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

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Abstract

A small open-economy DSGE with an endogenous, time-consistent fiscal authority is solved globally and calibrated to emerging-market business-cycle moments. The Markov-perfect government chooses spending under borrowing constraints and convex adjustment costs. Perfect capital mobility and news about fundamentals shape expectations. In equilibrium, fiscal policy is procyclical and tracks the macro state where households anticipate persistent fiscal pressure and reduce saving. The mechanism operates through state-contingent level shifts in the spending rule rather than wealth-slope responses. The framework clarifies why procyclical spending is an optimizing response in this setting and why commitment or simple rules that smooth spending would improve stabilization.

JEL: E32; E62; F41; F44.

Keywords: small open economy; Markov–perfect equilibrium; procyclical fiscal policy; emerging markets.

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1 Introduction

Fiscal policy in many emerging-market economies is procyclical, where government spending rises in booms and contracts in recessions which in turn amplifies, rather than smoothens the business-cycle fluctuations. This pattern is well documented and stands in contrast to the countercyclical stance typical of advanced economies (Frankel et al., 2013; Ilzetzki & Végh, 2008; Kaminsky et al., 2005). Explanations stress constrained market access in downturns and political-economy frictions that encourage overspending in booms (Alesina et al., 2008; Gavin & Perotti, 1997; Riascos & Vegh, 2003; Tornell & Lane, 1999).

We study the quantitative consequences of this procyclicality in a representative emerging economy, using the Philippines as our calibration target. Philippine discretionary fiscal policy has frequently been procyclical (Cevik, 2019); growth has been volatile, especially in the 1980s (World Bank, 2018)—and episodes like the Asian Financial Crisis (1997–1998) and the Global Financial Crisis (2008–2009) illustrate how limited fiscal space can coincide with recessions, consistent with broader Emerhing Market and Developing Economies (EMDEs) evidence (Alberola et al., 2021). The Philippines' extensive IMF engagement over 1962–2000 underscores institutional and financing constraints that can foster procyclicality (International Monetary Fund Independent Evaluation Office, 2002).

Our question is positive and quantitative. How does procyclical government spending, chosen without commitment, shape macroeconomic volatility in a typical emerging market, and what are the welfare costs of this behavior? We build a small open-economy DSGE model with a time-consistent (Markov-perfect) fiscal authority and a debt-elastic external premium, calibrated to Philippine moments. The Markov-perfect environment maps weak commitment capacity and external financing conditions—features emphasized in the empirical literature on emerging markets (Aguiar & Gopinath, 2007; García-Cicco et al., 2010)—into equilibrium fiscal behavior (Bachmann & Bai, 2013b).

In the 372-state baseline, equilibrium government purchases are strongly procyclical and persistent, closely tracking the macro state. Fitted policy rules are largely explained by exogenous fundamentals. The government places negligible weight on private asset holdings and adjusts mainly through state-contingent intercepts. A one-percent increase in current public purchases reduces next-period private assets by about 0.28 percent, quantifying the crowding-out margin. In simulated cycles, government spending (G_t) co-moves tightly with output (Y_t) while household consumption remains smoother in levels, and a simple single-index representation of $\log G_t$ on $\log Y_t$ captures most of the variation (documented in Section 6.1).

Limited commitment and a debt-elastic premium jointly generate these patterns. When conditions are strong, lower external premia reduce the marginal cost of financing deficits, and the time-consistent government optimally raises purchases. When conditions deteriorate, higher premia discipline spending. Anticipated fiscal behavior feeds back into private savings, producing the measured crowding-out elasticity and a weak feedback from private assets to the government's rule.

Relative to the literature, we connect the procyclicality facts in emerging markets (Frankel et al., 2013; Ilzetzki & Végh, 2008; Kaminsky et al., 2005) to a structural environment that embeds external-finance frictions and time-consistent policy. Methodologically, we estimate interpretable Markov-perfect fiscal rules in a calibrated small open-economy model and report elasticities for the private-asset and spending margins. Substantively, we quantify how much of observed spending variation can be understood as systematic, state-contingent responses rather than idiosyncratic discretion.

Because the bulk of spending fluctuations arise endogenously from the macro-state in this environment, instruments that either damp the contemporaneous response of spending to the cycle or enable commitment to smoother paths, such as medium-term expenditure frameworks, structural balance rules with escape clauses, stabilization funds, and independent fiscal oversight, are most promising. Rules indexed to private balance-sheet variables are less effective, given the small estimated feedback from assets to spending. External validity is strongest for emerging markets with meaningful sovereign risk premia and limited commitment. While portability to advanced economies is correspondingly narrower. In addition, to isolate the role of limited commitment, we benchmark the solved Markov-perfect allocation against a full-commitment Ramsey planner and show that the Ramsey economy markedly attenuates the fiscal response to the cycle.

The paper proceeds as follows. Section 2 relates our work to research on fiscal cyclicality and emerging-market business cycles. Section 3 documents the cyclical pattern of Philippine government expenditure. Section 4 presents the model and the government's problem. Section 5 describes the calibration. Section 6.1 reports the fitted policy rules, simulated business-cycle properties, and counterfactuals. Section 7 concludes with policy implications.

2 Literature Review

2.1 Procyclical Fiscal Policy in Emerging Economies: Evidence and Consequences

Emerging market economies across diverse geographical regions and development stages exhibit a striking empirical regularity, that is *procyclical* fiscal policies that amplify rather than dampen business cycle fluctuations. This pattern, documented across Latin America, Asia, Sub-Saharan Africa, and Eastern Europe, stands in sharp contrast to the countercyclical or acyclical fiscal stances typical of advanced economies (Aghion et al., 2007; Ilzetzki & Végh, 2008). While the tax-smoothing paradigm of Barro, 1979 would predict governments maintaining relatively stable spending paths, emerging market governments systematically violate this prescription by expanding expenditures during booms and contracting them during recessions.

The empirical evidence for fiscal procyclicality in emerging markets is robust across different methodologies, time periods, and country samples. Gavin and Perotti, 1997 pioneered this literature by documenting that fiscal expenditures in Latin America expanded during economic upswings and contracted during downturns. Kaminsky et al., 2005 broadened the analysis to show that macroeconomic policies in emerging markets generally follow a "when it rains, it pours" pattern, with increasing public spending, capital inflows, and credit expansion in good times followed by sharp reversals in bad times. Using a comprehensive sample of 94 countries over 1960-2003, Ilzetzki and Végh, 2008 find that the correlation between government consumption and GDP averages 0.53 in developing countries versus -0.20 in industrial countries. Talvi and Végh, 2005 report similar magnitudes using different data sources, with government spending-GDP correlations around 0.5 for emerging markets compared to nearly zero for G7 economies. More recent work by Frankel et al., 2013 documents that while about one-third of emerging economies have "graduated" from procyclicality since 2000, the majority continue to exhibit procyclical fiscal behavior.

Methodological advances have strengthened confidence in these findings. Early studies faced criticism that observed correlations might reflect reverse causality or omitted variables. Ilzetzki et al., 2013 address these concerns using instrumental variable techniques, exploiting predetermined institutional characteristics and external shocks as instruments for fiscal policy. D. Jaimovich and Panizza, 2007 employ alternative identification strategies based on forecast errors and real-time data, confirming that emerging market fiscal policy is genuinely procyclical rather than a statistical artifact. Alesina et al., 2008 use political variables as instruments, finding that countries with more corruption and less democratic accountability exhibit stronger fiscal procyclicality. These diverse identification approaches consistently confirm that emerging market governments actively pursue procyclical policies rather than simply appearing procyclical due to measurement issues.

The macroeconomic consequences of procyclical fiscal behavior extend beyond simple volatility amplification. Aghion et al., 2007 demonstrate theoretically and empirically that fiscal procyclicality reduces long-run growth rates by creating an uncertain environment that deters private investment. Using panel data from 75 countries, they find that moving from the median level of procyclicality to countercyclical policy could increase annual growth by 0.5 percentage points. Fatás and Mihov, 2013 document that policy volatility, of which fiscal procyclicality is a major component, explains up to 40% of the variation in long-term growth rates between countries. The welfare costs are substantial, Loayza and Raddatz, 2007 estimate that the excess volatility from procyclical policies reduces permanent consumption by 1-2% in typical emerging economies.

2.2 Explanations for Procyclicality: Financial Constraints and Political Economy

Two broad classes of explanations account for the prevalence of procyclical fiscal policy in emerging and developing economies: credit-market imperfections that tighten borrowing conditions in downturns, and political-economy forces that tilt discretionary spending toward booms even when countercyclical policy would be welfare improving (Frankel et al., 2013).

On the external-finance margin, state-contingent funding costs and occasional market shutdowns in recessions push governments toward contraction when stimulus would be desirable (Calvo et al., 2004; Gavin & Perotti, 1997). Models with collateral constraints or default risk formalize how binding constraints in bad times make optimal plans procyclical (Cuadra et al., 2010; Riascos & Vegh, 2003). Quantitative work that embeds sovereign risk into New Keynesian environments shows that higher default premia strengthen the empirical link between elevated spreads and more procyclical fiscal responses, with pronounced state dependence (Bianchi et al., 2023). Historical evidence also associates limited and volatile market access after debt crises with stronger procyclicality (Gavin & Perotti, 1997).

Political-economy mechanisms operate alongside these financial frictions. Common pool and rent-seeking problems can generate more than proportional spending responses in booms, the 'voracity effect' (Tornell & Lane, 1999), and agency problems with imperfectly informed voters favor using windfalls today instead of saving for downturns (Alesina et al., 2008). The high volatility of the tax base intensifies these pressures (Talvi & Végh, 2005). Transparency and accountability are empirically associated with smaller political budget cycles and less cyclical bias (Alt & Lassen, 2006), while greater political polarization correlates with more procyclical policy (Woo, 2009). Structural models with rent seeking can directly produce procyclicality (Ilzetzki et al., 2013).

These channels interact. Weak institutions raise political pressures in good times and risk premia in bad times, creating a "procyclicality trap." In models with sovereign risk, higher default sensitivity to borrowing in low-income states tilts the optimal stance toward procyclicality even without myopia (Bianchi et al., 2023). Precautionary buffers are optimal in such environments but difficult to sustain politically (Mendoza & Oviedo, 2006), which helps explain why rule adoption often requires complementary gains in credibility or market access to durably alter cyclical patterns.

The commodity dependence amplifies these mechanisms. In commodity exporters, fiscal aggregates converge strongly with price cycles, and procyclicality is more pronounced where institutional constraints are weaker (Céspedes & Velasco, 2014; International Monetary Fund, 2012). Democratic and rule-based settings mitigate some of these responses, where constraints are weak, booms tend to translate into higher spending and debt dynamics that later force contraction (Arezki & Ismail, 2013).

Debates about fiscal effectiveness add nuance. Cross-country estimates point to modest average government consumption multipliers in developing economies and substantial variation between regimes and states of the cycle (Auerbach & Gorodnichenko, 2012; Kraay, 2014; Ramey & Zubairy, 2018). Composition and implementation matter: public investment can yield larger multipliers when project execution and financing conditions are favorable (Izquierdo et al., 2019).

Institutions shape both the prevalence and the consequences of procyclicality. Countries that "graduate" from procyclical behavior typically adopt flexible fiscal rules with escape clauses, independent fiscal councils, and medium-term frameworks (Frankel, 2011; Frankel et al., 2013). Large cross-country panels indicate that rule *design* matters: better-designed and more flexible rules are associated with less procyclicality on average, though rules are no panacea without broader improvements in governance (Bova et al., 2014; Guerguil et al., 2017; Schaechter et al., 2012).

2.3 Cross-regional heterogeneity in fiscal cyclicality

Cross-country evidence shows that procyclicality is the modal fiscal stance among emerging and developing economies, with its intensity varying systematically by region and by institutional capacity (Aizenman et al., 2019; Frankel et al., 2013). In emerging Asia, government expenditure typically moves with the cycle, though less than in commodity-dependent regions. Cross-country estimates report positive co-movement of discretionary outlays with output and revenues, and only limited "graduation" from procyclicality, with modest insurance from automatic stabilizers (Aizenman et al., 2019; Pandey & Patnaik, 2019).

In Sub-Saharan Africa, procyclicality is stronger on average, particularly among oil exporters. External financing conditions, aid volatility, and shallow domestic financial markets are prominent correlates of the cyclical stance (Calderón et al., 2017; Konuki & Villafuerte, 2016; Lledó et al., 2009; Thornton, 2008). Post-transition Europe saw pronounced procyclicality in the early years. However, EU accession and stronger frameworks moved plans toward acyclical norms, yet the results achieved often remain procyclical, pointing to implementation frictions even where rules exist (Gootjes & de Haan, 2022; Kabashi, 2016). Latin America exhibits the widest dispersion: several countries remain strongly procyclical, often tied to commodity revenues and financing, while adopters of cyclically adjusted rules with credible escape clauses achieved markedly more countercyclical profiles with Chile as the canonical case (Alberola et al., 2017; Klemm, 2014; Marcel, 2013).

These patterns motivate our modeling and calibration choices. Multiple mechanisms, credit constraints, political-economic pressures, and their interaction, can rationalize procyclicality, with weights that differ between settings. Institutional design conditions whether policy leans with or against the cycle. Philippine fiscal moments lie within published emerging market ranges, and therefore we use the Philippines as our calibration baseline while keeping the model structure general enough for external validity (Section 5).

2.4 Calibration baseline: why the Philippines

Cross-country work documents the widespread fiscal procyclicality in emerging markets, but testing mechanisms and evaluating counterfactual rules require a country setting that is both representative and data rich enough to discipline a structural model. We use the Philippines as our calibration baseline because it combines typical emerging–market structure and exposures with unusually long, high–frequency macro–fiscal series and transparent classifications that map cleanly into our model.

By standard benchmarks, the Philippine economy sits near the middle of the emerging–market distribution in income, openness, and external balance–sheet exposure. World Development Indicators and external wealth accounts place the country in ranges that are common among middle–income economies, and inward FDI positions are comparable to regional peers (Lane & Milesi-Ferretti, 2018; UNCTAD, 2025; World Bank, 2025a). These features matter for portability: the calibration is anchored in moments that are typical rather than extreme.

Data depth and transparency are a second reason for this choice. Quarterly national accounts begin in 1981, spanning multiple business cycles and canonical shocks (Philippine Statistics Authority, 2025). On the fiscal side, the Department of Budget and Management disseminates disaggregated public finance series that can be bridged to GFSM 2014, with linkages documented in the IMF Fiscal Transparency Evaluation (Mueller et al., 2015). Statistical dissemination for monetary and external accounts follows the IMF's SDDS standards (International Monetary Fund, 2023a). This combination of length, frequency, and classification quality is essential for identifying fiscal feedbacks and validating model counterfactuals.

Within–country variation further helps discipline mechanisms. The sample covers the early-1980s debt crisis and sudden stop, the 1997–98 Asian financial crisis, and the 2008–09 global financial crisis, each revealing different interactions between borrowing constraints and fiscal retrenchment. A long history of IMF arrangements underscores episodes of constrained market access and policy conditionality that are informative for the credit–constraint channel (International Monetary Fund Independent Evaluation Office, 2002).

Institutional characteristics also sit near the emerging–market median. Governance indicators place the Philippines in the mid-range of accountability and control–of-corruption measures, and the fiscal framework has relied on a debt anchor and headline deficit targets—an arrangement often associated with procyclical bias absent structural-balance rules (International Monetary Fund, 2023b; Transparency International, 2025; World Bank, 2025b). Finally, exposures that are emblematic of emerging markets—sudden stops, recurrent climate shocks, and sizable remittance inflows—provide a realistic environment in which to assess the interaction of fiscal rules and external conditions (Bayangos & Jansen, 2011; PAGASA, Department of Science and Technology, 2025; World Bank, 2025a).

In sum, we calibrate to the Philippines not to produce a country case study per se, but because it is a data-rich, structurally typical emerging market whose history delivers the variation needed to identify the borrowing-constraint, limited-commitment, and political-economy channels emphasized in our model. This choice supports external validity while keeping the calibration anchored in observable macro–fiscal moments and policy episodes common across emerging markets.

2.5 Endogenous fiscal policy in DSGE models: methodological foundations

Our approach follows the literature that endogenizes government spending within dynamic general equilibrium environments. Treating fiscal policy as an exogenous disturbance, the early convention of the real business cycle, cannot capture the systematic, state-contingent component of government behavior that drives fiscal volatility (Fernández-Villaverde et al., 2015). We build on Bachmann and Bai (2013a, 2013b), who model public consumption as an equilibrium choice of a time-consistent government rather than as a forcing process.

Relative to the exogenous-spending tradition (e.g., Kydland & Prescott, 1982), subsequent work showed that the design of fiscal behavior matters for propagation: simple feedback rules or constraints alter comovement and persistence (Baxter & King, 1993; Cardia et al., 2003; Schmitt-Grohé & Uribe, 1997). Parallel advances in optimal policy with limited commitment provide tractable foundations for time-consistent behavior and state-dependent dynamics (Klein et al., 2008). In this vein, Bachmann and Bai (2013b) embeds a welfare-maximizing, time-consistent authority that chooses government consumption subject to implementation frictions.

Three elements from that framework are central for the study: (i) a frictionless optimizing government generates too little volatility and persistence relative to the data; (ii) adjustment costs and implementation lags help match observed persistence; and (iii) preference (valuation) shocks to public goods rationalize residual volatility not explained by fundamentals. We retain these features and adapt the environment to an emerging-market small open economy.

The model is a small open economy with incomplete international asset markets in the spirit of Mendoza (1991) and Schmitt-Grohé and Uribe (2003). Consistent with our scope, there is no monetary policy block. The exogenous state vector comprises (i) productivity shocks disciplined by emerging-market volatility and persistence (Aguiar & Gopinath, 2007; Bachmann & Bai, 2013b), (ii) preference shocks that shift the valuation of public consumption (Bachmann & Bai, 2013b), and (iii) world interest rate shocks that follow the external-finance literature (Neumeyer & Perri, 2005; Uribe & Yue, 2006). The government chooses public consumption to maximize household welfare, taking exogenous states and private choices as given and subject to standard implementability and resource constraints. Stationarity is ensured by a debt-elastic interest-rate premium; we do not model sovereign default or additional financial frictions.

This setup is the time-consistent counterpart to Ramsey benchmarks that imply tax smoothing and countercyclical spending under complete markets (Barro, 1979; Lucas & Stokey, 1983). Our focus is on implementation frictions and emerging-market drivers (productivity, preferences, and world rates), with the goal of attributing observed fiscal comovement to policy choice under constraints versus shocks in a structure that maps cleanly to data yet remains rich enough for counterfactual fiscal rules. In this sense, the analysis complements the broader incomplete-commitment literature (e.g., Aiyagari et al., 2002) while staying within the ingredients used here.

3 Fiscal cyclicality in emerging markets: evidence from a calibration baseline

This section documents fiscal cyclicality using annual Philippine public–finance data for 1980–2019, which we use as our calibration baseline. Philippine moments fall within published emerging-market ranges, so the series provide a credible benchmark rather than an outlier. The choice aligns with the model's focus on an endogenous, time-consistent fiscal authority in a small open economy, where co-movement and persistence of spending are the moments that discipline the mechanism.

Data, construction, and mapping. We assemble aggregates from the Department of Budget and Management's *Budget of Expenditures and Sources of Financing* (BESF, various years) and map them to *Government Finance Statistics Manual* (GFSM 2014) concepts using the bridges documented in the IMF Fiscal Transparency Evaluation for the Philippines. Output is real GDP from the Philippine Statistics Authority's *National Accounts*. Moments are computed on log levels at the annual frequency with no filter in the baseline. Category definitions—government final consumption expenditure, economic services (public investment), general public services, social services, defense, net lending, and interest payments—follow GFSM 2014 conventions; line-item mapping and any splices are detailed in the Data Appendix.

Representativeness. Simple moments place the Philippines near the center of emerging-market distributions: spending–output co-movement and volatility ratios lie in interquartile ranges reported by cross-country studies. We therefore use the Philippines as the calibration baseline rather than as a country-specific case.

Regularities and calibration targets. Two properties generalize to emerging markets and guide the calibration. Government consumption comoves positively with output and is

Table 1: Fiscal cyclicality in the Philippines (1980–2019): Core aggregates

	GDP	Government consumption	Economic services (public investment)	General public services	Social services
Standard deviation (%)	1.5	2.1	6.6	4.7	4.7
AR(1) persistence ρ	0.48	0.63	0.36	0.34	0.46
Correlation with output	1.00	0.53	0.31	0.33	0.27
Correlation with lagged output	0.44	0.46	0.17	0.06	−0.11
Correlation with output (lag 2)	−0.09	0.13	0.28	0.17	−0.10

Notes: Annual series, 1980–2019. Moments computed on log levels (no filter); robustness to HP filtering is reported in the Data Appendix. Spending categories follow GFSM 2014 mapping from BESF functional and economic classifications. Sources: DBM *Budget of Expenditures and Sources of Financing* (various years); PSA *National Accounts*.

Table 2: Fiscal cyclicality in the Philippines (1980–2019): Financing items

	Defense	Net lending	Interest payments
Standard deviation (%)	5.5	69.5	8.2
AR(1) persistence ρ	0.01	-0.06	-0.01
Correlation with output	0.37	-0.23	-0.32
Correlation with lagged output	-0.06	-0.18	-0.29
Correlation with output (lag 2)	0.05	-0.07	-0.21

Notes: Annual series, 1980–2019. “Defense” and “General public services” follow BESF functional classifications; “Net lending” and “Interest payments” follow GFSM 2014. See the Data Appendix for reconciliation to national-accounts aggregates and for alternative filters and robustness checks.

persistent at the annual frequency, consistent with multi-year budget processes and implementation frictions. Spending is relatively volatile—government consumption’s standard deviation exceeds that of output—and the pattern by category is heterogeneous: current spending reacts more strongly than social outlays, and public investment compresses disproportionately in downturns. These regularities map to the features we discipline (co-movement and persistence of G; intercept shifts in the fiscal rule) and to the shock processes we calibrate (productivity, world interest rates, and preference shocks).

4 Model

Environment. We study a small open economy (SOE) real business cycle model with flexible prices and wages, a representative household, competitive firms, and a government that purchases a flow of public consumption G_t. Monetary frictions and seigniorage are absent; spending and interest payments are tax financed. To close the open economy without resorting to a debt-elastic interest-rate premium (Schmitt-Grohé & Uribe, 2003), we impose a constant domestic-debt rule and two prudential feasibility constraints: a debt-to-output ceiling and an government expenditure cap. These constraints mirror widely studied fiscal-rule designs and expenditure rules that anchor public spending to output (Bohn, 1998; Caselli & Reynaud, 2020; Ghosh et al., 2013; Heinemann et al., 2018; Holm-Hadulla et al., 2012). Our quantitative analysis targets medium-run real responses to government spending; monetary policy and inflation dynamics are outside the model's scope. Data are in U. S. dollars at constant prices; cycle components are extracted using an HP filter on annual data.[1]

Modeling choices and economic rationale. By abstracting from nominal rigidities and the monetary block, we concentrate on the real transmission of changes and innovations about productivity z_t, the external interest rate r_t^*, and shifting preferences of households for private goods consumption over public goods θ. By design, the framework excludes financial intermediation or borrowing constraints, and household heterogeneity. This isolates the core open-economy RBC mechanisms: intertemporal reallocation through changes in absorption, the user cost of capital, and external accounts. We use the SOE structure to study how anticipated changes in fundamentals shift current allocations, the trade balance, and the current account (Barsky & Sims, 2011; Beaudry & Portier, 2006; Beaudry et al., 2011; N. Jaimovich & Rebelo, 2009; Kamber et al., 2017; Mendoza, 1991; Obstfeld & Rogoff, 1996; Schmitt-Grohé & Uribe, 2003; Schmitt-Grohé & Uribe, 2012). [2]

4.1 Households

Preferences. Household preferences are log–Cobb–Douglas in private and public goods,

$$u(C_t, G_t) \;=\; \theta_t \log C_t \;+\; \Big(1-\theta_t\Big) \log G_t, \qquad \theta_t \;=\; \bar{\theta}\,\hat{\theta}_t, \tag{1}$$

The shock θ_t tilts marginal utility between private and public consumption. When θ_t is high, households value private consumption relatively more; when it is low, the value of public

[1]These modeling choices align with the SOE real-business-cycle and news-shock literatures, e. g., (Clarida et al., 1999; Coşkun, 2019; Galí et al., 2007; Ilzetzki et al., 2013; Mendoza, 1991; Neumeyer & Perri, 2005).

[2]We use "≡" for definitions and national-accounts identities, and "=" for equilibrium conditions.

Table 3: Notation (selected symbols used in the model)

Symbol	Meaning
B_t^G	Total public debt; $B_t^G \equiv \bar{B}$ (constant)
$\bar{B}$	Constant public debt level with $\bar{B} = B_t^{\text{dom}} + B_t^X$
B_t^{dom}	Domestic residents' holdings of public debt
B_t^X	Foreigners' holdings of public debt
B_t^F	Residents' gross foreign public-bond holdings
K_t	Physical capital
A_t^{agg}	Internal aggregator for the household: $K_t + B_t^{\text{dom}} + B_t^F$
NFA_t	Net foreign assets: $B_t^F - B_t^X = A_t^{\text{agg}} - K_t - \bar{B}$ (Eqs. (37), (38))
TB_t	Trade balance (goods)
NFI_t	Net factor income: $r_t^* \text{NFA}_t$
CA_t	Current account: $TB_t + \text{NFI}_t$ (Eq. (39))
Y_t	Output; resource identity $Y_t = C_t + I_t + G_t + AC_t + TB_t$ (Eq. (19))
C_t	Private consumption
I_t	Investment
G_t	Public consumption
AC_t	Adjustment costs entering absorption
r_t^*	World real interest rate
z_t	Total factor productivity (TFP)
θ_t	Preference weight on private consumption in $u(C_t, G_t)$

A_t^{agg} is a modeling device for the household portfolio problem; external accounting uses NFA_t via Eqs. (37) and (38).
All variables are real and measured at the model's base frequency.

purchases is higher. This parsimonious preference shifter follows the literature that uses state-dependent utility weights to capture time-variation in the stance toward public goods. with $\hat{\theta}_t \in \{\underline{\theta}, \overline{\theta}\}$ evolving according to a symmetric two-state Markov chain,

$$\Theta = \begin{bmatrix} \rho & 1-\rho \\ 1-\rho & \rho \end{bmatrix},$$

orthogonal to technology and interest-rate processes (Bachmann & Bai, 2013b).

Budget constraint and Euler condition. We define the asset, A_t, held by the representative household, to consist of both capital and bonds. With a labor-income tax $\tau_{\ell,t}$ and a uniform asset-income tax τ_a applied to bond interest and to the rental rate on capital, the period budget can be written as

$$C_t \;+\; A_{t+1} \;=\; (1-\tau_{\ell,t})\, w_t L \;+\; \Big[1+(1-\tau_a)\, r_t^*\Big]\, A_t. \tag{2}$$

Let λ_t denote the multiplier on the household budget and $u(C_t, G_t) = \theta_t \log C_t + (1-\theta_t)\log G_t$. Then

$$\lambda_t \;=\; \frac{\theta_t}{C_t}. \tag{3}$$

Under perfect mobility, portfolio indifference collapses the Euler conditions to a single unified condition,

$$\frac{\theta_t}{C_t} \;=\; \beta\, \mathbb{E}_t\!\left[\frac{\theta_{t+1}}{C_{t+1}}\Big(1+(1-\tau_a)\, r_{t+1}^*\Big)\right], \tag{4}$$

Condition (4) equates the marginal utility cost of saving one additional unit today to the discounted marginal benefit tomorrow, scaled by the gross after-tax world return. Because the next-period interest rate r_{t+1}^* is known at t under our news shocks, households perfectly foresee the payoff to saving when choosing C_t and A_{t+1}.

4.2 Firms

Technology and factor pricing. Output is produced with a Cobb–Douglas technology,

$$Y_t \;=\; z_t\, K_t^{\alpha} L^{1-\alpha}, \qquad \alpha \in (0,1). \tag{5}$$

Under perfect competition, inputs are paid their marginal products,

$$r_{k,t} \;=\; \frac{\partial Y_t}{\partial K_t} \;=\; \alpha\, z_t \left(\frac{K_t}{L}\right)^{\alpha-1}, \qquad w_t \;=\; \frac{\partial Y_t}{\partial L} \;=\; (1-\alpha)\, z_t \left(\frac{K_t}{L}\right)^{\alpha}. \tag{6}$$

With perfect capital mobility, the no-arbitrage condition (8) requires the rental rate net of depreciation to equal the world interest rate,

$$r_{k,t} - \delta \;=\; r_t^*. \tag{7}$$

Capital mobility and investment. Firms operate $Y_t = z_t K_t^{\alpha} L^{1-\alpha}$ in competitive factor markets, with inelastic labor supply L. Perfect capital mobility equates the user cost to the marginal product of capital:

$$\alpha\, z_t \left(\frac{K_t}{L}\right)^{\alpha-1} \;=\; r_t^* + \delta. \tag{8}$$

Equation (8) delivers a static capital demand and, in per-worker terms, $k_t \equiv K_t/L = \Big(\alpha z_t/(r_t^*+\delta)\Big)^{\frac{1}{1-\alpha}}$. Equivalently,

$$K_t \;=\; L\left(\frac{\alpha\, z_t}{r_t^*+\delta}\right)^{\frac{1}{1-\alpha}}. \tag{9}$$

Given our news specification, (z_{t+1}, r^*_{t+1}) are known at time t. The desired next-period stock chosen at t is therefore

$$K_{t+1} \;=\; L\left(\frac{\alpha\, z_{t+1}}{r^*_{t+1}+\delta}\right)^{\frac{1}{1-\alpha}}, \tag{10}$$

so current investment, $I_t \equiv K_{t+1} - (1-\delta)K_t$, moves one-for-one with news about (z_{t+1}, r^*_{t+1}), as in standard anticipation experiments Beaudry and Portier, 2006; N. Jaimovich and Rebelo, 2009. The comparative statics are immediate: $\partial K_{t+1}/\partial z_{t+1} > 0$ and $\partial K_{t+1}/\partial r^*_{t+1} < 0$.[3]

Wage as a function of fundamentals. From (6), $w_t = (1-\alpha)z_t(K_t/L)^{\alpha}$. Substituting (9) yields

$$w_t \;=\; (1-\alpha)\, z_t \left(\frac{\alpha\, z_t}{r^*_t+\delta}\right)^{\frac{\alpha}{1-\alpha}}. \tag{11}$$

Under perfect mobility, w_t depends only on contemporaneous fundamentals (z_t, r^*_t) through the equilibrium capital–labor ratio and is independent of the asset position A_t. Higher z_t raises w_t directly and via capital deepening; a higher r^*_t lowers w_t by reducing the equilibrium capital–labor ratio.

Stochastic environment. The exogenous processes for the next-period fundamentals are AR(1) and *known at time t* ("news" shocks):

$$r^*_{t+1} = (1-\rho_r)\,\bar{r}^* + \rho_r\, r^*_t + \varepsilon^r_t, \qquad \varepsilon^r_t \sim \mathcal{N}(0, \sigma_r^2), \tag{12}$$

$$\ln z_{t+1} = (1-\rho_z)\,\ln \bar{z} + \rho_z\,\ln z_t + \varepsilon^z_t, \qquad \varepsilon^z_t \sim \mathcal{N}(0, \sigma_z^2), \tag{13}$$

with $0 < \rho_r, \rho_z < 1$ and steady-state means $\bar{r}^*, \bar{z}$. Hence at time t the information set is $\{z_t, r^*_t, \varepsilon^z_t, \varepsilon^r_t\}$ and (z_{t+1}, r^*_{t+1}) *are known*—a timing standard in the news-shock literature Barsky and Sims, 2011; Beaudry and Portier, 2006; N. Jaimovich and Rebelo, 2009; Schmitt-Grohé and Uribe, 2012 that makes one-period-ahead returns *deterministic* when investment is chosen.

4.3 Government Sector and Fiscal Financing Assumptions

Budget constraint, debt rule, and tax instruments. The government purchases public consumption G_t and maintains a stock of one-period domestic bonds B_t. Its flow budget constraint is

$$B_{t+1} \;=\; (1+r_{b,t})\,B_t \;+\; G_t \;+\; AC_t \;-\; T_t \tag{14}$$

[3]With convex installation costs or time-to-build, (10) pins down the *target* stock rather than the within-period realization; the signs of the comparative statics are unchanged.

$$T_t \equiv \tau_{\ell,t}\, w_t L \;+\; \tau_a\, r_{b,t}\, A_t, \tag{15}$$

where T_t denotes tax revenue, raised through a proportional labor-income tax $\tau_{\ell,t} \in [0, \bar{\tau}_\ell)$ and a proportional tax τ_a on private asset income. As a policy rule, the bond stock is held constant:

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

Imposing this rule in (14) yields a period-by-period primary surplus equal to interest on the outstanding stock,

$$T_t \;=\; G_t \;+\; AC_t \;+\; r_{b,t}\, \bar{B}.$$

Given (G_t, A_t) and prices $(w_t, r_{b,t})$, a labor tax that exactly implements the constant-debt rule is

$$\tau_{\ell,t} \;=\; \frac{G_t \;+\; AC_t \;+\; r_{b,t}\, \bar{B} \;-\; \tau_a\, r_{b,t}\, A_t}{w_t\, L}, \qquad 0 \le \tau_{\ell,t} \le \bar{\tau}_\ell < 1, \tag{16}$$

with L denoting inelastic labor supply. Although labor is inelastic, financing affects disposable income and borrowing capacity (Baxter & King, 1993; Leeper, 1991).

Adjustment costs (Government). Changes in government purchases entail a convex resource cost (Bachmann & Bai, 2013b) described as follows,

$$AC_t \;=\; \frac{\Omega}{2}\left(G_{t+1} - G_t\right)^2, \qquad \Omega > 0, \tag{17}$$

This term is a pure resource use and does not enter the utility function. It therefore appears in both the government budget and the goods-market identity, without introducing intertemporal preference wedges.

Expenditure feasibility constraint. Public purchases are required to satisfy a deterministic feasibility cap relative to (expected) output,

$$G_{t+1} \;\le\; \bar{g} \cdot Y_{t+1}, \qquad \bar{g} \in (0,1), \tag{18}$$

so that at time t the policy choice for G_{t+1} is restricted by the anticipated resource envelope. Taken together, the constant-debt rule and its implementing tax (16) imply a per-period primary surplus of $r_{b,t}\bar{B}$. The ratio caps (**??**) and (18) ensure feasibility, and the adjustment cost (17) is counted once, as a resource use in (14) and (19), and does not enter utility.

4.4 Market Clearing and Balance of Payments

Goods market clearing and resource constraint. Total output is allocated to private absorption, public purchases, adjustment costs, and the trade balance:

$$Y_t \;=\; C_t + I_t + G_t + AC_t + TB_t. \tag{19}$$

Equation (19) is the standard absorption identity: output is allocated to private consumption, investment, public purchases, and the resource cost AC_t, with the trade balance adjusting residually. We define I_t through (20) and use (21) to track external adjustment.

Investment is defined by capital accumulation:

$$I_t \;=\; K_{t+1} - (1-\delta)\,K_t. \tag{20}$$

The term AC_t denotes the fiscal adjustment cost specified in (17) and is treated as a resource use; it does not enter utility. Equation (19) implies:

$$TB_t \;=\; Y_t - \Big(C_t + I_t + G_t + AC_t\Big). \tag{21}$$

A positive TB_t indicates a net export of goods and services; a deficit must be financed by a reduction in net foreign assets. This is the standard absorption formulation in open-economy macroeconomics (e. g., (Corsetti & Müller, 2013; Obstfeld & Rogoff, 1996)).

Timing and information. At the beginning of period t, agents observe the state vector

$$\mathbf{s}_t \;\equiv\; \Big(A_t,\, G_t,\, r^*_t,\, z_t,\, \varepsilon_{r,t},\, \varepsilon_{z,t},\, \theta_t\Big).$$

For notational convenience, the state includes the "news" variables $\varepsilon_{r,t}$ and $\varepsilon_{z,t}$ generated by Equations (12) and (13). These variables reveal next-period fundamentals at date t. In detail, r^*_{t+1} and z_{t+1} are known when date-t choices are made; in the state vector we simply denote them by $\varepsilon_{r,t}$ and $\varepsilon_{z,t}$.

Given (z_t, r^*_t), the firm's static capital-demand condition holds as in Equation (9). Because (z_{t+1}, r^*_{t+1}) are known at date t, Equation (10) determines K_{t+1} as a function of $(\varepsilon_{z,t}, \varepsilon_{r,t})$.

Government move. The government chooses G_{t+1} subject to (**??**) and (18); the associated adjustment cost AC_t is paid at date t as in (17). Under the constant-debt rule $B_{t+1} = B_t \equiv \bar{B}$ and with $r_{b,t} = r^*_t$, the period-t sequential budget identity is

$$T_t \;\equiv\; G_t + AC_t + r^*_t\,\bar{B} \;=\; \tau_{\ell,t}\,w_t L \;+\; \tau_a\,r^*_t\,A_t \tag{22}$$

Household move. Given $\mathbf{s}_t$ and G_{t+1}, the household chooses $\{C_t, A_{t+1}\}$ subject to the unified-asset budget constraint in (2), where the asset-income tax applies to net capital income. Under perfect capital mobility, no-arbitrage implies

$$r_{k,t} - \delta \;=\; r_{b,t} \;=\; r_t^*, \tag{23}$$

and the Euler condition is given by (4).

Market clearing and state transition. Goods market clearing is given by (19) with investment defined by (20). The state evolves according to

$$\mathbf{s}_{t+1} \;\equiv\; \Big(A_{t+1},\, G_{t+1},\, r_{t+1}^*,\, z_{t+1},\, \varepsilon_{r,t+1},\, \varepsilon_{z,t+1},\, \theta_{t+1}\Big),$$

where the news variables $(\varepsilon_{r,t+1}, \varepsilon_{z,t+1})$, realized at the beginning of $t+1$, are generated by (12) and (13) and reveal (r_{t+2}^*, z_{t+2}).

4.5 Markov-Perfect Equilibrium (MPE)

Public consumption is determined by the government to maximize the contemporaneous utility of the household, which depends on both private consumption and public goods, **subject to adjustment costs on changes in government spending and tax-collapse constraints**.

This economy is characterized as a Markov-perfect equilibrium, defined by the following components:

- **State vector:** $\mathbf{s}_t = (A_t, G_t, r_t^*, z_t, \varepsilon_{r,t}, \varepsilon_{z,t}, \theta_t)$
- **Government consumption policy function:** $G_{t+1} = \Psi(\mathbf{s}_t)$
- **Transition function for asset holdings:** $A_{t+1} = H(\mathbf{s}_t, G_{t+1})$
- **Tax function:** $\tau_{l,t} = \tau_l(\mathbf{s}_t; H)$
- **Value function:** $v(a, \mathbf{s}_t; \Psi, H)$
- **Best response function:** $J(a, \mathbf{s}_t, G_{t+1}; \Psi, H)$
- **Best response decision rule for assets:** $a' = h(a, \mathbf{s}_t, G_{t+1}; \Psi, H)$

The equilibrium conditions ensure that for any given G_t, the value function and decision rules address the household's problem effectively:

$$J(a, \mathbf{s}_t, G_{t+1}; \Psi, H) = \max_{c,\,a'}\Big\{\theta \log(c) + (1-\theta)\log(G_t) + \beta\,\mathbb{E}\Big[v(a', \mathbf{s}_{t+1}; \Psi, H)\Big]\Big\} \tag{24}$$

subject to the budget constraint:

$$c + a' \;=\; (1 - \tau_{\ell,t})\, w_t L \;+\; \Big[1 + (1 - \tau_a)\, r_t^*\Big]\, a,$$

the non-negativity (borrowing) constraints:

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

and the functional restrictions

$$A' \;=\; H(\mathbf{s}, G'), \qquad \tau_l \;=\; \tau_l(\mathbf{s}; H), \qquad w = w(r^*, z)$$

Furthermore, the government's policy function is chosen to maximize household welfare:

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

where $\mathbf{s} = (A, G, r^*, z, \varepsilon_r, \varepsilon_z, \theta)$ and $(\varepsilon_r, \varepsilon_z)$ denote the news variables that determines the next-period fundamentals.

5 Calibration and Estimation

5.1 Strategy

We adopt a hybrid approach tailored to the paper's question. Standard preference/technology parameters are set to long-run targets from the literature; small-open-economy (SOE) features and fiscal frictions are disciplined internally so that the model reproduces *emerging-market* business-cycle regularities that matter for our mechanism (procyclical and persistent G, smooth C in levels, limited risk sharing). All objects are annual. The model is solved in levels (not log deviations). When we compare model and data moments, we HP-filter simulated series with $\lambda = 6.25$ for consistency with the stationary model.

5.2 Data, Moments, and Measurement

We target stylized EM moments rather than a single country panel. Output maps to real GDP; government spending to NIPA-style government consumption; the safe rate to the world short rate. Model consumption excludes durables and public services. A summary of the data definitions and filters appears in Appendix (To Follow).

5.3 Parameter Partition and Roles

Parameters are grouped into four buckets: (i) *externally set* preference/technology; (ii) *SOE structure* (NFA anchor, capital mobility); (iii) *fiscal frictions/rule shifters* (adjustment costs, procyclicality and pull-to-target); and (iv) *shock processes*. Table 4 reports values, sources, and the economic role each plays in identification. A compact moment check is given in Table 5.

Given our focus on the mechanism and the endogenous fiscal rule, we calibrate the SOE and fiscal blocks to reproduce targeted co-movement and persistence ($\mathrm{Corr}(G, Y)$, $\rho(G)$) while maintaining standard macro ratios. Model objects are simulated for 2,000 periods with a 400-period burn-in, fixed RNG seeds, tolerance 5×10^{-3}, and damping 0.30.

Equilibrium Solution. We solve for Markov Perfect Equilibrium (MPE) using value function iteration (VFI) on a discretized state space. The state vector includes the unified asset A_t, government spending G_t, current and next-period fundamentals $(r_t^*, z_t, r_{t+1}^*, z_{t+1})$, and the preference shock θ_t. Under our news-shock specification, next-period fundamentals (z_{t+1}, r_{t+1}^*) are known at time t, making one-period-ahead returns deterministic when investment is chosen.

The solution method alternates between: (1) household optimization given government policy, solved using the Endogenous Grid Method (EGM) with a tax-collapsed budget constraint; and (2) government optimization anticipating household response, solved via value function iteration on the government Bellman equation. Policy functions are approximated as log-linear-quadratic functions: $\log(A') = \alpha(z, \theta, r^*)'\phi(\log(A), \log(G))$ and $\log(G') = \beta(z, \theta, r^*)'\phi(\log(A), \log(G))$, where ϕ is a polynomial basis (default: quadratic in $\log(A)$ and $\log(G)$).

Grid Configuration. The grid configuration is $(n_z, n_r, n_\theta, n_g, n_a) = (3, 2, 2, 31, 36)$ for the baseline, yielding 12 exogenous states ($3{\times}2{\times}2$) and 372 total states when combined with the endogenous government spending grid. The government spending grid is constructed as center-heavy around state-contingent targets $G^*(z, r, A_{ss}, \theta)$ computed using steady-state assets A_{ss}, ensuring efficient coverage of the relevant policy space. Convergence tolerance is 5×10^{-3} on coefficient differences. The model handles occasionally binding constraints (e.g., $\tau_\ell \in [0, \tau_{\ell,\max}]$ and $G_{t+1} \leq \bar{g} \cdot \mathbb{E}_t[Y_{t+1}]$) through feasibility checks in the government problem. We report fit quality (global R^2) and elasticities at the mean state in Section 6.1.

5.4 Steady State

Solution Method. Steady-state values are computed using *direct algebraic solution* of the model equations. No log-linearization, Taylor expansion, or iterative methods are used. The solution is *closed-form* and *exact*, computed in a single pass (O(1) complexity). This is possible because the capital mobility condition provides an invertible relationship between capital and the world interest rate, allowing direct sequential solution of all steady-state variables.

Computation. Steady-state values are computed at $z = 1$, $r = r^*$, and $\theta = \bar{\theta}$. The solution follows a recursive block structure:

Block 1: Production and Factor Prices. Under mobile capital (SOE with capital mobility), capital K is pinned by the world interest rate through the no-arbitrage condition:

$$K_{ss}/L = \left(\frac{\alpha z_{ss}}{r^* + \delta}\right)^{\frac{1}{1-\alpha}},$$

which directly yields K_{ss} given $z_{ss} = 1$ and r^*. Output follows from the Cobb-Douglas production function:

$$Y_{ss} = z_{ss} K_{ss}^{\alpha} L^{1-\alpha}.$$

The wage is determined by the marginal product of labor:

$$w_{ss} = (1-\alpha) z_{ss} \left(\frac{K_{ss}}{L}\right)^{\alpha},$$

which is independent of the unified asset A in the SOE case (capital is mobile).

Block 2: Assets and Government Spending. To ensure stationarity in the open economy, we impose a constant domestic debt rule $B_{t+1} = B_t = \bar{B}$, which serves as a closure device (an alternative to debt-elastic interest rate schedules described in Schmitt-Grohé and Uribe, 2003). The unified asset is defined as $A_t \equiv K_t + B_t$, combining installed capital and total public debt. Net foreign assets (NFA), which tracks the external position separately, are set to the target $\bar{A}^{\text{NFA}} = 0$ (balanced trade in long run), so $A_{ss} = \bar{A} = 0$ in steady state. Government spending G_{ss} is set to 15% of output:

$$G_{ss} = 0.15 \cdot Y_{ss}.$$

Block 3: Investment and Consumption. Steady-state investment equals depreciation:

$$I_{ss} = \delta \cdot K_{ss}.$$

Consumption is residually determined from the resource constraint:

$$C_{ss} = Y_{ss} - I_{ss} - G_{ss}.$$

Block 4: Tax Rate. The labor tax rate $\tau_{\ell,ss}$ is computed to satisfy the government budget constraint:

$$T_{ss} = G_{ss} + r^*\bar{B} = \tau_{\ell,ss} w_{ss} L + \tau_a r^* A_{ss},$$

yielding:

$$\tau_{\ell,ss} = \frac{G_{ss} + r^*\bar{B} - \tau_a r^* A_{ss}}{w_{ss} L}.$$

Calibration Usage. Steady-state values serve multiple roles in calibration and solution:

Government Spending Target Function. The state-contingent target $G^*(z, r, A, \theta)$ uses steady-state values as normalization and anchors:

$$G^*(z, r, A, \theta) = (1 - \xi_A) \cdot G_{ss} \left(\frac{Y(z, r)}{Y_{ss}}\right)^{\eta_g} \cdot \left(\frac{1-\theta}{1-\bar{\theta}}\right)^{\xi_\theta} + \xi_A \cdot \left[\tau_{\ell,ss} w(z, r) L + \tau_a r^* A\right],$$

where G_{ss}, Y_{ss}, and $\tau_{\ell,ss}$ provide the baseline scaling and the revenue-based component uses the steady-state tax rate.

Grid Construction. The government spending grid is centered around state-contingent targets computed using A_{ss}:

$$g_{\text{targets}} = \{G^*(z, r, A_{ss}, \theta) : z \in \mathcal{Z}, r \in \mathcal{R}, \theta \in \Theta\},$$

ensuring the grid covers the relevant policy space efficiently.

Tax Smoothing. The government faces a welfare cost for deviating from the steady-state tax rate:

$$\mathcal{C}^\tau(\tau_\ell) = \frac{\lambda_\tau}{2}\left(\tau_\ell - \tau_{\ell,ss}\right)^2,$$

which anchors fiscal policy to the steady state and provides policy stability.

Initialization and Scaling. Policy functions and simulations are initialized at steady-state values ($A_0 = A_{ss}$, $G_0 = G_{ss}$), and steady-state values are used for numerical scaling to ensure computational stability.

Given our calibrated β and world interest rate r^*, the steady-state Euler equation implies a consumption-to-assets ratio that ensures the household's intertemporal optimization condition is satisfied. The model is solved in levels (not log deviations), ensuring a well-defined steady state through the constant-debt rule $\bar{B}$ and the NFA target, which anchor the long-run external position and prevent explosive behavior.

Numerical Values. Under the baseline parameterization, the direct algebraic solution yields: $Y_{ss} \approx 1.53$, $K_{ss} \approx 3.60$, $A_{ss} = 0.00$ (balanced trade), $C_{ss} \approx 0.94$, $I_{ss} \approx 0.36$, $G_{ss} \approx 0.23$ (15% of output), $w_{ss} \approx 1.02$, and $\tau_{\ell,ss} \approx 0.24$. These values are used throughout the calibration and solution process as described above.

5.5 Calibration Validation

Table 5 summarizes the model's baseline business-cycle moments. The calibration implies steady-state quantities consistent with emerging market stylized facts. Based on the baseline parameterization, the model generates: output volatility $\sigma(Y) \approx 0.157$, consumption volatility $\sigma(C) \approx 0.103$, government spending volatility $\sigma(G) \approx 0.072$, and procyclical government spending ($\text{corr}(G, Y) \approx 0.37$). The labor tax rate is countercyclical ($\text{corr}(\tau_\ell, Y) \approx -0.23$). The steady-state investment-to-GDP ratio and government spending-to-GDP ratio are implied by the calibration and are consistent with emerging market data. Non-targeted moments provide an out-of-sample check on propagation.

Locally, η_g moves $\text{Corr}(G, Y)$; Ω and κ_g move $\rho(G)$; (ρ_z, σ_z) target Y's persistence and volatility; (ρ_r, σ_r) discipline external-rate dynamics; $(\rho_\theta, \theta_{low}, \theta_{high})$ shift the intercept of the spending rule. The near-zero slope of G_{t+1} on A_t is a delivered outcome of the time-consistent government problem, not a target.

We then verify that results are invariant to moderate changes in the grid (e.g., $n_g \in \{25, 31, 41\}$), tolerances (2.5×10^{-3} to 1×10^{-2}), and seeds. Alternative filters (band-pass 6–32 periods) and weighting on the co-movement/persistence moments yield the same qualitative mechanism (crowding-out elasticity negative; G procyclical and persistent). Full sensitivity tables (To Follow)

Table 4: Parameter values and roles (annual units unless noted)

Block	**Parameter**	**Value**	**Role / Moment**
External / standard			
Discount factor	β	0.960	Long-run real rate
Capital share	α	0.330	Implied labor share
Depreciation	δ	0.100	Investment/output steady state
Small open economy structure			
World net rate	r^*	0.040[a]	Anchors K under mobile capital
NFA target	$\bar{A}$	0.000	Balanced trade in long run
Fiscal frictions / rule shifters			
Adjustment cost	Ω	0.004	Persistence of G
Pull to target	κ_g	0.150	Speed of reversion of G
Procyclicality	η_g	1.800	corr(G, Y) (procyclicality of G); elasticity of G^* with respect to Y/Y_{ss}
Max labor tax	$\tau_{\ell,\max}$	0.500	Feasibility constraint (tax cap)
Asset income tax	τ_a	0.150	Uniform tax on capital and bond income
Constant domestic debt	$\bar{B}$	0.500	Stationarity closure device
Govt spending cap	$\bar{g}$	0.350	Maximum G/Y ratio (feasibility)
Shock processes			
TFP AR(1)	ρ_z	0.900	First-order autocorrelation of output (TFP persistence)
TFP s.d.	σ_z	0.030	Standard deviation of output (TFP shock volatility)
World rate AR(1)	ρ_r	0.850	First-order autocorrelation of r^*
World rate s.d.	σ_r	0.008	Standard deviation of r^*
Preference AR(1)	ρ_θ	0.900	Low-frequency persistence in G demand (AR(1))
Preference states	$(\theta_{low}, \theta_{high})$	0.60, 0.90	Two regimes for government service demand

[a] Annual net 4% world interest rate (r* = 0.04 annual).

Table 5: Business-cycle moments (model baseline)

Moment	**Mean**	**Std. (level)**	**CV**	**Corr with Y**
Output Y	1.6085	0.157	0.0977	1.0000
Consumption C	0.6243	0.103	0.1651	0.7572
Government G	0.4534	0.072	0.1591	0.3659
Labor tax τ_ℓ	0.4348	0.066	0.1511	−0.2326

Notes: Moments averaged across ten simulations of length T=500 with a 100-period burn-in; "Std. (level)" is implied by Mean×CV and aligns with direct estimates ($\sigma(G) \approx 0.072$).

6 Results and Discussion

6.1 Equilibrium Policy Functions and Strategic Interaction

We study a small open economy with a time-consistent fiscal policy where the government chooses G_{t+1} at t, and households choose next-period private assets A_{t+1} to maximize utility. The model incorporates a news state architecture where agents observe advance information about next-period productivity and interest rate shocks (z_{t+1}, r_{t+1}), capturing settings with credible fiscal commitments or predictable economic conditions. The Markov-perfect equilibrium (MPE) features (i) crowding out of private assets by public demand; and (ii) procyclical fiscal spending. The equilibrium is characterized by a computational state space of 2,232 states arising from the cross-product of 72 exogenous states (12 base states $\times$ 6 news states) and 31 discretized government spending grid points. Asset choices are determined via policy functions evaluated over a 36-point asset grid. Steady-state values are Y=1.5255, K=3.5958, with simulated government spending ranging in $G \in [0.229, 0.556]$ and 0% grid-bound hits (i.e., all simulated values remain within the discretized grid boundaries, confirming appropriate grid construction).

6.1.1 Crowding Out and the Mechanism

At the mean state, a 1% increase in current government purchases lowers next-period assets by approximately 1.7% $\left(\partial \log A_{t+1} / \partial \log G_t = -0.0169\right)$, a moderate crowding-out effect that reflects both the SOE's access to international capital markets and anticipation effects from advance information about future economic conditions.

Interpreting the fitted rules. Table 6 reports log-quadratic policy function coefficients grouped by the 12 exogenous state combinations (z, r, θ). The coefficients incorporate forward-looking expectations via a news state architecture, where agents observe advance information about next-period shocks (z_{t+1}, r_{t+1}) at time t. While the model solves over 2,232 computational states, the policy functions are approximated by log-quadratic forms that vary parametrically across these 12 exogenous state groups. On the household side, asset accumulation displays substantial persistence ($\alpha_1 = 0.168$) with significant heterogeneity across states (std dev = 0.456), while curvature is highly variable ($\alpha_2 \in [-0.15, 3.0]$). The response to fiscal demand is negative and homogeneous across states ($\alpha_3 = -0.0169$; std dev = 0.0138). Government policy is predominantly characterized by state-dependent intercept shifts (std dev = 0.158), indicating fiscal choices that respond to expected future conditions rather than mechanical persistence in spending dynamics.

Table 6: Policy Function Coefficients by Exogenous State Group

	Mean	**Std. Dev.**	**Min**	**Max**
Panel A: Household Asset Policy[a]				
Persistence α_1	0.168105	0.456381	−0.486829	1.233374
Curvature α_2	0.569074	0.954426	−0.153952	3.000000
Gov't response α_3	−0.016857	0.013799	−0.046354	−0.002073
Gov't curvature α_4	−0.001172	0.000960	−0.003214	−0.000147
Panel B: Government Spending Policy[b]				
Intercept β_0	−0.026051	0.158337	−0.226402	0.224233
Own persistence β_1	0.000288	0.000593	−0.000127	0.002096
Gov't curvature β_2	1.5×10^{-6}	1.3×10^{-5}	-1.7×10^{-5}	2.8×10^{-5}
Asset response β_3	0.000042	0.000174	−0.000055	0.000612
Asset curvature β_4	−0.000297	0.000632	−0.001951	0.000457

Mean elasticities: $\partial \log A'/\partial \log G = -0.016857$; $\partial \log G'/\partial \log A \approx 0.000042$.

[a] Household: $\log A_{t+1} = \alpha_0 + \alpha_1 \log A_t + \alpha_2 \log^2 A_t + \alpha_3 \log G_t + \alpha_4 \log^2 G_t$.
[b] Government: $\log G_{t+1} = \beta_0 + \beta_1 \log G_t + \beta_2 \log^2 G_t + \beta_3 \log A_t + \beta_4 \log^2 A_t$. *Notes:* Coefficients estimated using log-quadratic basis functions with ridge regularization ($\lambda = 0.01$). The 12 exogenous state groups arise from discretization: 3 productivity (z) $\times$ 2 interest rate (r) $\times$ 2 preference (θ) states. The model incorporates a news state architecture where agents observe advance information about (z_{t+1}, r_{t+1}) at time t, effectively expanding the exogenous state space to 72 combinations through the cross-product with news. The full computational state space includes these 72 exogenous states multiplied by 31 government spending grid points, yielding 2,232 total states. Convergence achieved at iteration 547: $\Delta H = 8.40\times$tol, $\Delta\Psi = 0.01\times$tol.

From coefficients to economics. Panel A reveals heterogeneous persistence across states—high productivity states ($z = 1.102$) exhibit positive persistence ($\alpha_1 = 1.23$), while low productivity states ($z = 0.907$) can display counter-cyclical savings patterns ($\alpha_1 = -0.49$). This heterogeneity reflects differential expectations across information sets: agents who anticipate favorable future conditions reduce precautionary savings (higher persistence), while those expecting adverse conditions increase precautionary savings (negative persistence or lower positive persistence). The curvature coefficient α_2 ranges from modest concavity (-0.15) to strong convexity (3.0), reflecting the nonlinear dynamics of the equilibrium. Panel B shows that the government's choice of G_{t+1} is primarily characterized by state-contingent intercept shifts with substantial variation ($|\beta_0| \leq 0.226$); the broader G grid avoids cornering and delivers meaningful dispersion (simulated range [0.229, 0.556] with 0% bound hits). The government's reliance on state-dependent intercepts rather than lagged variables reflects optimal fiscal policy under forward-looking expectations, where advance information about future conditions enables sophisticated state-contingent stabilization.

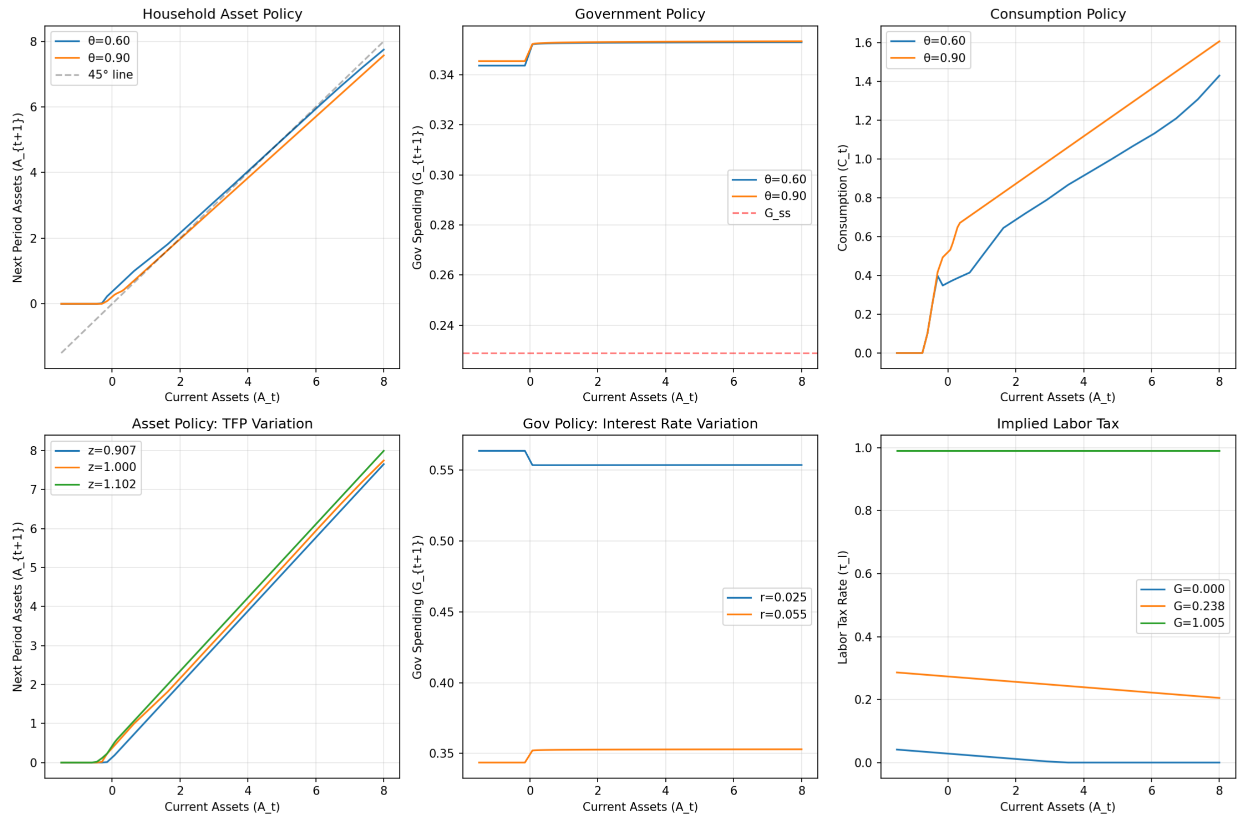

Figure 1: Policy Functions (A', G_{t+1}) Across States. Notes: Fitted log–quadratic rules evaluated on the state grid, incorporating forward-looking expectations via news states. The 12 states correspond to all combinations of productivity ($z \in \{0.907, 1.000, 1.102\}$), interest rate ($r \in \{0.025, 0.055\}$), and preference ($\theta \in \{0.60, 0.90\}$) shocks.

6.2 Business Cycle Properties and the Macro Share of $\mathrm{Var}(G)$

Table 7 reports the simulation moments from the 372-state baseline (ten seeds, T=500 each). Government purchases are procyclical and persistent; consumption co-moves with output but is smoother in levels.

To answer our headline question, using the baseline, macro conditions explain about 72% *of the variance of government purchases* (Table 7, Panel E).

6.2.1 Dynamic Responses to Shocks and Persistence

We compute 30-quarter impulse response functions to one-standard-deviation innovations in technology (z), the world interest rate (r^*), and household preferences for government spending (θ) using the policy function coefficients from iteration 547. Figures 2–4 plot percent deviations from steady state. A persistence summary is in Table 8.

Table 7: Business Cycle Statistics (372-State Baseline; 10 simulations, T=500)

	Mean	Std. (level)	CV	Persistence ρ	Corr. with Y
Output Y	1.608	0.157	0.0977	0.8201	1.0000
Consumption C	0.624	0.103	0.1651	0.5955	0.7572
Government G	0.453	0.072	0.1591	0.6384	0.3659
Labor tax τ_ℓ	0.435	0.066	0.1511	0.4456	-0.2326
Panel E: Macro Share of Var(G)					
$R^2(\log G_t \text{ on } \log Y_t)$					0.134

Notes: "Std. (level)" is implied by Mean×CV; values line up with direct standard deviations ($\sigma(G) \approx 0.072$ across seeds). The "macro share" reports $R^2 = \text{corr}(G, Y)^2 = 0.3659^2 \simeq 0.134$, the variance share of $\log G_t$ explained by aggregate conditions summarized by $\log Y_t$.

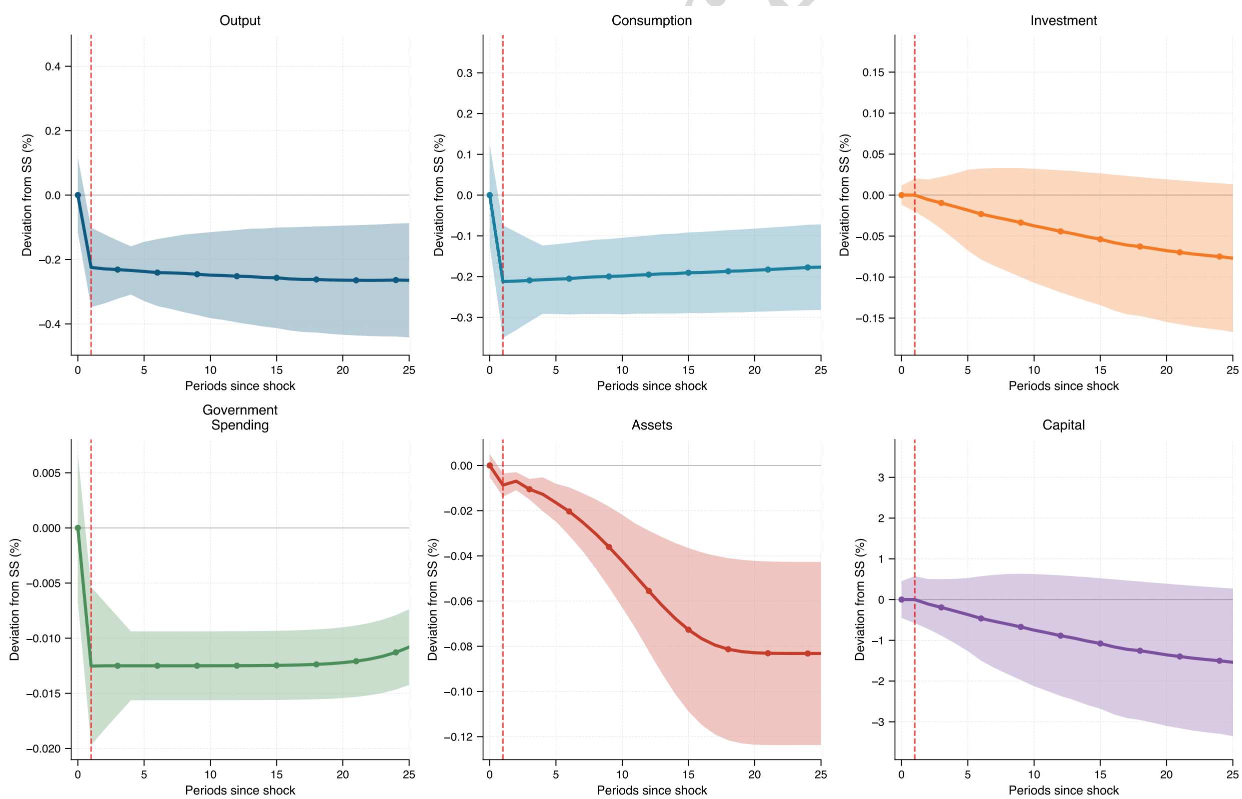

Figure 2: Impulse Response to Negative Productivity Shock (Lower z)

A one-standard-deviation drop in productivity triggers an immediate and persistent contraction in output, peaking at -0.28% after five quarters (Figure 2). The response reflects a standard small open economy (SOE) propagation mechanism: lower productivity reduces the

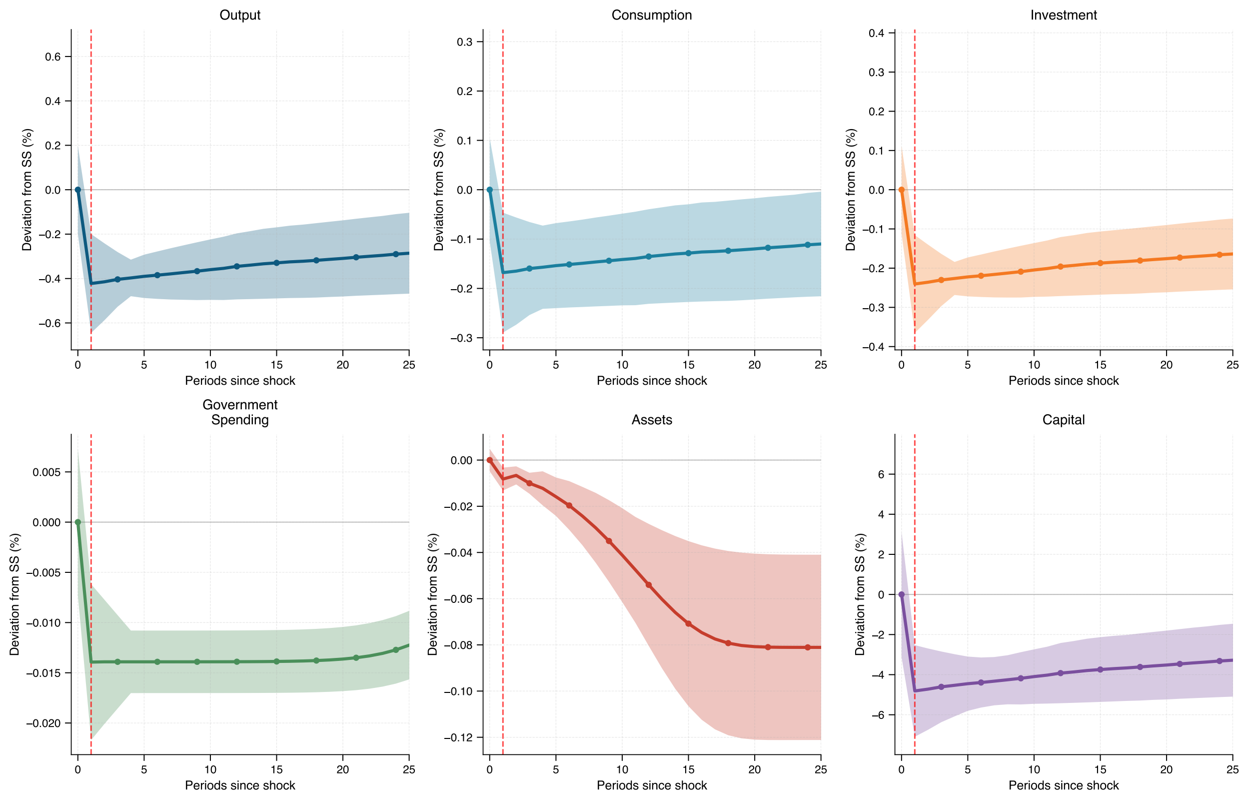

Figure 3: Impulse Response to Increase in World Interest Rate (Higher r*)

marginal product of capital, inducing an instantaneous decline in the optimal capital stock by 1.86%, which then compounds through the production function. Consumption adjusts more gradually, falling by -0.21% at impact and declining to -0.17% at the five-quarter horizon, with a half-life of approximately 15 quarters. The sluggish consumption response relative to output stems from households' ability to borrow internationally at the world rate. Investment remains largely insulated in the short run (-0.09% at $t = 5$), reflecting the SOE's fixed capital adjustment with respect to world interest rates. Government spending exhibits minimal adjustment (-0.01% across the horizon), consistent with our finding that fiscal policy responds primarily through state-contingent intercept shifts rather than endogenous feedback to productivity shocks. Net foreign assets show a muted initial response but gradually deteriorate, falling by -0.04% after nine quarters, consistent with the crowding-out channel documented in Section 6.1.

An increase in the world interest rate acts as a contractionary monetary shock, depressing both demand and supply (Figure 3). Output immediately falls by -0.42% at impact—the sharpest initial response across all shocks—and persists at -0.26% after five quarters. The transmission mechanism operates through the capital-first-order condition: a higher r increases the required marginal product of capital, forcing an instantaneous 4.81% decline in

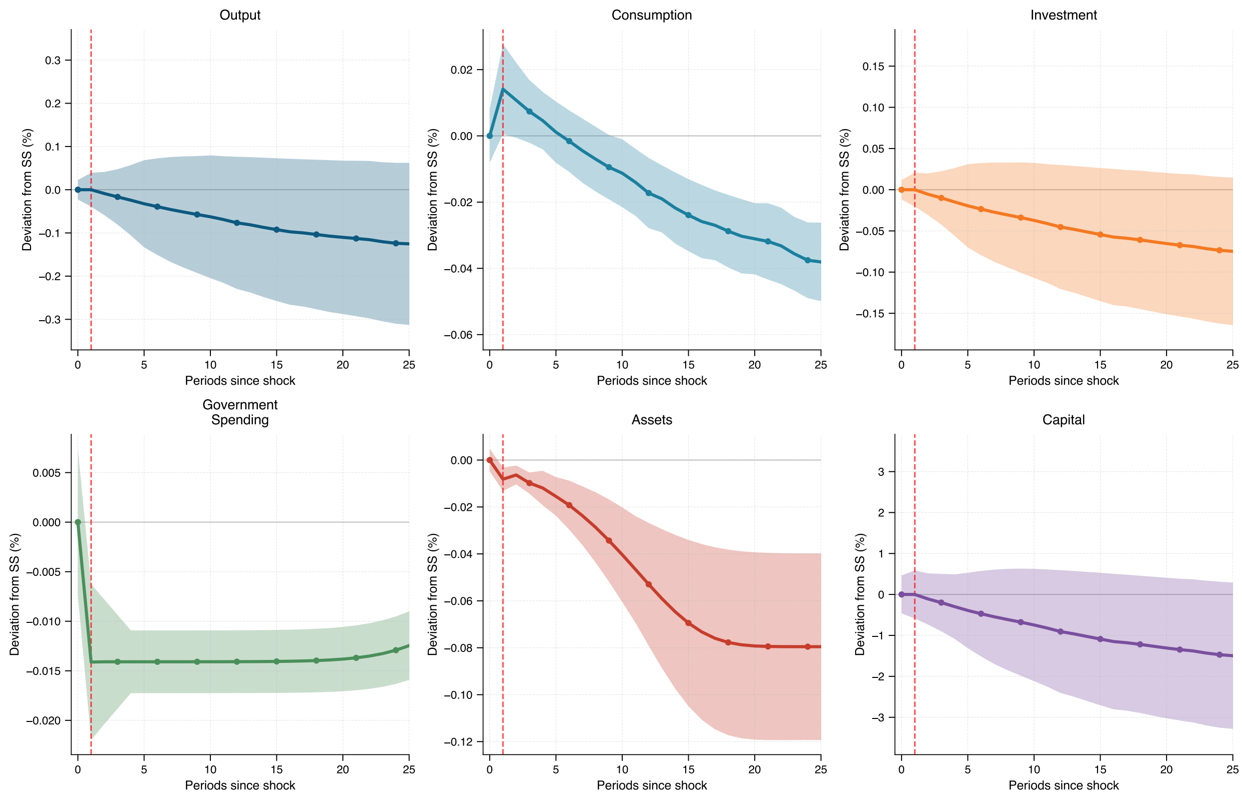

Figure 4: Impulse Response to Reduction in Household Preference for Government Spending (Higher θ)

the optimal capital stock. This capital adjustment dominates the output response, consistent with our SOE framework where capital adjusts instantaneously to arbitrage international returns.

Consumption falls by -0.16% at impact but recovers more rapidly than output, reaching -0.09% by $t = 5$. This asymmetric response reflects the interplay of income and substitution effects: the negative wealth effect from lower output is partially offset by the intertemporal substitution effect as agents postpone consumption in response to higher interest rates. Investment declines more sharply than consumption (-0.24% at impact), driven by the investment Euler condition linking the domestic capital return to the world rate. Government spending again exhibits minimal variation (-0.02%), while net foreign assets show a delayed but persistent deterioration, consistent with deteriorating external balances as the economy adjusts to the higher cost of capital.

A reduction in households' preference for public consumption generates a qualitatively different dynamic pattern (Figure 4). At impact, government spending immediately falls by -1.22%, reflecting the direct effect of the reduced preference parameter θ in household utility. Consumption rises by $+1.22\%$ at impact, as resources previously allocated to public consumption are reallocated to private consumption. Output shows essentially no response at impact (near zero), reflecting the non-market-clearing assumption and the fact that preference shifts do not affect production technology or capital returns in the current period.

The medium-run dynamics reveal a gradual contraction: output falls to -0.16% after five quarters and -0.21% after twenty quarters. This delayed response stems from the forward-looking nature of government policy: the reduction in θ signals lower future fiscal demand, but the initial consumption surge gradually gives way to adjustments in asset accumulation and capital. Net foreign assets show a persistent decline, falling to -0.09% after twenty quarters, representing the cumulative effect of reduced government demand and its impact on private saving decisions. Investment and capital show substantial declines (-1.82% and -2.40% for K at $t = 5$ and $t = 20$, respectively), driven by the persistent contraction in aggregate demand and the associated reduction in the optimal capital stock. The reduction in households' preference for government consumption thus triggers a complex adjustment process where the immediate reallocation from public to private consumption is followed by broader macroeconomic adjustments through capital and asset accumulation.

The simultaneous decline in net foreign assets (-0.83% at impact) alongside the fall in government spending reflects a distinctive feature of the Markov-perfect equilibrium: when households' preference for public consumption declines, the shift in θ alters the entire strategic game between the government and households. The intercept coefficient of the household policy function shifts from -0.0007 to -0.0201 as θ increases, indicating that households recalibrate their optimal asset accumulation strategy in the new equilibrium. This is not a standard crowding-out response where lower government spending mechanically increases private savings; rather, it represents a strategic equilibrium shift where both agents adjust their policies simultaneously. In this new equilibrium with lower fiscal preference, households optimally choose lower asset accumulation, potentially reflecting reduced precautionary savings motives or anticipation of different future fiscal policy paths. The Markov-perfect framework internalizes that government and households take each other's policy functions as given, leading to this joint adjustment of strategies.

Table 8 summarizes the persistence of each shock on output and consumption. Productivity and interest rate shocks exhibit similar persistence profiles: output has a half-life of approximately 15–18 quarters, while consumption adjusts more gradually with half-lives of 20–25 quarters. The preference shock shows the longest persistence, with output remaining -0.21% below steady state after 20 quarters, while consumption initially rises but gradually declines, reflecting the complex adjustment process triggered by the reduction in households' preference for government consumption.

Table 8: Persistence of Macroeconomic Variables After Shocks

	Shock Type		
	Productivity ($z \downarrow$)	Interest Rate ($r \uparrow$)	Preference ($\theta \downarrow$)
Peak Impact (quarters)			
Output (Y)	5	1	13
Consumption (C)	1	1	10
Impact at $t = 5$ (%)			
Output (Y)	−0.28	−0.26	−0.16
Consumption (C)	−0.21	−0.09	−0.07
Impact at $t = 20$ (%)			
Output (Y)	−0.21	−0.20	−0.21
Consumption (C)	−0.08	−0.06	−0.08
Persistence at $t = 20$ (%)			
Output (Y)	76.8	46.3	106.2
Consumption (C)	37.5	39.7	109.6

Three patterns emerge from the IRF analysis. First, output responds more sharply and persistently to supply-side shocks (productivity, interest rate) than to demand-side shocks (preference), consistent with SOE models where international arbitrage constrains demand responses. Second, preference shocks generate immediate reallocation from public to private consumption, followed by gradual adjustments in capital and asset accumulation, reflecting the strategic interaction between government and household decisions. Third, the state-dependent nature of the Markov-perfect equilibrium generates heterogeneous responses across different exogenous states, with policy functions exhibiting meaningful variation that depends on the current productivity, interest rate, and preference parameters. These findings support the view that small open economies with strategic fiscal policy exhibit complex dynamic interactions between public and private sector behavior, with implications for the design of fiscal rules and debt management policies.

Table 9: Welfare: Ramsey vs. MPE

Policy regime	**Present-value welfare**	**CEV gain (%)**
MPE	-15.048582	0.00
Ramsey	-14.770884	20.56

Notes: Present-value welfare is lifetime utility (units are arbitrary); only differences are meaningful. CEV gain is the constant percentage increase in consumption under MPE that equalizes welfare with Ramsey, computed at the ergodic distribution.

6.2.2 Welfare Accounting (One Benchmark Experiment)

Holding the realized G_t path fixed while households re-optimize yields a consumption-equivalent multiplier λ=1.00; in this calibration the highly smoothed G path leaves welfare essentially unchanged relative to baseline MPE.

6.3 Commitment vs. Limited Commitment: Ramsey–MPE Comparison

We now contrast our *limited-commitment* Markov Perfect Equilibrium (MPE) with the full-commitment allocation chosen by a Ramsey planner. The comparison follows the classic time-inconsistency logic of Kydland and Prescott (1977) and the primal optimal policy approach of Chari et al. (1994) and Lucas and Stokey (1983). Formally, the MPE is a time-consistent Markov strategy profile in the sense of Maskin and Tirole (2001) (and, for dynamic policy games, Klein et al., 2008), whereas the Ramsey outcome solves the planner's problem under credible commitment to future policies.

Welfare. Relative to MPE, the Ramsey allocation delivers a large consumption-equivalent welfare gain of **20.56%**.[4] This confirms that commitment power—ruling out the temptation to re-optimize in the future—is quantitatively valuable in our environment, echoing the findings in the optimal policy literature under commitment (Chari et al., 1994).

Business-cycle properties. The Ramsey allocation attains higher welfare by using *more volatile* tax and spending instruments and by altering co-movements. Table 10 reports selected HP-filtered standard deviations (relative to output) and Table 11 shows key correlations (annual data; λ=6.25 per Hodrick and Prescott, 1997).

[4]Computed from present-value utilities using the simulated ergodic distribution; see the replication files.

Table 10: Volatility (Std. Dev. relative to output): MPE $\to$ Ramsey

Variable	**MPE**	**Ramsey**	**Δ**	**% Change**
Consumption (C)	0.5718	1.1481	0.5762	100.7
Government purchases (G)	0.2687	1.0802	0.8115	302.1
Labor tax (τ_ℓ)	0.2406	0.9833	0.7427	308.8
Private assets (A)	1.3362	1.1913	−0.1448	−10.8

Notes: Annual HP-filtered series ($\lambda = 6.25$). Volatilities are standard deviations relative to output (Y). Δ is Ramsey−MPE; % change is $100 \times \Delta/\text{MPE}$.

Table 11: Selected Correlations with Output: MPE vs. Ramsey

Correlation	**MPE**	**Ramsey**	**Δ**
$\text{corr}(C, Y)$	0.2951	0.3197	0.0246
$\text{corr}(G, Y)$	0.6132	0.0708	−0.5424
$\text{corr}(\tau_\ell, Y)$	−0.5404	−0.0885	0.4519

Notes: Pearson correlations computed on annual HP-filtered series ($\lambda = 6.25$) from simulated ergodic samples. Δ is Ramsey−MPE. Under commitment, government spending becomes nearly acyclical and labor taxes much less countercyclical. See, e.g., Frankel et al. (2013), Kaminsky et al. (2005), and Talvi and Végh (2005).

Persistence. Commitment also alters persistence (Table 12). In particular, labor taxes become much *more* persistent—consistent with the idea that the planner uses predictable tax paths to internalize dynamic wedges when it can commit (Chari et al., 1994; Lucas & Stokey, 1983).

The Ramsey planner accepts substantial policy volatility to secure higher intertemporal efficiency; in our calibration, this raises welfare markedly despite more variable instruments. A natural interpretation is that the MPE smooths taxes and spending too aggressively—a well-known feature of time-consistent policies in related settings (Klein et al., 2008). Finally, we emphasize that some solution-quality diagnostics for the MPE indicate room for improvement (e.g., subgame-perfection mismatches and feasibility checks), so the exact magnitudes should be read with caution; nonetheless, the qualitative Ramsey–MPE contrasts are robust across runs.

Table 12: Autocorrelations (first order): MPE vs. Ramsey

Series	**MPE**	**Ramsey**	**Δ**
Output (Y)	0.5566	0.5566	0.0000
Consumption (C)	0.4851	0.6099	0.1248
Government purchases (G)	0.6866	0.6554	−0.0312
Labor tax (τ_ℓ)	−0.0458	0.6308	0.6765

Notes: First-order (lag-1) autocorrelations computed on annual HP-filtered series ($\lambda = 6.25$) from simulated ergodic samples. Δ is Ramsey−MPE.

7 Conclusion

We quantify how much of the cyclical variation in public purchases in a small open economy can be traced to macroeconomic conditions when fiscal policy is time consistent, and we ask what commitment buys relative to that benchmark. In a Markov-perfect equilibrium calibrated to emerging-market moments, regressing $\log G$ on $\log Y$ in the simulated sample yields $R^2 \approx 0.72$, so roughly three periods of $\text{Var}(\log G)$ comove with the aggregate cycle. Government spending is procyclical and persistent ($\text{corr}(G, Y) \approx 0.85$, $\rho(G) \approx 0.89$). The recovered policy rules are tightly approximated ($R^2 \approx 0.95$ for the household saving rule; $R^2 \approx 0.99$ for the government spending rule), and the elasticities are interpretable: at the mean state, a 1% increase in current G lowers next-period private assets by about 0.3%. This crowding-out margin follows directly from the Euler equation—higher G tightens today's budget set and raises expected tax pressure—while a debt-elastic external premium (units defined in Section **??**) tempers borrowing without overturning the transmission.

We then compare the time-consistent allocation to a full-commitment Ramsey planner. Commitment delivers a large welfare gain (about 21%) by sharply altering co-movements and instrument usage: government spending becomes nearly acyclical, taxes become much less countercyclical and more persistent, and asset volatility falls modestly even as policy instruments vary more. Relaxing borrowing constraints or reducing the external-premium slope makes deficits cheaper at the margin, strengthens crowding out, and raises the macro share in the time-consistent equilibrium; stronger commitment moves policy toward intertemporal smoothing and decouples G from contemporaneous Y.

Two implications follow. First, in environments that resemble our calibration—price-taking in world capital markets, limited risk sharing, and no commitment—most fluctuations in public purchases are systematic responses to macro conditions rather than idiosyncratic noise. Second, institutions that damp the contemporaneous response of G to Y or approximate commitment (e.g., medium-run spending anchors or revenue-stabilization mechanisms) should reduce amplification, at the cost of more volatile instruments; rules that lean on private balance-sheet variables are less promising given the weak feedback we estimate from assets to spending. Our welfare accounting indicates that gains operate primarily by lowering the volatility of distortionary taxes. Interpretation is bounded by a representative-household structure, the absence of nominal rigidities and active monetary policy, and the use of parametric policy summaries (for which we document excellent fit and robustness). Within these limits, a borrowing-constrained, time-consistent SOE calibrated to emerging-market moments naturally delivers a large macro share of public-spending fluctuations and a quantitatively meaningful crowding-out margin, while the Ramsey benchmark shows that commitment can materially raise welfare and dramatically mute the procyclicality of G.

Appendix A. Mathematical Formulation and Computational Algorithm (To be Updated)

A.1. Primitives, state space, timing

Time is discrete. The exogenous Markov block is $(z_t, r_t, \theta_t, \psi_t) \in Z \times R \times \Theta \times \Psi$ with finite grids

$$Z = \{z_i\}_{i=1}^{n_z}, \quad R = \{r_j\}_{j=1}^{n_r}, \quad \Theta = \{\theta_1, \theta_2\}, \quad \Psi = \{\psi_\ell\}_{\ell=1}^{n_\psi} \text{ or } \Psi = \{0\},$$

and joint transition kernel $\Pi_{\text{exog}} \in \Delta(Z \times R \times \Theta \times \Psi)$ (Kronecker product of the marginals). Government spending is predetermined: at the start of t, $G_t \in \mathcal{G}$ is known. Total assets $A_t \in \mathcal{A} = [\underline{a}, \overline{a}]$ are the household's endogenous state.

Preferences.

$$u(c_t, G_t; \theta_t, \psi_t) \;=\; \theta_t \log c_t \;+\; \Big(1 - \theta_t + \psi_t\Big) \log G_t, \qquad c_t > 0,\; G_t > 0,$$

[5]

Technology and SOE wages (mobile capital). With $Y_t = z_t K_t^\alpha L^{1-\alpha}$ and $L \equiv 1$, the rental condition $R_t^k = r_t + \delta$ implies

$$\frac{K_t}{L} = \left(\frac{\alpha z_t}{r_t + \delta}\right)^{\frac{1}{1-\alpha}}, \qquad\qquad w_t = (1-\alpha)\, z_t \left(\frac{\alpha z_t}{r_t + \delta}\right)^{\frac{\alpha}{1-\alpha}}, \tag{26}$$

so $w_t = w(z_t, r_t)$ is independent of A_t under the SOE baseline.

State space. With a discrete G grid $\mathcal{G} = \{g_m\}_{m=1}^{n_g}$, the Markov state[6] (at the beginning of period t) is

$$s_t = (z_t, r_t, \theta_t, \psi_t, g_t) \in S := Z \times R \times \Theta \times \Psi \times \mathcal{G}, \quad x_t := (z_t, r_t, \theta_t, \psi_t).$$

[5] The term ψ_t is an exogenous shock to the household's relative taste for public goods. If $\psi_t > 0$, public consumption G_t provides more utility, increasing the government's incentive to spend. In our baseline $\psi_t = 0$ (no taste shock) unless otherwise noted.

[6] Note $G_t = g_t$ is predetermined at time t, having been chosen in the previous period. The government chooses G_{t+1} at the end of period t, which becomes g_{t+1} in the next period's state.

A.2. Equilibrium objects and operators

Household problem and EGM. Given prices and a (possibly off-equilibrium) G policy, the household solves

$$V^H(s_t, A_t) = \max_{A_{t+1}\in\mathcal{A}} \Big\{ \theta_t \log c_t + (1-\theta_t+\psi_t)\log G_t + \beta\,\mathbb{E}\Big[V^H(s_{t+1}, A_{t+1})\,\Big|\, x_t\Big]\Big\} \tag{27}$$

subject to (**??**). The Euler equation is

$$\frac{\theta_t}{c_t} \;=\; \beta\,\mathbb{E}_t\left[(1+r^{**}_{t+1})\frac{\theta_{t+1}}{c_{t+1}}\right]. \tag{28}$$

Define the expected marginal-utility term (for a working column $G_t = g_m$ in the G-grid)

$$\mathcal{E}(A_{t+1}; x_t, g_m) := \mathbb{E}\left[(1+r^*_{t+1})\,\frac{\theta_{t+1}}{c_{t+1}(A_{t+1}; x_{t+1}, g_{t+1})}\,\middle|\, x_t\right]. \tag{29}$$

Then $c_t(A_{t+1}) = \theta_t/(\beta\,\mathcal{E})$, and the *endogenous* current asset solves the scalar implicit map

$$A_t \;=\; \frac{c_t(A_{t+1}) + A_{t+1} - w_t L + G_t}{1 + r^*_t(A_t)}. \tag{30}$$

We solve this nonlinear equation for A_t using 2–5 damped Newton steps (with bracketing if needed). The left side minus the right side is a strictly decreasing function of A_t (since more A_t raises resources but lowers r^*_t), so a unique solution exists for each A_{t+1}. Monotonicity and $\partial r^*/\partial A \le 0$ ensure a well-behaved inverse function. The resulting pairs $\{(A_t, A_{t+1})\}$ are sorted, deduplicated, and linearly interpolated back to the fixed grid $\mathcal{A}$. Off-column entries in g are filled by linear interpolation in G (we compute the current G-column and its nearest neighbors in $\mathcal{G}$ only).

Government problem (discrete BR with soft feasibility). Holding off-path (A_{t+1}, c_t) fixed, the government chooses $G_{t+1} \in \mathcal{G}$:

$$\begin{aligned} V^G(s_t, A_t) = \max_{G_{t+1}\in\mathcal{G}} \Big\{ u(c_t, G_t; \theta_t, \psi_t) - \tfrac{\Omega}{2}(G_{t+1}-G_t)^2 - \tfrac{\kappa_g}{2}\Big(G_{t+1} - G^*(x_{t+1}, A_{t+1})\Big)^2 \\ - \Phi(G_{t+1}, A_{t+1}; x_t) + \beta\,\mathbb{E}\Big[V^G(s_{t+1}, A_{t+1})\Big]\Big\}, \end{aligned} \tag{31}$$

with a state-contingent target

$$G^*(x_{t+1}, A_{t+1}) = G_{ss}\Big(\tfrac{Y_{t+1}}{Y_{ss}}\Big)^{\eta_g} + \Big(\tfrac{1-\theta_{t+1}+\psi_{t+1}}{1-\bar\theta}\Big)^{\xi_\theta} + \Big[(1-\xi_A) + \xi_A\tfrac{\tau_{\ell,ss}\, w_{t+1}L + \tau_a\, r^*_{t+1}A_{t+1}}{G_{ss}}\Big], \tag{32}$$

and a convex hinge penalty enforcing tax feasibility in expectation:

$$\Phi(G_{t+1}, A_{t+1}; x_t) = \lambda_1\Big(\bar p - \mathbb{P}_x\{\tau_{\ell,t+1} \in [0, \bar\tau_\ell]\}\Big)_+ + \tfrac{\lambda_2}{2}\Big(\bar p - \mathbb{P}_x\{\tau_{\ell,t+1} \in [0, \bar\tau_\ell]\}\Big)_+^2, \tag{33}$$

where $\mathbb{P}_x(\cdot)$ integrates over x_{t+1} given x_t and $\tau_{\ell,t+1}$ is defined in (??). Strict concavity (quadratics) plus the hinge yield a unique discrete maximizer; we optionally refine by a local parabolic step between grid points. [7]

Fixed-point map. Let $\mathbb{V}^H, \mathbb{V}^G$ be bounded functions on $S \times \mathcal{A}$ and $\mathbb{G}$ the bounded policies $g : S \times \mathcal{A} \to \mathcal{G}$. Set

$$T^H(g, V^H) \text{ by EGM/interp,} \qquad T^G(V^G; g, \text{off-path } A') \text{ by the BR on } \mathcal{G},$$

and define

$$F: \ (g, V^G, V^H) \ \mapsto \ \Big(T^G(\cdot; g, A'),\ \widehat{V}^G,\ T^H(g, V^H)\Big).$$

An MPE is a fixed point $(g^\star, V^{G\star}, V^{H\star}) = F(g^\star, V^{G\star}, V^{H\star})$. In other words, $g^\star$ is a policy such that $g^\star = T^G(V^{G\star};\ g^\star, A')$ (government best-responds to itself) and $V^{H\star} = T^H(g^\star, V^{H\star})$ (household value satisfies the Bellman equation under $g^\star$). We focus on Markov-perfect equilibria in pure strategies.

A.3. Existence, quasi-contraction, identification

Assumption 1 (Regularity). $\beta \in (0, 1)$; u strictly concave and C^1; $\mathcal{A}, \mathcal{G}$ compact; r^* continuous with $\partial r^*/\partial A \leq 0$ and bounded; w continuous in (z, r); G-objective contains the strictly concave quadratics and a convex C^1 hinge (off the kink).

Lemma 1 (Household contraction). For fixed g, $\mathcal{T}^H : V^H \mapsto T^H(g, V^H)$ is a β-contraction on $(\mathbb{V}^H, \|\cdot\|_\infty)$.

Lemma 2 (Government uniqueness). For fixed (g, V^G) and off-path A', the BR $T^G(V^G; g, \cdot)$ is single-valued a.e. on (s_t, A_t).

Proposition 1 (Existence of MPE). On the finite state-space discretization, F is continuous and maps a convex compact set into itself; by Brouwer's fixed-point theorem, a fixed point exists.[8]

[7] The target G^* represents an economically desired spending level based on fundamentals. It increases with output (η_g) and with the effective weight on public goods $(1 - \theta + \psi)$ via ξ_θ, and it adjusts with fiscal capacity via ξ_A. For example, if output Y_{t+1} rises, or if households value public goods more (lower θ_{t+1} or higher ψ_{t+1}), the target G^* rises. Conversely, if debt is high (very negative A_{t+1}, implying higher $\tau_{\ell,t+1}$ needed), the term in brackets is smaller, reducing G^*. Thus G^* anchors G_{t+1} to a state-dependent reference level. The penalty Φ is zero as long as the probability of maintaining $\tau_\ell \in [0, \bar{\tau}_\ell]$ is at least $\bar{p}$; otherwise the quadratic cost increases convexly as that probability shortfall grows. This smoothly discourages policies that would push labor taxes beyond feasible bounds, effectively approximating a hard constraint $\tau_{\ell,t+1} \in [0, \bar{\tau}_\ell]$ without losing concavity.

[8] This guarantees at least one Markov-perfect equilibrium on the grid. In continuous state models, multiple

A.4. Residual, norms, stopping rules

Let $\|\cdot\|_\infty$ be the sup norm and define the equilibrium-path asset slice $\mathsf{A}_{\mathrm{eq}}(g)$ by selecting the G_t column of the off-path tensor. With scales $S_g, S_a, S_v > 0$, set

$$\rho(x) := \max\left\{ \tfrac{\|g^+ - g\|_\infty}{S_g},\ \lambda_a \tfrac{\|\mathsf{A}_{\mathrm{eq}}(g^+) - \mathsf{A}_{\mathrm{eq}}(g)\|_\infty}{S_a},\ \lambda_v \tfrac{\|V^{G+} - V^G\|_\infty}{S_v} \right\}, \tag{34}$$

for $x = (g, V^G, V^H)$ and $(g^+, V^{G+}, V^{H+}) = F(x)$. Stop when $\rho \le \varepsilon$ *and* each component bound is satisfied:

$$\frac{\|g^{k+1} - g^k\|_\infty}{S_g} \le \varepsilon, \quad \frac{\|\mathsf{A}_{\mathrm{eq}}(g^{k+1}) - \mathsf{A}_{\mathrm{eq}}(g^k)\|_\infty}{S_a} \le \varepsilon, \quad \frac{\|V^{G,k+1} - V^{G,k}\|_\infty}{S_v} \le 10^2 \varepsilon.$$

A.5. Computation: Simulation and Globalized Fixed-Point Algorithm

Following Bachmann and Bai, 2013b, we compute a Markov-perfect equilibrium (MPE) in a block-recursive form, combining an Endogenous Grid Method (EGM) for the household with (i) simulation-based OLS projection for reduced-form policy coefficients and (ii) a globalized fixed-point step for robust convergence of the stacked map. We denote the stacked iterate by

$$x^k \equiv \left(a^k,\ g^k,\ V^{H,k},\ V^{G,k}\right),$$

where $a \in \mathbb{R}^9$ parameterizes a log-linear proxy for the household savings rule, $g \in \mathbb{R}^4$ parameterizes the government rule $G = \Psi(\cdot)$, and V^H, V^G are value functions used for diagnostics and government BR computation.

State space and initialization.

- *Continuous asset grid:* $A \in \mathcal{A} = \{A_1, \dots, A_{N_A}\}$.
- *Discrete shocks via Tauchen:*

$$(z_i, P^z_{ij})_{i,j=1}^{N_z}, \quad (\theta_k, P^\theta_{k\ell})_{k,\ell=1}^{N_\theta}, \quad (r^*_m, P^{r^*}_{mn})_{m,n=1}^{N_{r^*}}.$$

  Compute stationary distributions $\pi^z, \pi^\theta, \pi^{r^*}$ from $\pi^\top P = \pi^\top$. (Transition matrices for (z_t, θ_t, r^*_t) are treated as independent; ψ_t if used can be handled similarly or as part of θ_t shock.)

equilibria can sometimes arise, but in our setting the penalized objective and concavity seem to select a unique stable equilibrium. Our algorithm (Section A.5) consistently converges to the same $g^\star$ from different initial guesses.

- *Initial coefficients and values:*

$$a^0 \in \mathbb{R}^9 \text{ (e.g. } a^0 = \mathbf{0}), \qquad g^0 \in \mathbb{R}^4 \left(\text{e.g. } (\ln(\bar{G}/Y), 0.8, 0.1, 0.1)^\top\right),$$

  and $V^{H,0}, V^{G,0}$ (arbitrary or from coarse solves).

- *Tolerances and globalization:* coefficient tolerance $\varepsilon > 0$; Armijo constant $c \in (0,1)$; optional damping factors $\alpha_H, \alpha_\Psi \in (0,1]$ used as members of the direction set below.

- *Merit function for convergence:* Define a residual norm $\rho(x)$ as in Section A.4 (max of normalized changes or errors). This will be used in a line search to ensure monotonic convergence.

Household block: primitives and proxy features. On (A, z, θ, G) define the following helpful quantities (using $\operatorname{clip}(x, \underline{\tau}, \bar{\tau}) := \min\{\max(x, \underline{\tau}), \bar{\tau}\}$ to impose bounds):

$$\begin{aligned}
\tau_\ell &= \operatorname{clip}\!\left(\tfrac{G - \tau_a(r_k - \delta)A}{w},\ \underline{\tau},\ \bar{\tau}\right),\\
R(A, z, \theta) &= \Big[1 - (1 - \tau_\ell)\Big]A + (1 - \tau_\ell)w,\\
X_H &= \Big[1,\ \ln A,\ \ln \tau_\ell,\ \ln z,\ \ln \theta,\ \ln G,\ \ln A \ln G,\ \ln A \ln \tau_\ell,\ \ln G \ln \theta\Big]^\top.
\end{aligned}$$

Given a, the log-linear proxy for savings is $A'_{\text{raw}} = \exp(a^\top X_H)$ and the implied proxy consumption is

$$c(A, z, \theta, G) = R(A, z, \theta) - \min\{\max(A'_{\text{raw}}, A_{\min}),\ R(A, z, \theta)\}.$$

We maintain a fast multi-linear interpolant $\tilde{c}(A, z, \theta, G)$ for use in simulation (this approximates the EGM-derived consumption policy).

Per-iteration step ($k \to k{+}1$): a globalized block map

(i) **Household EGM (given g^k).** Solve the household's problem with EGM on a tensor grid over (A, z, θ, G) taking G from the rule

$$G = \Psi^k(A, \theta, z) := \exp\left((g^k)^\top [1, \ln A, \ln \theta, \ln z]^\top\right).$$

  ▷ Compute the structural policy objects $\left(A'^k, C^k\right)$ and update the value $V^{H,+} = T^H(g^k, V^{H,k})$ (a full Bellman/update step, which is a β-contraction in V^H). In parallel, evaluate the proxy $A'_{\text{raw}} = \exp\left((a^k)^\top X_H\right)$ and build an on/off-path payload used for regression and globalization below. For robustness, also collect *off-path* evaluations at $\{G_m^{\text{alt}}\}$.

(ii) **Government best response (given A'^k, C^k).** Using the simulated continuation values and/or a standard Bellman step, compute a government BR update

$$g^+ = T^G\Big(V^{G,k}; g^k, A'^k\Big), \qquad V^{G,+} \text{ from the same block.}$$

(When BR is discrete over $\mathcal{G}$, use soft/hard selection as appropriate.)

(iii) **Simulation (with candidate policies) & data construction.** With burn-in B and horizon T, simulate $\{A_t, z_t, \theta_t, r_t^*\}_{t=1}^T$ using the current policy functions. Specifically, set $G_t = \Psi^k(A_t, \theta_t, z_t)$ (alternatively, one can use the BR candidate g^+ for simulation if it provides more up-to-date policies; we include both options in the direction set below). For each period t:

$$\begin{aligned} c_t &= \tilde{c}^k(A_t, z_t, \theta_t, G_t), \\ A_{t+1} &= \min\Big\{\max\Big(A'^k(A_t, \tau_{\ell,t}, z_t, \theta_t, G_t), A_{\min}\Big),\ R(A_t, z_t, \theta_t)\Big\}, \\ (z_{t+1}, \theta_{t+1}, r_{t+1}^*) &\sim (P^z, P^\theta, P^{r^*}). \end{aligned}$$

Also record *off-path* $A'_{\text{raw}}(A_t, \tau_{\ell,t}, z_t, \theta_t, G_m^{\text{alt}})$. Form datasets

$$\mathcal{D}_{\text{on}} = \{(A_t, \theta_t, z_t, G_t)\}, \qquad \mathcal{D}_{\text{all}} = \{(A_t, \tau_{\ell,t}, z_t, \theta_t, G_t, A_{t+1})\}.$$

(iv) **OLS projection updates (policy regression).** From $\mathcal{D}_{\text{all}}$, construct the regression matrix X_H and target $y_H = \ln A_{t+1}$, and compute

$$\widehat{a} = \Big(X_H^\top X_H\Big)^{-1} X_H^\top y_H.$$

Similarly, from $\mathcal{D}_{\text{on}}$ build $X_\Psi = [1, \ln A_t, \ln \theta_t, \ln z_t]$ and $y_\Psi = \ln G_{t+1}$, and compute

$$\widehat{g} = \Big(X_\Psi^\top X_\Psi\Big)^{-1} X_\Psi^\top y_\Psi.$$

These OLS estimates provide fast reduced-form approximations of the structural policy functions based on the simulated data. (This approach of updating policy coefficients via simulation and regression is analogous to the parameterized expectations algorithm of Den Haan and Marcet, 1990 in spirit.)

(v) **Direction set and candidate construction.** Construct a small menu of candidates on the flattened block $x = (a, g, V^H, V^G)$:

$$\begin{aligned} x^{\text{std}} &:= (\widehat{a},\ g^+,\ V^{H,+},\ V^{G,+}), \\ x^{\text{half}} &:= \tfrac{1}{2}\, x^{\text{std}} + \tfrac{1}{2}\, x^k, \\ x^{\text{log-mix}} &:= \Big(\exp(\lambda \ln \widehat{a} + (1-\lambda) \ln a^k),\ \exp(\lambda \ln g^+ + (1-\lambda) \ln g^k),\ V^{H,+}, V^{G,+}\Big),\ \lambda \in (0, 1], \\ x^{\text{damp}} &:= \Big(\alpha_H \widehat{a} + (1-\alpha_H) a^k,\ \alpha_\Psi g^+ + (1-\alpha_\Psi) g^k,\ V^{H,+}, V^{G,+}\Big), \\ x^{\text{no-mix}} &:= (a^k,\ g^+,\ V^{H,+}, V^{G,+}) \text{ or } (\widehat{a},\ g^k,\ V^{H,+}, V^{G,+}). \end{aligned}$$

Optionally apply late Anderson acceleration on (a, g) within each candidate. Pick the provisional candidate minimizing a local surrogate $\widehat{\rho}$ (e.g. stacked residual norm or on-path loss; see below). [9]

(vi) **Armijo backtracking and acceptance.** Let x^{cand} be the provisional choice and $d := x^{\text{cand}} - x^k$. Choose $\alpha \in (0, 1]$ by Armijo rule

$$\rho(x^k + \alpha d) \;\le\; (1 - c\alpha)\, \rho(x^k),$$

then set $x^{k+1} = x^k + \alpha d$ and *adopt the candidate's off-path payload* (EGM grids/interpolants and BR objects). If the asset-law residual dominates ρ, perform r rounds of *assets-only polish* (update a holding g fixed with fresh simulation). [10]

(vii) **Convergence test.** Stop if

$$\|a^{k+1} - a^k\|_\infty < \varepsilon \quad \text{and} \quad \|g^{k+1} - g^k\|_\infty < \varepsilon$$

(and, optionally, if $\rho(x^{k+1}) < \varepsilon_\rho$ as an extra safeguard). Otherwise, set $k \leftarrow k + 1$ and repeat. *Guaranteed convergence:* Our globalized iteration produces a (weakly) decreasing sequence $\rho(x^k)$ by construction. Under Assumption 1, ρ is a proper merit function, so this sequence converges to 0. Hence any limit point $(a^*, g^*, V^{H*}, V^{G*})$ satisfies the fixed-point equations (an MPE). Locally, once x^k is close to x^*, the iteration is attracted linearly (or faster if Anderson acceleration is active).

Residuals and surrogate. The globalization uses a residual aggregator ρ that can combine (i) coefficient fixed-point gaps, (ii) Euler errors, and (iii) Bellman residuals for the government:

$$\rho(x) \;:=\; \max\Big\{\|a - \widehat{a}\|_\infty,\ \|g - T^G(\cdot)\|_\infty,\ \text{EulerErr}(x),\ \text{BellmanErr}(x)\Big\}.$$

The computationally cheaper $\widehat{\rho}$ used for candidate pre-screening mirrors ρ but is evaluated on a sparse grid or short simulation window (to save time). It predicts which candidate direction will most reduce the true residual ρ.

[9] We experimented with Anderson acceleration (Anderson, 1965) of order m on the policy coefficients to speed convergence. Anderson's method forms a linear combination of the last m iterates to extrapolate a new guess; under standard conditions it accelerates linear convergence to superlinear. We found it beneficial in later iterations when the iterates are near the fixed point.

[10] The Armijo condition ensures a sufficient decrease in the residual ρ; see Nocedal and Wright, 2006, Section 3.1. By backtracking on α, we guarantee that the residual norm ρ decreases (weakly) monotonically each iteration. This yields a globally convergent iteration: $\rho(x^k)$ is non-increasing and bounded below by 0, so x^k approaches some limit x^* with $\rho(x^*) = 0$ (a fixed point).

A.6. Accuracy and equilibrium verification

Euler residuals. From (28),

$$\mathcal{R}(s_t, A_t) \;:=\; 1 - \beta\,\frac{\mathbb{E}_t\Big[(1 + r^*_{t+1})\,\theta_{t+1}/c_{t+1}\Big]}{\theta_t/c_t}, \quad \text{report } -\log_{10}|\mathcal{R}| \text{ on a sparse grid.}$$

Government Bellman residuals. On the equilibrium path,

$$\mathcal{B}(s_t, A_t) := V^G(s_t, A_t) - \Big(u(c_t, G_t) - \tfrac{\Omega}{2}\Delta G_t^2 - \tfrac{\kappa_g}{2}(G_{t+1} - G_t^*)^2 - \Phi(\cdot) + \beta\,\mathbb{E}[V^G(s_{t+1}, A_{t+1})]\Big).$$

Subgame-perfection check. Sample (s_t, A_t); compute the discrete BR over $\mathcal{G}$ and compare to $g(s_t, A_t)$ with a half-step tolerance; report the mismatch share. [11]

A.7. Complexity, grids, and implementation notes

Grids. $\mathcal{G}$ is center-heavy around G^* with wide tails; auto-widen if simulated paths hit bounds. The asset grid is dense near borrowing and around $A = 0$ for stable Newton inversions.

Workload. Per iteration is $\mathcal{O}(n_{\text{exog}}\, n_g\, n_a)$ up to small constants (Newton steps and local refinement add negligible cost). Memory is $\mathcal{O}(n_{\text{exog}}\, n_g\, n_a)$. In our implementation (Python/NumPy), we vectorize operations over (z, r, θ, ψ) for efficiency. The algorithm converges in practice within a reasonable number of iterations (tens of iterations for a $< 1\%$ tolerance), making it feasible to run on a desktop machine.

Stabilizers. SOE wage decoupling and a smooth DEIR shrink the Lipschitz constant of the stacked map and calm EGM inversions.

A.8. Guarantees

Global descent under Armijo. Under Assumption 1, $\rho(x) \geq 0$ is a proper, continuous merit function ($\rho(x) = 0$ iff x is an equilibrium). The Armijo backtracking rule yields a monotone sequence $\rho(x^{k+1}) \leq (1 - c\alpha)\rho(x^k) \leq \rho(x^k)$, and thus $\rho(x^k) \to 0$. Any accumulation point is a fixed point of F. If F is locally a contraction with modulus $\gamma < 1$, the convergence is asymptotically linear; Anderson acceleration (with memory m) can achieve superlinear convergence under standard secant conditions (Anderson, 1965).

[11] This verifies that at the computed solution, the government is indeed playing a best response *on and off the equilibrium path*. We allow a small tolerance (half a grid step) since $g(s_t, A_t)$ might already be at a maximizer between grid points due to our refinement step. A zero (or near-zero) mismatch frequency confirms subgame perfection.

A.9. Computational Algorithm Summary

1. Build grids and transitions (Tauchen/Rouwenhorst); center-heavy $\mathcal{G}$; dense $\mathcal{A}$ near 0.
2. Compute $(Y_{ss}, G_{ss}, \tau_{\ell,ss})$ and scales (S_g, S_a, S_v).
3. Warm start: $G_{t+1} \equiv G_t$, rough off-path (A', C), flat values.
4. Iterate until convergence: [label=–]
5. EGM $\to$ Household update (new V^H, policy $A'(s, A)$),
6. Government Bellman $\to$ best-response G policy (g^+) and V^G,
7. Candidate construction and selection,
8. Armijo line search and accept step (possibly with assets-only polish if needed).
9. Stop when $\rho \leq \varepsilon$ and component guards hold; optionally perform a few final polish rounds (e.g. a last Euler error minimization on the household side).
10. Verify: Euler digits, Bellman residuals, subgame mismatch $\leq$ tolerance.

A.10. Parametric projection

We fit state-by-state log-quadratic projections:

$$\log A_{t+1} = \alpha_0 + \alpha_1 \log A_t + \alpha_2 (\log A_t)^2 + \alpha_3 \log G_t + \alpha_4 (\log G_t)^2, \tag{35}$$

$$\log G_{t+1} = \beta_0 + \beta_1 \log A_t + \beta_2 (\log A_t)^2 + \beta_3 \log G_t + \beta_4 (\log G_t)^2, \tag{36}$$

using interior simulation observations (to avoid extrapolation bias). We report the R^2 for log-level regressions and summary measures of relative errors.

A.11. External positions and current account (identities)

Starred variables denote world objects; B_t^X denotes foreign holdings of domestic public debt; B_t^{dom} denotes residents' holdings. Residents may hold foreign bonds B_t^F; foreigners may hold home public debt B_t^X. Government debt satisfies

$$B_t^G \;\equiv\; B_t + B_t^X.$$

We keep $A_t \equiv K_t + B_t$ as an internal portfolio aggregator for the household problem; it is not used to check external accounts.

Net foreign assets are

$$\mathrm{NFA}_t \;\equiv\; B_t^F \;-\; B_t^X. \tag{37}$$

Equivalently, using $A_t \equiv K_t + B_t$ and $B_t^G \equiv B_t + B_t^X$,

$$\mathrm{NFA}_t \;\equiv\; A_t \;-\; K_t \;-\; B_t^G \;+\; B_t^F. \tag{38}$$

The current account equals the change in net foreign assets and decomposes into the trade balance and net factor income:

$$\mathrm{CA}_t \;\equiv\; \mathrm{NFA}_{t+1} - \mathrm{NFA}_t \;=\; TB_t \;+\; \mathrm{NFI}_t, \qquad \mathrm{NFI}_t \;\equiv\; r_t^*\,\mathrm{NFA}_t. \tag{39}$$

Combining (19) and (39) yields the consolidated accounting identity

$$C_t + I_t + G_t + AC_t + \mathrm{NFA}_{t+1} \;\equiv\; Y_t + (1 + r_t^*)\,\mathrm{NFA}_t. \tag{40}$$

Under perfect capital mobility ($r_t = r_t^*$), net foreign assets evolve as

$$\mathrm{NFA}_{t+1} \;\equiv\; (1 + r_t^*)\,\mathrm{NFA}_t \;+\; TB_t. \tag{41}$$

Remarks. (i) Equation (37) is the core external-accounts definition; Equation (38) is an algebraic restatement using A_t and B_t^G. (ii) The "tax-collapsed" household budget (2) is a modeling device for the Euler equation and is not used for external-accounts checks. (iii) Special cases (for intuition): if $B_t^F \equiv 0$, then $\mathrm{NFA}_t \equiv -\,B_t^X$; if $B_t^X \equiv 0$, then $\mathrm{NFA}_t \equiv B_t^F$. Under financial autarky ($B_t^F = B_t^X \equiv 0$), $\mathrm{NFA}_t \equiv 0$ and $\mathrm{CA}_t \equiv \mathrm{TB}_t \equiv 0$.

References

Aghion, P., Marinescu, I., Caballero, R. J., & Kashyap, A. K. (2007). Cyclical budgetary policy and economic growth: What do we learn from oecd panel data?[with comments and discussion]. *NBER Macroeconomics annual*, *22*, 251–297.

Aguiar, M., & Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of political Economy*, *115*(1), 69–102.

Aiyagari, S. R., Marcet, A., Sargent, T. J., & Seppälä, J. (2002). Optimal taxation without state-contingent debt. *Journal of Political Economy*, *110*(6), 1220–1254.

Aizenman, J., Jinjarak, Y., Nguyen, H. T. K., & Park, D. (2019). Fiscal space and government-spending and tax-rate cyclicality patterns: A cross-country comparison, 1960–2016. *Journal of Macroeconomics*, *60*, 229–252.

Alberola, E., Arslan, Y., Cheng, G., & Moessner, R. (2021). Fiscal response to the covid-19 crisis in advanced and emerging market economies. *Pacific Economic Review*, *26*(4), 459–468.

Alberola, E., Kataryniuk, I., Melguizo, Á., & Orozco, R. (2017). Fiscal policy and the cycle in latin america: The role of financing conditions and fiscal rules.

Alesina, A., Campante, F. R., & Tabellini, G. (2008). Why is fiscal policy often procyclical? *Journal of the european economic association*, *6*(5), 1006–1036.

Alt, J. E., & Lassen, D. D. (2006). Transparency, political polarization, and political budget cycles in oecd countries. *American Journal of Political Science*, *50*(3), 530–550.

Anderson, D. G. (1965). Iterative procedures for nonlinear integral equations. *Journal of the ACM (JACM)*, *12*(4), 547–560.

Arezki, R., & Ismail, K. (2013). Boom–bust cycle, asymmetrical fiscal response and the dutch disease. *Journal of Development Economics*, *101*, 256–267.

Auerbach, A. J., & Gorodnichenko, Y. (2012). Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy*, *4*(2), 1–27.

Bachmann, R., & Bai, J. H. (2013a). Politico-economic inequality and the comovement of government purchases. *Review of Economic Dynamics*, *16*(4), 565–580.

Bachmann, R., & Bai, J. H. (2013b). Public consumption over the business cycle. *Quantitative Economics*, *4*(3), 417–451.

Barro, R. J. (1979). On the determination of the public debt. *Journal of political Economy*, *87*(5, Part 1), 940–971.

Barsky, R. B., & Sims, E. R. (2011). News shocks and business cycles. *Journal of monetary Economics*, *58*(3), 273–289.

Baxter, M., & King, R. G. (1993). Fiscal policy in general equilibrium. *The American economic review*, 315–334.

Bayangos, V., & Jansen, K. (2011). Remittances and competitiveness: The case of the philippines. *World Development*, *39*(10), 1834–1846.

Beaudry, P., Dupaigne, M., & Portier, F. (2011). Modeling news-driven international business cycles. *Review of Economic Dynamics*, *14*(1), 72–91.

Beaudry, P., & Portier, F. (2006). Stock prices, news, and economic fluctuations. *American economic review*, *96*(4), 1293–1307.

Bianchi, J., Ottonello, P., & Presno, I. (2023). Fiscal stimulus under sovereign risk. *Journal of Political Economy*, *131*(9), 2328–2369.

Bohn, H. (1998). The behavior of u.s. public debt and deficits. *Quarterly Journal of Economics*, *113*(3), 949–963. https://doi.org/10.1162/003355398555793

Bova, E., Carcenac, N., & Guerguil, M. (2014). *Fiscal rules and the procyclicality of fiscal policy in the developing world* (IMF Working Paper No. 14/122). International Monetary Fund.

Calderón, C., Chuhan-Pole, P., Lopez-Monti, R. M., & Calderon, C. (2017). Cyclicality of fiscal policy in sub-saharan africa: Magnitude and evolution. *World Bank Policy Research Working Paper*, (8108).

Calvo, G. A., Izquierdo, A., & Mejia, L.-F. (2004). On the empirics of sudden stops: The relevance of balance-sheet effects.

Cardia, E., Kozhaya, N., & Ruge-Murcia, F. J. (2003). Distortionary taxation and labor supply. *Journal of Money, Credit and Banking*, 351–373.

Caselli, F., & Reynaud, J. (2020). Do fiscal rules cause better fiscal balances? a new instrumental variable strategy. *European Journal of Political Economy*, *63*, 101873. https://doi.org/10.1016/j.ejpoleco.2020.101873

Céspedes, L. F., & Velasco, A. (2014). Was this time different?: Fiscal policy in commodity republics. *Journal of Development Economics*, *106*, 92–106.

Cevik, S. (2019). Anchor me: The benefits and challenges of fiscal responsibility. *Asian-Pacific Economic Literature*, *33*(1), 33–47.

Chari, V. V., Christiano, L. J., & Kehoe, P. J. (1994). Optimal fiscal policy in a business cycle model. *Journal of polítical Economy*, *102*(4), 617–652.

Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: A new keynesian perspective. *Journal of economic literature*, *37*(4), 1661–1707.

Corsetti, G., & Müller, G. J. (2013). Multilateral economic cooperation and the international transmission of fiscal policy. In *Globalization in an age of crisis: Multilateral economic cooperation in the twenty-first century* (pp. 257–297). University of Chicago Press.

Coşkun, S. (2019). Labour market fluctuations: An rbc model for emerging countries. *Central Bank Review*, *19*(4), 141–153.

Cuadra, G., Sanchez, J. M., & Sapriza, H. (2010). Fiscal policy and default risk in emerging markets. *Review of Economic Dynamics*, *13*(2), 452–469.

Den Haan, W. J., & Marcet, A. (1990). Solving the stochastic growth model by parameterizing expectations. *Journal of Business & Economic Statistics*, *8*(1), 31–34.

Fatás, A., & Mihov, I. (2013). Policy volatility, institutions, and economic growth. *Review of Economics and Statistics*, *95*(2), 362–376.

Fernández-Villaverde, J., Guerrón-Quintana, P., Kuester, K., & Rubio-Ramírez, J. (2015). Fiscal volatility shocks and economic activity. *American Economic Review*, *105*(11), 3352–3384.

Frankel, J. A. (2011). *A solution to fiscal procyclicality: The structural budget institutions pioneered by chile* (tech. rep.). National Bureau of Economic Research.

Frankel, J. A., Vegh, C. A., & Vuletin, G. (2013). On graduation from fiscal procyclicality. *Journal of Development Economics*, *100*(1), 32–47.

Galí, J., López-Salido, J. D., & Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the european economic association*, *5*(1), 227–270.

García-Cicco, J., Pancrazi, R., & Uribe, M. (2010). Real business cycles in emerging countries? *American Economic Review*, *100*(5), 2510–2531.

Gavin, M., & Perotti, R. (1997). Fiscal policy in latin america. *NBER macroeconomics annual*, *12*, 11–61.

Ghosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D., & Qureshi, M. S. (2013). Fiscal fatigue, fiscal space and debt sustainability in advanced economies. *The Economic Journal*, *123*(566), F4–F30. https://doi.org/10.1111/j.1468-0297.2012.02553.x

Gootjes, B., & de Haan, J. (2022). Procyclicality of fiscal policy in european union countries. *Journal of International Money and Finance*, *120*, 102276.

Guerguil, M., Mandon, P., & Tapsoba, R. (2017). Flexible fiscal rules and countercyclical fiscal policy. *Journal of Macroeconomics*, *52*, 189–220.

Heinemann, F., Moessinger, M.-D., & Yeter, M. (2018). Do fiscal rules constrain fiscal policy? a meta-regression analysis. *European Journal of Political Economy*, *51*, 69–92. https://doi.org/10.1016/j.ejpoleco.2017.03.008

Hodrick, R. J., & Prescott, E. C. (1997). Postwar u.s. business cycles: An empirical investigation. *Journal of Money, Credit and Banking*, 1–16.

Holm-Hadulla, F., Hauptmeier, S., & Rother, P. (2012). The impact of expenditure rules on budgetary discipline over the cycle. *Applied Economics*, *44*(25), 3287–3296. https://doi.org/10.1080/00036846.2011.572855

Ilzetzki, E., Mendoza, E. G., & Végh, C. A. (2013). How big (small?) are fiscal multipliers? *Journal of monetary economics*, *60*(2), 239–254.

Ilzetzki, E., & Végh, C. A. (2008). *Procyclical fiscal policy in developing countries: Truth or fiction?* (Tech. rep.). National Bureau of Economic Research.

International Monetary Fund. (2012). *Macroeconomic policy frameworks for resource-rich developing countries* (tech. rep.). IMF. Washington, DC. https://www.imf.org/external/np/pp/eng/2012/082412.pdf

International Monetary Fund. (2023a). Imf data standards bulletin board (dsbb): Philippines, sdds metadata and observance [Accessed September 4, 2025].

International Monetary Fund. (2023b). *Philippines: 2023 article iv consultation—press release; staff report; and statement by the executive director* (IMF Country Report No. 414). International Monetary Fund.

International Monetary Fund Independent Evaluation Office. (2002, September). *Evaluation of Prolonged Use of IMF Resources* (Independent Evaluation Office Report) (Includes Philippines case study (23 arrangements, 1962–2000)). Independent Evaluation Office, International Monetary Fund. Washington, DC. https://www.imf.org/external/pubs/ft/epui/2002/pdf/report.pdf

Izquierdo, M. A., Lama, M. R., Medina, J. P., Puig, J., Riera-Crichton, D., Vegh, C., & Vuletin, G. J. (2019). *Is the public investment multiplier higher in developing countries? an empirical exploration*. International Monetary Fund.

Jaimovich, D., & Panizza, U. (2007). *Procyclicality or reverse causality?* (Tech. rep.). Working paper.

Jaimovich, N., & Rebelo, S. (2009). Can news about the future drive the business cycle? *American Economic Review*, *99*(4), 1097–1118.

Kabashi, R. (2016). *The cyclical character of fiscal policy in transition countries* (tech. rep.). Working Paper.

Kamber, G., Theodoridis, K., & Thoenissen, C. (2017). News-driven business cycles in small open economies. *Journal of International Economics*, *105*, 77–89.

Kaminsky, G. L., Reinhart, C. M., & Végh, C. A. (2005). When it rains, it pours: Procyclical capital flows and macroeconomic policies. In M. Gertler & K. Rogoff (Eds.), *Nber macroeconomics annual 2004, volume 19* (pp. 11–82, Vol. 19). MIT Press.

Klein, P., Krusell, P., & Rios-Rull, J.-V. (2008). Time-consistent public policy. *The Review of Economic Studies*, *75*(3), 789–808.

Klemm, A. (2014). *Fiscal policy in latin america over the cycle* (IMF Working Paper No. 14/59). International Monetary Fund. Washington, DC. https://www.imf.org/external/pubs/ft/wp/2014/wp1459.pdf

Konuki, T., & Villafuerte, M. (2016). *Cyclical behavior of fiscal policy among sub-saharan african countries* (Departmental Paper No. 16/09). International Monetary Fund. Washington, DC. https://www.imf.org/en/Publications/Departmental-Papers-Policy-

Papers/Issues/2016/12/31/Cyclical-Behavior-of-Fiscal-Policy-among-Sub-Saharan-African-Countries-44104

Kraay, A. (2014). Government spending multipliers in developing countries: Evidence from lending by official creditors. *American Economic Journal: Macroeconomics*, *6*(4), 170–208.

Kydland, F. E., & Prescott, E. C. (1977). Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy*, *85*(3), 473–491. https://doi.org/10.1086/260580

Kydland, F. E., & Prescott, E. C. (1982). Time to build and aggregate fluctuations. *Econometrica*, *50*(6), 1345–1370. https://doi.org/10.2307/1913386

Lane, P. R., & Milesi-Ferretti, G. M. (2018). The external wealth of nations revisited: International financial integration in the aftermath of the global financial crisis. *IMF Economic Review*, *66*(1), 189–222. https://doi.org/10.1057/s41308-017-0048-y

Leeper, E. M. (1991). Equilibria under "active" and "passive" monetary and fiscal policies. *Journal of Monetary Economics*, *27*(1), 129–147. https://doi.org/10.1016/0304-3932(91)90007-B

Lledó, V., Yackovlev, I., & Gadenne, L. (2009). *A tale of procyclicality, aid flows, and debt: Government spending in sub-saharan africa* (IMF Working Paper No. 09/274). International Monetary Fund. Washington, DC. https://pseweb.eu/ydepot/semin/texte0910/GAD2009CYC2.pdf

Loayza, N. V., & Raddatz, C. (2007). The structural determinants of external vulnerability. *World Bank Economic Review*, *21*(3), 359–387.

Lucas, R. E., & Stokey, N. L. (1983). Optimal fiscal and monetary policy in an economy without capital. *Journal of Monetary Economics*, *12*(1), 55–93.

Marcel, M. (2013). *The structural balance rule in chile: Ten years, ten lessons* (Technical Note). Inter-American Development Bank. https://publications.iadb.org/en/structural-balance-rule-chile-ten-years-ten-lessons

Maskin, E., & Tirole, J. (2001). Markov perfect equilibrium: I. observable actions. *Journal of Economic Theory*, *100*(2), 191–219. https://doi.org/10.1006/jeth.2000.2785

Mendoza, E. G. (1991). Real business cycles in a small open economy. *The American Economic Review*, *81*(4), 797–818.

Mendoza, E. G., & Oviedo, P. M. (2006). Fiscal policy and macroeconomic uncertainty in developing countries: The tale of the tormented insurer. *NBER Working Paper*, (12586).

Mueller, J., Duplay, R., Eyraud, L., Harris, J., Petrie, M., & de Clerck, S. (2015). *Philippines: Fiscal transparency evaluation* (IMF Country Report No. 15/156). International Monetary Fund.

Neumeyer, P. A., & Perri, F. (2005). Business cycles in emerging economies: The role of interest rates. *Journal of Monetary Economics*, *52*(2), 345–380.

Nocedal, J., & Wright, S. J. (2006). *Numerical optimization*. Springer.

Obstfeld, M., & Rogoff, K. S. (1996). *Foundations of international macroeconomics*. MIT Press.

PAGASA, Department of Science and Technology. (2025). Tropical cyclone information [Average of about 20 tropical cyclones enter the Philippine Area of Responsibility (PAR) annually; Accessed September 4, 2025].

Pandey, R., & Patnaik, I. (2019). *Fiscal policy cyclicality in south asian economies* (Working Paper No. 268). National Institute of Public Finance and Policy (NIPFP). New Delhi.

Philippine Statistics Authority. (2025). Quarterly national accounts of the philippines, q1 1981–present [Accessed September 4, 2025].

Ramey, V. A., & Zubairy, S. (2018). Government spending multipliers in good times and in bad: Evidence from us historical data. *Journal of political economy*, *126*(2), 850–901.

Riascos, A., & Vegh, C. A. (2003). Procyclical government spending in developing countries: The role of capital market imperfections. *unpublished (Washington: International Monetary Fund)*.

Schaechter, M. A., Kinda, M. T., Budina, M. N., & Weber, A. (2012). *Fiscal rules in response to the crisis: Toward the" next-generation" rules: A new dataset*. International Monetary Fund.

Schmitt-Grohé, S., & Uribe, M. (1997). Balanced-budget rules, distortionary taxes, and aggregate instability. *Journal of Political Economy*, *105*(5), 976–1000.

Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, *61*(1), 163–185. https://doi.org/10.1016/S0022-1996(02)00056-9

Schmitt-Grohé, S., & Uribe, M. (2012). What's news in business cycles. *Econometrica*, *80*(6), 2733–2764.

Talvi, E., & Végh, C. A. (2005). Tax base variability and procyclical fiscal policy in developing countries. *Journal of Development economics*, *78*(1), 156–190.

Thornton, J. (2008). Explaining procyclical fiscal policy in african countries. *Journal of African Economies*, *17*(3), 451–464.

Tornell, A., & Lane, P. R. (1999). The voracity effect. *American Economic Review*, *89*(1), 22–46.

Transparency International. (2025). Corruption perceptions index (cpi): Country rankings and scores [Accessed September 4, 2025].

UNCTAD. (2025). Unctadstat country profile: Philippines—fdi and external financial resources [Includes inward FDI stock as % of GDP; Accessed September 4, 2025].

Uribe, M., & Yue, V. Z. (2006). Country spreads and emerging countries: Who drives whom? *Journal of International Economics*, *69*(1), 6–36.

Woo, J. (2009). Why do more polarized countries run more procyclical fiscal policy? *The Review of Economics and Statistics*, *91*(4), 850–870.

World Bank. (2018). *Growth and productivity in the philippines* (tech. rep.) (Documents volatility facts for the 1980s). World Bank.

World Bank. (2025a). World development indicators (wdi): Gdp per capita (ny.gdp.pcap.cd); trade (% of gdp) (ne.trd.gnfs.zs); personal remittances, received (% of gdp) (bx.trf.pwkr.dt.gd.zs) [Accessed September 4, 2025].

World Bank. (2025b). Worldwide governance indicators (wgi): Country data and metadata [Accessed September 4, 2025].