comovement:** strong, consistent with SOE benchmarks.
- **Government spending:** moderately procyclical ($\mathrm{corr}(G, Y) \approx 0.366$) and persistent ($\rho_G \approx 0.638$).
- **Macro share:** $R^2(\log G \mid \log Y) \approx 0.134$ — aggregate conditions account for about $0.134 \times 100\%$ of $\mathrm{Var}(G)$.
- **Taxes:** labor tax τ_ℓ countercyclical.

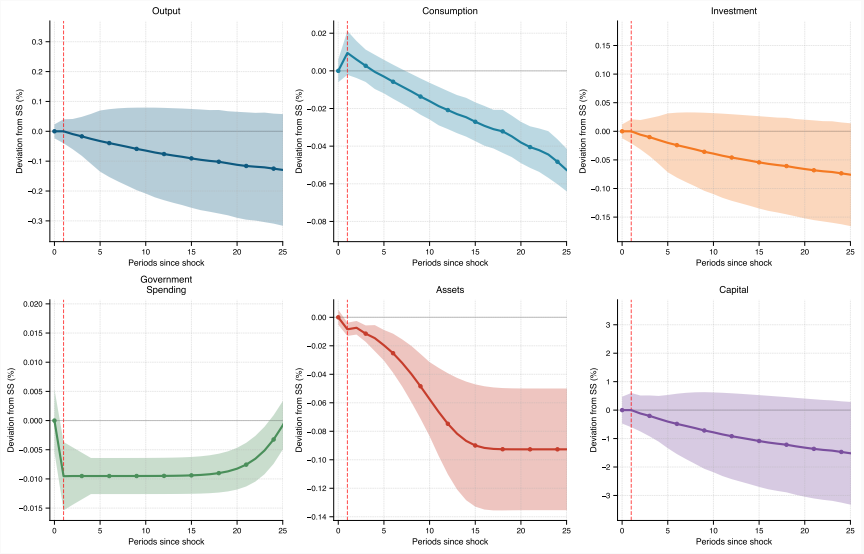
Impulse response — productivity ($z \downarrow$))



Impulse response — world interest rate ($r^* \uparrow$)



Impulse response — world interest rate ($\theta \uparrow$)



IRFs — what to remember

- **Productivity shock ($z \downarrow$):** $Y \downarrow$ on impact via K adjustment; G moves with the cycle; consumption smooths.
- **Interest-rate shock ($r^* \uparrow$):** largest near-term fall in Y via user-cost jump; investment contracts; G adjusts mainly through intercepts.
- **Across shocks:** G responds modestly but procyclically; A' drifts lower after $G \uparrow$ (crowding out).

Conclusion

Conclusion — headline quantitative findings

- Macro share of government-spending fluctuations: $R^2(\log G \mid \log Y) \approx 0.134$.
- Government purchases are moderately procyclical $\mathrm{corr}(G, Y) \approx 0.366$ and persistent $\rho_G \approx 0.638$.
- Persistence reflects fundamentals and convex adjustment costs that penalize rapid changes in G_t.
- A low-dimensional parametric rule summarizes government behavior and provides a moderate fit for household saving.

Conclusion — mechanism and dynamics

- Government places near-zero weight on private assets in its rule (wealth slope close to zero).
- Crowding-out margin is sizable: $+1\%$ in $G_t \Rightarrow\approx -1.69\%$ in A_{t+1} at the mean state.
- News on (z_{t+1}, r^*_{t+1}) makes spending forward-looking; adjustment costs imply gradual movement toward the target $G^\star_{t+1}$.
- SOE user cost $MPK_t = r^*_t + \delta$ anchors rapid capital adjustment; fiscal policy moves mainly through intercept shifts.

Conclusion — policy implications

- A substantial but incomplete share of G variation is systematic; the residual likely reflects political-economy shocks, implementation lags, off-budget actions, commodity and disaster risks, and measurement.
- Institutions that damp the contemporaneous response of G to the cycle can reduce amplification; the trade-off is more volatility in taxes and debt.
- Because adjustment costs already generate internal smoothing, incremental stabilization from external rules depends on their strength relative to the estimated adjustment-cost parameter.

Conclusion — scope, limits, and robustness

- Representative-household setting without nominal rigidities or active monetary policy; parametric policy summary and specific adjustment-cost form.
- Within these limits the model delivers: a sizable systematic component of public-spending fluctuations, quantitatively meaningful crowding-out of private saving, and a clear role for adjustment costs in the timing and persistence of fiscal responses.

Appendix

Computation — solver workflow

Model solve (Markov-perfect equilibrium)

- *Setup:* build grids (center-heavy $\mathcal{G}$; dense $\mathcal{A}$ near 0); discretize shocks (Rouwenhorst, 1995; Tauchen, 1986); precompute transitions.
- *Scale & steady state:* pin $(Y_{ss}, G_{ss}, \tau_{\ell,ss})$ and normalize value/policy scales.
- *Warm start:* initialize $G' \equiv G$, rough off-path (A', C), flat values.
- *Fixed-point loop (each iteration):* household EGM update $\rightarrow$ government Bellman best reply g^+ (feasibility projection).
- **Convergence test:** stop if $\|a^{k+1} - a^k\|_\infty < \varepsilon$ and $\|g^{k+1} - g^k\|_\infty < \varepsilon$; otherwise go back to the EGM step and continue.
- *Diagnostics:* check Euler digits, Bellman residuals, and feasibility.

Parametric projection

$$\log A_{t+1} = \alpha_0 + \alpha_1 \log A_t + \alpha_2 (\log A_t)^2 + \alpha_3 \log G_t + \alpha_4 (\log G_t)^2,$$
$$\log G_{t+1} = \beta_0 + \beta_1 \log A_t + \beta_2 (\log A_t)^2 + \beta_3 \log G_t + \beta_4 (\log G_t)^2.$$

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