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

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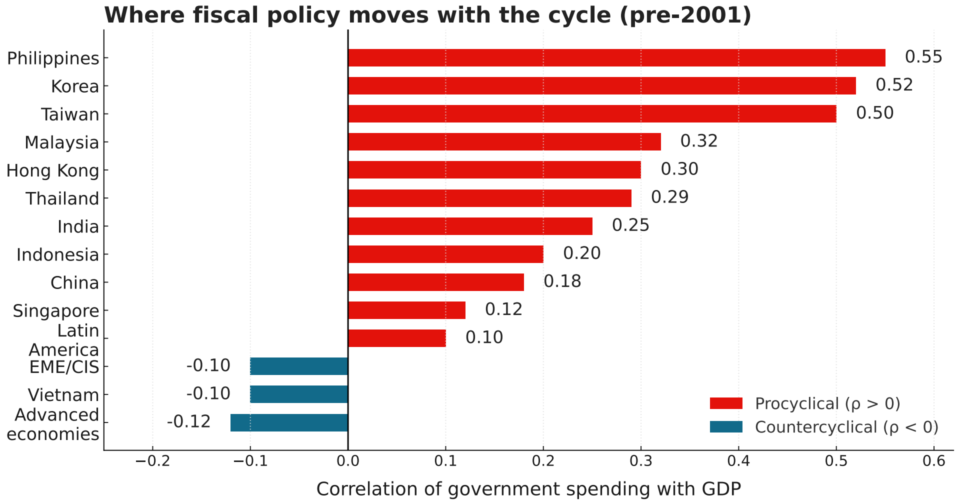
Roadmap

- Motivation and facts on procyclical government spending in Emerging Markets
- Model: time-consistent fiscal policy in a small open economy
- Results
- Conclusions and Future Directions

Motivation

Procyclicality in Emerging Markets



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

Why it matters

- G **(government purchases):** government *consumption expenditures* + *gross public investment* (fixed assets). *Excludes* transfers, subsidies, and interest. Includes collective services (defense, public safety) and individual services *produced by government units* (e.g., public schools, public/VA hospitals) as well as infrastructure.
- Y **(output):** real gross domestic product (real GDP).
- **Procyclicality:** $(\mathrm{corr}(\tilde{Y}, \tilde{G}) > 0)$ is the contemporaneous correlation of the *cyclical components* of Y and G; procyclical (> 0), acyclical (≈ 0), countercyclical (< 0).

$\tilde{X}$ denotes the cyclical component of X (HP-detrended log series). Convention used here: G follows the NIPA aggregate "government consumption expenditures and *gross* investment." Social benefits (including insurance-type reimbursements) and interest are outside G; health care *financed* for households is not in G unless the services are produced by government units. Some SNA presentations include social transfers in kind in "government consumption (U.S. Bureau of Economic Analysis, 2024)."

Why it matters

- **Stylized facts.** Government *purchases* (not transfers) are procyclical in both **advanced economies (AEs)** and **emerging market economies (EMEs)**: the cyclical components of Y and G move together ($\mathrm{corr}(\tilde{Y}, \tilde{G}) > 0$). Volatility of purchases is substantially higher in **emerging market and developing economies** and in **low-income countries (LICs)** than in AEs.
- **Public-goods channel.** Once public services enter utility, the cyclicality of G pins down how much risk-sharing the government can provide over the cycle. In our constrained EM environment, procyclical G is *welfare-maximising*, but implies that public goods contract when they are especially valuable, leaving limited scope for additional insurance via G.

Evidence: purchases vs. totals (Ilzetzki & Végh, 2008; Lane, 2003); volatility gaps (Marioli et al., 2024); welfare & market incompleteness (Pallage & Robe, 2003; Riascos & Vegh, 2003).

Research Question & Contributions

Research question

- **Question.** How does **procyclical government purchases**, chosen **without commitment**, shape macroeconomic **volatility** and **welfare** in a typical emerging market?
- **Environment.** Small open economy; the fiscal authority is **time-consistent** (Markov-perfect) and chooses next-period G subject to feasibility conditions.

Contributions — modeling & equilibrium

- **Emerging-market environment.**
  - **EM small open economy with endogenous public goods.** Government purchases enter household utility in a calibrated EM SOE, so the level of G is a central policy margin rather than a residual.
  - **Fiscal institutions.** A constant-debt anchor and simple feasibility caps on spending mirror EM fiscal frameworks and hard budget constraints, and discipline the time-consistent policy choices.
  - **Shocks & limited commitment.** Preference, world interest-rate, and productivity shocks reflect EM exposure to external and domestic risk; outcomes are evaluated in a *time-consistent* (limited-commitment) Markov–perfect equilibrium.

Contributions — data discipline & computation

- **Data discipline.** The model is calibrated so that the simulated economy *reproduces the key business-cycle moments of government purchases*: the average level of G, its volatility and persistence, and its co-movement with output and interest rates (details and moments shown later).
- **Technically demanding solution.** We solve a high-dimensional MPE with non-linear aggregation using global, non-linear numerical methods and large-scale simulation.

▸ How do we solve the MPE?

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 limited commitment, market access, institutions, and data standards.

Philippines, 2000–2020: core fiscal aggregates vs. GDP

Volatility and comovement with real GDP

	G	$G^{\text{non-def}}$	Y	ES	SS
Standard deviation (%)	6.6	6.8	3.0	12.6	6.2
AR(1) persistence ρ	0.36	0.31	0.67	0.37	0.26
Correlation with output	0.34	0.33	1.00	0.21	0.47

Acronyms: Y = output (GDP); ES = economic services (public investment); G = government purchases; $G^{\text{non-def}}$ = government purchases excluding defense; SS = social services.

Notes: Annual log deviations from trend, HP filter $\lambda = 100$, sample 2000–2020. Net lending and interest payments omitted to focus on *purchases* corresponding to model G.

Key facts for the model

- **Procyclical spending:** all purchase aggregates move with output
- **Model discipline:** motivates a small-open EM model where the government chooses a composite purchases aggregate G and we ask whether a time-consistent policy can match this volatility and procyclicality.

Model

What we solve?

- **Environment.** An emerging-market small open economy with an open capital account. The government chooses public spending; households choose consumption and saving.
- **Interaction over time.** Each period, the current macro state and news are observed; the government sets next-period spending as a function of the state; households then choose consumption and savings; shocks realize and the state transitions.
- **Equilibrium concept.** A Markov-perfect (dynamic Stackelberg) equilibrium in which government and households follow policy rules that are mutual best responses, satisfy feasibility and institutional caps, and depend only on the current state.

Equations and transition laws appear next.

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)
- **Open economy**: households trade assets internationally at r^* (perfect capital mobility) (Corsetti and Müller, 2013; Mendoza, 1991; Obstfeld and Rogoff, 1996).
- **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

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

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

Intuition

- (1): intratemporal trade-off between private consumption and the public good via the time-varying taste weight θ_t.
- (2): disposable resources = after-tax labor income $(1-\tau_{\ell,t}) w_t L$ plus after-tax asset returns $\big(1+(1-\tau_A) r_t^*\big) A_t$.
- Perfect capital mobility: the intertemporal margin is pinned to the world rate r_t^*.

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

Firms & SOE closure — technology & factor prices

Equations

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

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

$$\ln z_{t+1} = (1-\rho_z)\ln \bar{z} + \rho_z \ln z_t + \varepsilon_t^z, \quad \varepsilon_t^z \sim \mathcal{N}(0,\sigma_z^2) \tag{5}$$

Intuition

- Cobb–Douglas $\Rightarrow$ factor prices equal marginal products.
- Higher TFP raises the rental rate and the wage (through K_t/L).
- TFP follows log-AR(1) with persistence ρ_z, variance σ_z^2, mean $\bar{z}$.

Symbols: z_t TFP; K_t capital; L labor; α capital share; $r_{k,t}$ rental rate; w_t wage; $\rho_z, \bar{z}, \sigma_z$ TFP parameters.

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

Equations (using (4))

$$r_{k,t} = r_t^* + \delta \tag{6}$$

$$K_t = L\left(\frac{\alpha\, z_t}{r_t^* + \delta}\right)^{\frac{1}{1-\alpha}} \tag{7}$$

$$r_{t+1}^* = (1-\rho_r)\,\bar{r}^* + \rho_r\, r_t^* + \varepsilon_t^r, \quad \varepsilon_t^r \sim \mathcal{N}(0, \sigma_r^2) \tag{8}$$

Intuition

- Small open economy: perfect mobility equates the user cost $r_t^* + \delta$ with MPK (combine (4) and (6)).
- Given (z_t, r_t^*), (7) pins down K_t/L and thus factor prices.
- The world interest rate follows an *AR(1) in levels* with persistence ρ_r, variance σ_r^2, mean $\bar{r}^*$ ((8)).

Symbols: K_t capital; L labor; δ depreciation; r_t^* world rate; $\rho_r, \bar{r}^*, \sigma_r$ AR(1) parameters.

Firms & SOE closure — news & investment

Equations

$$K_{t+1} = L\left(\frac{\alpha\, z_{t+1}}{r^*_{t+1} + \delta}\right)^{\frac{1}{1-\alpha}} \tag{9}$$

$$I_t = K_{t+1} - (1-\delta)K_t \tag{10}$$

Intuition

- News at time t about (z_{t+1}, r^*_{t+1}) pins down desired next-period capital via (9).
- Investment adjusts according to (10); $\partial K_{t+1}/\partial z_{t+1} > 0$, $\partial K_{t+1}/\partial r^*_{t+1} < 0$.

Symbols: K_{t+1} next-period capital; I_t gross investment; δ depreciation; r^*_t world rate.

Government — budget & financing (I)

Equations

$$B_{t+1} = (1 + r_t^*)\, B_t \; + \; G_t \; + \; AC_t \; - \; T_t \tag{11}$$

$$T_t = \tau_{\ell,t}\, w_t L \; + \; \tau_a\, r_t^*\, A_t \tag{12}$$

Intuition

- (11): debt evolves with the borrowing rate, purchases, adjustment costs, and tax revenue.
- (12): revenue from labor taxes and asset–income taxation.

Symbols: B_t public debt; G_t purchases; AC_t adjustment cost for G; T_t taxes; $\tau_{\ell,t}$ labor-tax rate; τ_a asset-income tax; w_t wage; L labor; A_t private foreign assets; r_t^* world rate.

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

Equations (from (11))

$$B_{t+1} = B_t \;\equiv\; \bar{B} \tag{13}$$

$$T_t = G_t \;+\; AC_t \;+\; r_t^* \, \bar{B} \tag{14}$$

$$\tau_{\ell,t} = \frac{G_t + AC_t + r_t^* \, \bar{B} - \tau_a \, r_t^* \, A_t}{w_t \, L} \tag{15}$$

Intuition

- With (13), (11) implies (14): the primary surplus must cover interest $r_t^* \bar{B}$.
- Given prices and (G_t, AC_t), (15) gives the labor tax required to implement the constant-debt rule.

Symbols: $\bar{B}$ debt target.

Government — feasibility caps & adjustment costs (III)

Equations

$$AC_t = \frac{\Omega}{2}\left(G_{t+1} - G_t\right)^2, \qquad \Omega > 0 \tag{16}$$

$$G_{t+1} \le \bar{g}\, Y_{t+1}, \qquad \bar{g} \in (0,1) \tag{17}$$

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

Intuition

- (16): adjustment cost is a resource use (not utility) and enters both the budget and goods market.
- (17): spending cap as a share of next-period output; with news on Y_{t+1}, it can bind at choice time.
- (18): open-economy resource constraint; TB_t is the trade balance (net exports).

Symbols: Ω adjustment-cost parameter; $\bar{g}$ spending cap; Y_t output; C_t consumption; I_t investment; G_t purchases; TB_t trade balance.

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))

$$J(a, \mathbf{s}, G'; \Psi, H) = \max_{c,\, a' \geq \underline{a}} \Big\{ \theta \log c + (1-\theta) \log G + \beta\, \mathbb{E}\big[v(a', \mathbf{s}'; \Psi, H) \big] \Big\} \tag{19}$$

$$\text{s.t.} \quad c + a' = (1-\tau_\ell)\, w(r^*, z)\, L + \big[\, 1 + (1-\tau_A)\, r^* \,\big]\, a \tag{20}$$

Intuition

- (19): one-period utility plus discounted continuation value given policy rule Ψ and aggregator H.
- (20): 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)

Constraints & laws of motion

$$c \geq 0, \qquad a' \geq \underline{a} \tag{21}$$

$$A' = H(\mathbf{s}, G') \tag{22}$$

$$\tau_\ell = \tau_\ell(\mathbf{s}; H) \quad \text{(implements gov't financing, see (15))} \tag{23}$$

$$w = w(r^*, z) \quad \text{(factor pricing, see (4))} \tag{24}$$

Intuition

- (24) Aggregates private choices into next-period aggregates (e.g., A').
- (25) Ties the labor tax to the financing rule (e.g., constant-debt) via (15).

Symbols: $H(\mathbf{s}, G')$ law of motion for aggregate assets A'; τ_ℓ labor-income tax rate implementing the government financing rule (15); $w(r^*, z)$ wage from firm pricing (see (4)); $\underline{a}$ borrowing limit; $\mathbf{s}$ Markov state vector.

MPE — government policy & fixed point (III)

Government problem (limited commitment / Markov–perfect)

$$\Psi\big(A, r^*, z, \varepsilon_r, \varepsilon_z, \theta, G\big) \;=\; \arg\max_{G'} J\big(a, \mathbf{s}, G'; \Psi, H\big) \tag{25}$$

s.t. government budget and caps: (13), (14), (16), (17).

Markov–perfect equilibrium (definition)

A pair of functions (Ψ, H) is a Markov–perfect equilibrium if:

(i) Given (Ψ, H), the policy rule Ψ solves (25) for all admissible states $(A, r^*, z, \varepsilon_r, \varepsilon_z, \theta, G)$.

(ii) Given Ψ, household value and policy functions solve (19)–(20) subject to the feasibility, aggregation, and pricing conditions (21)–(24).

(iii) The law of motion H is consistent with aggregation of optimal individual choices, as in (22).

Symbols: Ψ government spending rule (so that $G' = \Psi(A, r^*, z, \varepsilon_r, \varepsilon_z, \theta, G)$); H law of motion for aggregate assets A'; $\mathcal{P}$ transition kernel for the state vector $\mathbf{s}$; $(\varepsilon_r, \varepsilon_z)$ news shocks for $(r^{*\prime}, z')$.

Results & Discussion

Business-cycle moments of cyclical G

Moment (cyclical G)	**Model**	**Data (ES)**
Std. dev. (%)	7.2*	6.6
AR(1)	0.64	0.36
Corr.G,Y)	0.37	0.34

Notes: All statistics refer to the *cyclical component* of government spending G (log deviations from trend). Std. dev. = standard deviation of cyclical G (percent). AR(1) = first-order autocorrelation of cyclical G. Corr. = contemporaneous correlation between cyclical G and output Y. * Model baseline simulation.

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Results — policy function coefficients (summary)

	Mean	Std. dev.
Panel A. Household asset rule		
Persistence α_1	0.88	0.20
Curvature α_2	−0.03	0.14
Government response α_3	−0.47	0.34
Panel B. Government spending rule		
Level (intercept) β_0	0.04	0.05
Own persistence β_1	0.05	0.01
Asset response β_3	−0.01	0.02

‣ See state-by-state asset rule coefficients

Policy rules — main messages from the estimates

- **Savings persistence.** Assets are highly persistent (average AR **0.88**): households mostly carry today's balance into tomorrow. Curvature terms are small on average but vary by macro state, so some environments induce sharper saving adjustments.
- **Response to public spending.** Higher current G leads households to save less next period (average response **0.47** per 1% higher G), a negative effect in all environments (crowding out).
- **Policy rule.** The government mainly shifts the *level* of G across states; it leans only mildly on last period's G (persistence **0.05**) and reacts little to household wealth (asset sensitivity **0.01**).
- **Bottom line.** In a time-consistent EM equilibrium, G moves with the cycle and expected conditions; households partially offset it (average saving elasticity **0.35**), and feedback from private wealth back to policy is limited.

Figures summarise coefficient means across 12 macro environments (z, r, θ).

Macro effects of shocks

Key patterns

- **Supply vs. demand.** Output reacts more sharply and persistently to supply-side shocks (TFP $z\downarrow$, world rate $r^*\uparrow$) than to preference shocks. Small-open-economy arbitrage limits pure demand expansions; investment responds mainly through the *cost of capital* (higher r^* makes investing more expensive), and G remains modestly procyclical.
- **Preference shocks.** Preference shocks trigger an immediate reallocation from public to private consumption. Capital and external assets adjust gradually, reflecting government–household strategic interaction in MPE.
- **State dependence.** Responses differ across current states (z, r^*, θ). Policy functions shift mainly through state-contingent intercepts, so IRFs are heterogeneous across booms, busts, and interest-rate regimes.

‣ See full IRF for a productivity shock

Implications for procyclical G

Link to the research question

- **Procyclicality is supply-driven.** Increases in TFP ($z \uparrow$) or declines in the world rate ($r^* \downarrow$) raise output and, in equilibrium, raise G; preference shocks mainly reshuffle private vs. public consumption with limited gains from moving G. The main margin of procyclicality comes from supply-side and external shocks.
- **State-contingent fiscal rules.** Because policy coefficients vary primarily through intercepts across (z, r^*, θ), the model points toward rules that *tie the level of G to macro states* (output, interest rates, valuation of public goods), rather than relying on high mechanical persistence in G itself.
- **Interpretation.** In this model, government spending rises in good times mainly because the economy and external conditions improve, not because the government is mechanically copying past spending or reacting strongly to households' wealth.

Conclusion

Where this study sits in the literature (I)

(1) Endogenous fiscal policy in DSGE models.

- Early RBC/DSGE: G is an *exogenous* AR(1) shock (e.g. Ambler and Paquet (1996), Baxter and King (1993), and Kydland and Prescott (1982)).
- We follow Bachmann and Bai (2013a, 2013b): a *time-consistent*, welfare-maximizing government chooses G in equilibrium, rather than taking it as a forcing process.
- As in Bachmann and Bai (2013b), we keep implementation frictions and valuation (preference) shocks to public goods as key drivers of G's volatility, persistence, and comovement with the cycle.

(2) Business-cycle behavior of government purchases.

- Data: in EMs G is strongly procyclical (Gavin & Perotti, 1997; Kaminsky et al., 2005; Talvi & Végh, 2005).
- Our calibration is disciplined by these facts and by business-cycle analyses of G's volatility and co-movement (Ambler & Paquet, 1996; Bachmann & Bai, 2013b; Fernández-Villaverde et al., 2015).

Where this study sits in the literature (II)

(3) EM small open economy & procyclical G.

- Embed endogenous G in an EM SOE with incomplete asset markets and a debt-elastic interest-rate premium (Mendoza, 1991; Schmitt-Grohé & Uribe, 2003).
- Discipline TFP, preference, and world interest-rate shocks using EM business-cycle evidence (Aguiar & Gopinath, 2007; Neumeyer & Perri, 2005; Uribe & Yue, 2006).

(4) Limited commitment & policy design.

- Provide a time-consistent (Markov–perfect) counterpart to Ramsey benchmarks (Barro, 1979; Lucas & Stokey, 1983), complementing incomplete-commitment work (Aiyagari et al., 2002; Debortoli & Nunes, 2010).
- Deliver a data-disciplined EM–SOE DSGE where *procyclical G without commitment* is an equilibrium outcome, allowing us to decompose fiscal comovement into constrained-optimal policy vs. exogenous shocks.

Conclusion — time-consistent fiscal policy in EM cycles

- **What the model says.** In an EM small open economy with limited commitment, procyclicality is a *time-consistent equilibrium outcome*:
  - In *good states* (high z, low r^*), fundamentals and external conditions improve, the financing constraint relaxes, and the optimal rule shifts the *level* of G up.
  - In *bad states* (low z, high r^*), revenue falls, borrowing is more expensive, and caps/adjustment costs limit how much the government can smooth, so the optimal rule shifts G down.
  - Because G is a valued public good and the government cannot fully insure across states, the time-consistent policy moves G with the macro state rather than perfectly stabilizing it—yielding $\mathrm{corr}(g, y) > 0$ as in the data.

Policy implications & next steps

- **Implications for fiscal rules.** The key margin is the *state-contingent level* of G, not mechanical persistence. This points toward rules that tie G to observable macro states (output, interest rates, debt) rather than "last year's budget plus a bit."
- **Model as a policy lab.** The calibrated model can be used to evaluate counterfactual fiscal frameworks: different debt anchors and adjustment costs, structural-balance or stabilization-fund rules, and (in extensions) political or financial frictions and cross-country EM comparisons.

Appendix

Calibration — baseline parameters : model vs data

Parameter	Symbol	Value	Source / Target
Preferences & Technology			
Discount factor	β	0.96	Standard annual ($\approx$4% real rate)
Capital share	α	0.33	Standard in growth/RBC
Depreciation	δ	0.10	Annual depreciation (10% p.a.)
Private-good weight	$\bar{\theta}$	0.75	Utility aggregator weight
International Finance			
World real rate	r^*	0.04	Long-run external rate (4% annual)
Domestic bonds (constant)	B_{dom}	0.50	Stationarity device (no DEIR)
Asset-income tax	τ_a	0.15	Effective capital/bond tax (15%)
Exogenous Processes (annual)			
TFP AR(1)	(ρ_z, σ_z)	$(0.90,\ 0.03)$	$n_z = 3$ states (Rouwenhorst)
World rate AR(1)	(ρ_r, σ_r)	$(0.85,\ 0.008)$	$n_r = 2$ states (Rouwenhorst)
Preference shock	ρ_θ	0.90	Two-state preference process
Preference states	$(\theta_{\text{low}}, \theta_{\text{high}})$	$(0.60,\ 0.90)$	Low vs. high weight on C

How we solve it?

- **Fixed point.** Compute the equilibrium as the fixed point of "government best response to the households' best response."
- **Households' best response.** Endogenous Grid Method builds expectations from signals, delivers savings and consumption rules, enforces feasibility and borrowing limits.
- **Government's best response.** Choose next period's spending while internalizing effects on consumption and savings; impose fiscal rules and convex adjustment costs; verify subgame perfection.
- **Convergence.** Iterate the policy rule until the maximum change is below the tolerance; approximate policy and value functions with low-dimensional polynomials under ridge regularization.

◂ Back to contributions

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.

Asset law of motion — coefficients by (z, θ)

Household asset policy:

$$\log A_{t+1} = \alpha_0 + \alpha_1 \log A_t + \alpha_2 \log^2 A_t + \alpha_3 \log G_t + \alpha_4 \log^2 G_t$$

	α_0		α_1		α_2		α_3		α_4	
	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$
$z = 0.907$	-0.404	-0.458	1.058	1.132	-0.150	-0.203	-0.761	-0.874	-0.053	-0.061
$z = 1.000$	0.008	-0.253	0.736	0.976	0.089	-0.093	-0.207	-0.604	-0.014	-0.042
$z = 1.102$	0.141	0.077	0.669	0.718	0.099	0.092	-0.166	-0.187	-0.011	-0.013

Coefficients averaged over the two world-rate states for each (z, θ) pair. Figures rounded to three decimals.

◂ Back to summary coefficients

Asset law of motion — coefficients by (r^*, θ)

Household asset policy:

$$\log A_{t+1} = \alpha_0 + \alpha_1 \log A_t + \alpha_2 \log^2 A_t + \alpha_3 \log G_t + \alpha_4 \log^2 G_t$$

	α_0		α_1		α_2		α_3		α_4	
	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$
$r^* = 0.025$	-0.005	-0.084	0.768	0.856	0.049	-0.011	-0.285	-0.399	-0.019	-0.027
$r^* = 0.055$	-0.165	-0.339	0.874	1.028	-0.023	-0.126	-0.471	-0.712	-0.032	-0.049

Coefficients averaged over the three productivity states for each (r^*, θ) pair. Interest rates correspond to roughly 2.5% and 5.5% annualised values.

Government policy — coefficients by (z, θ)

Government spending rule:

$$\log G_{t+1} = \beta_0 + \beta_1 \log G_t + \beta_2 \log^2 G_t + \beta_3 \log A_t + \beta_4 \log^2 A_t$$

	β_0		β_1		β_2		β_3		β_4	
	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$
$z = 0.907$	-0.031	0.045	0.051	0.050	0.007	0.006	-0.026	-0.022	-0.002	-0.002
$z = 1.000$	0.090	-0.020	0.042	0.050	0.008	0.007	-0.006	-0.015	-0.000	-0.001
$z = 1.102$	0.057	0.093	0.045	0.045	0.011	0.010	-0.002	-0.001	-0.000	0.000

Coefficients averaged over the two world-rate states for each (z, θ) pair. Terms rounded to three decimals.

Government policy — coefficients by (r^*, θ)

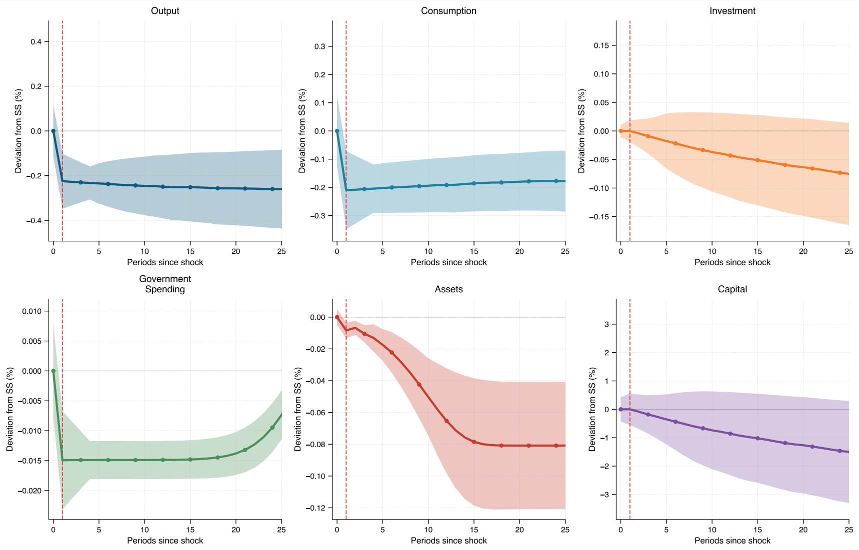
Government spending rule:

$$\log G_{t+1} = \beta_0 + \beta_1 \log G_t + \beta_2 \log^2 G_t + \beta_3 \log A_t + \beta_4 \log^2 A_t$$

	β_0		β_1		β_2		β_3		β_4	
	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$	$\theta = 0.60$	$\theta = 0.90$
$r^* = 0.025$	0.063	0.062	0.059	0.055	0.025	0.029	0.002	0.006	0.000	0.000
$r^* = 0.055$	0.014	0.017	0.033	0.041	-0.007	-0.014	-0.024	-0.031	-0.002	-0.002

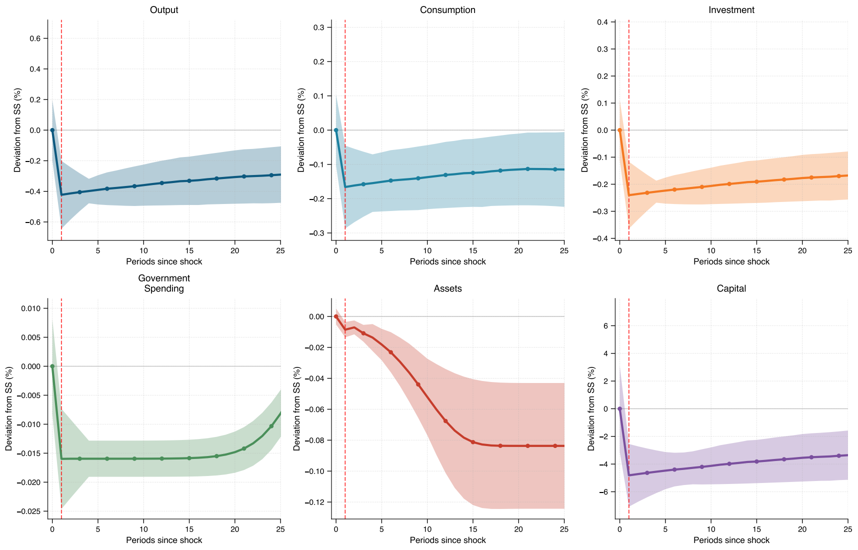
Coefficients averaged over the three productivity states for each (r^*, θ) pair; interest rates correspond to roughly 2.5% and 5.5% annualised values.

Impulse response — productivity ($z \downarrow$)

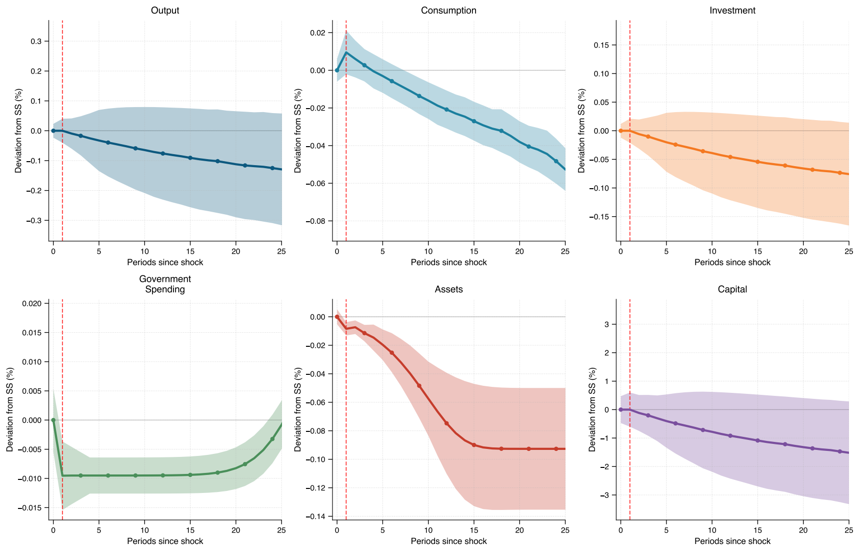


◂ Back to macro effects

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



Impulse response — private consumption preference ($\theta \uparrow$)



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