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Armenia and Georgia in the Global Economy

Seven-Region GIMF Models: Structure, Calibration and Simulation Properties

VAZGEN POGHOSYAN
Central Bank of Armenia

ASYA KOSTANYAN
The Better Policy Project

DOUGLAS LAXTON
The Better Policy Project

ANNA AGHAJANYAN
The Better Policy Project

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Vazgen Poghosyan Asya Kostanyan
Douglas Laxton Anna Aghajanyan

Abstract

This paper documents two seven-region configurations of the Global Integrated Monetary and Fiscal Model for Armenia and Georgia and presents their fiscal, financing, productivity and international transmission properties. Finite-horizon optimizing households coexist with liquidity-constrained households; firms face nominal and investment adjustment costs, productive public capital, and a corporate financial accelerator. We set out the economic equations, regional accounting system, fiscal and monetary closures, loaded calibration and measurement of simulated responses. A common sourcing rule closes one fifth of the remaining bilateral adjustment gap each year while retaining the original long-run substitution targets. An aggregation correction makes the rule consistent with productivity-dependent intermediate-import units at first order. The audit includes 2,058 core scenarios across both systems and all seven shock origins. Seven fiscal instruments are compared for one- and two-year expansions under endogenous policy and anticipated one- and two-year interest-rate holds. Country-risk, dispersion, income-loss, capital-destruction, productivity and monetary innovations are reported separately. Additional productivity experiments hold the realized technology path fixed while agents recognize persistence over five years. Slow sourcing reverses the initial GDP increase in the domestic country-risk experiments, while some operating-income-loss experiments still raise consumption and GDP initially. Joint dispersion shocks generate larger contractions than domestic shocks alone. The results provide a reproducible research benchmark, with distinctions between numerical consistency, economic interpretation and empirical validation.

Keywords: GIMF; Armenia; Georgia; fiscal multipliers; trade adjustment; financial accelerator; learning; international spillovers.

JEL classification: E17, E32, E52, E62, F41, H54, H63.

Lead author: Vazgen Poghosyan. We thank Robert (Bob) Ford for the research and mentoring tradition that informs this work. The country calibration contains inherited observations, proxies and behavioral priors; sourcing speed and the learning schedule are specified experiments rather than estimated coefficients. All reported transitions are first-order solutions around the supplied stationary equilibria.

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1 Introduction

Armenia and Georgia are small economies with important and uneven external links. Fiscal policy operates through domestic purchasing power, imported inputs, public capital, private investment and financing conditions. International risk can depress domestic demand while also depreciating the currency and changing export competitiveness. The strength and timing of those channels determine whether a model provides a useful account of an episode. An initial GDP increase after an adverse financing shock is therefore a result to understand, not a sufficient reason to change a parameter until the sign becomes negative.

This paper develops the earlier stationary-calibration paper into a simulation-properties paper. It documents two distinct seven-region systems, explains their economic equations and closures, and reports numerical experiments reproducible from the delivered states. Armenia is not simply a relabeled Georgia block: the systems identify different neighbors and retain material differences in home elasticities and external positions.

The structure follows the GIMF tradition. Kumhof et al. (2010) provide the theoretical foundation for a multi-region general-equilibrium framework. Anderson et al. (2013) illustrate its simulation properties across fiscal and other shocks. Our contribution is a country-specific implementation and an audit of sourcing dynamics, finance and information assumptions. The inherited operational source is the authority for the implemented equations; the paper identifies the changes actually applied to that source.

Three distinctions organize the analysis. An elasticity determines a long-run target, while adjustment costs or inertia determine how quickly quantities approach it. Import compression caused by falling expenditure differs from replacing imported goods with domestic goods. Finally, satisfying a system of equations is not equivalent to empirical validation. These distinctions matter when the same depreciation both contracts domestic spending and redirects foreign demand.

The trade diagnosis found that virtually all of the immediate domestic export expansion after a country-risk shock came from foreign buyers changing suppliers. Delaying that switch reduced the initial export response. Here the candidate mechanism is carried through every included shock origin, including productivity shocks where supplier demand must respect changes in the units of intermediate-import aggregation.

The principal results are economically differentiated. Government purchases have larger initial GDP effects than broad transfers or tax reductions. Productive public investment has more persistent effects than government consumption. Anticipated interest-rate holds amplify many fiscal responses. Slower sourcing changes the sign of the domestic country-risk GDP response. Dispersion shocks contract consumption and investment but also generate a substantial default increase at the benchmark amplitude. Operating-income losses can initially raise consumption and GDP. Gradual recognition of productivity persistence reduces the initial expansion even with an unchanged realized supply path.

The paper covers the two seven-region systems and their included countries, not a rerun of the entire GIMF59 collection. The sourcing law is a first-order extension rather than an estimated nonlinear technology. The learning experiment specifies public belief revisions rather than a Bayesian likelihood. Permanent debt and inflation-target transitions require separate endpoints and announcements and are not represented by the temporary experiments reported here.

2 Regional structure and accounting conventions

2.1 Two regional systems

Each system identifies the United States, the home economy, the euro area, Russia, China and a residual rest of world. Armenia additionally identifies Georgia; Georgia instead identifies Turkiye. A region is an aggregate block, not a claim that its internal countries behave identically. The euro area is a single monetary region, so shocks to separate member countries are not identified.

The home economy is R2. R1 is the United States, R3 the euro area, R4 Russia, R5 the residual world, R6 China and R7 the additional neighbor. This mapping is part of the executable specification. Reporting names prevents an R7 shock from being mistaken for the same economy in both systems.

An import purchased by one region is an export sold by another. GDP sizes, partner weights, external positions and nominal valuation must satisfy a common accounting system. The residual world's final demand and selected partner coefficients solve jointly with the other regions; they are equilibrium residuals rather than independent observations.

2.2 Frequency, detrending and reported units

The delivered models are annual. Let g_t^A and g_t^N denote gross trend productivity and population growth. Stocks and flows use the source's detrended units, so capital accumulation includes $g_t^A g_t^N$. Regional consumption-price units and a common international numeraire govern nominal accounting. Gross inflation factors must be distinguished from rates in percent.

A hat denotes a proportional first-order deviation and Δ a level deviation. Thus $100\widehat{C}_t$ is a percentage consumption response, while $100\Delta\Pi_t^C$ is the audit's percentage-point CPI inflation response. Ratios already expressed as percentages of GDP retain their source scale. Appendix B gives the exact reporting transformations.

Currency, price and composition changes affect nominal trade values. Export and import volumes therefore use first-order chain-Fisher quantity indices, as does real GDP. A regional nominal GDP level in its own price normalization is not itself a common-currency world GDP weight.

3 Households, consumption and public debt

3.1 Finite-horizon optimizing households

Optimizing households combine finite planning horizons, declining income profiles and intertemporal choice. Let C_t^O be optimizing-household consumption, m_t its marginal propensity to consume from wealth, and W_t total wealth. The implemented aggregate relations are

$$C_t^O = m_t W_t, \tag{1}$$

$$W_t = FW_t + HW_t + OW_t. \tag{2}$$

Financial wealth contains inherited government and corporate bonds and the domestic value of international assets. Human wealth values future after-tax labor-income endowments. Other wealth contains dividends, transfers, taxes and distributional income flows.

Define the effective marginal consumption price $p_t^O = PR_t^O + \tau_t^c P_t^C$. With planning factor θ, income-decline factor χ and source consumption kernel $\mathcal{J}_t$,

$$m_t^{-1} = p_t^O/\eta_O + \frac{\theta}{R_t}\mathcal{J}_t m_{t+1}^{-1}, \tag{3}$$

$$HW_t = n(1-\psi)MRS_t(1-\tau_t^l)SL_t + \frac{\theta\chi g_{t+1}^A}{R_t}HW_{t+1}. \tag{4}$$

Here R_t is the gross real return, n the population normalization, ψ the constrained-household share and SL_t the labor-endowment shifter. The source discount notation satisfies $RSDF_{t+1} = 1/R_t$. Future quantities mean expectations conditional on the decision-date information set.

The kernel $\mathcal{J}_t$ collects preference, tax, labor-leisure and consumption-persistence terms; it is not an independently selected reduced-form MPC. Equation (3) shows how effective consumption prices, discounting and future conditions affect current consumption. The full expanded kernel and labor-supply equations remain in the source equation catalog.

Government bonds affect wealth because finite horizons and income profiles alter the valuation of future taxes relative to an infinitely lived dynasty. This gives debt and fiscal incidence an economic role. It does not imply immediate spending of every debt-financed transfer: optimizing households still save and alter labor supply.

3.2 Constrained households and transfer incidence

Liquidity-constrained households consume current disposable resources. Their compact budget constraint is

$$p_t^L C_t^L = (1-\tau_t^l)MRS_t L_t^L + \mathcal{D}_t^L + \psi(TRANSFER_t - LSTAX_t) + TRANSFER_t^{targ,L}, \tag{5}$$

where p_t^L is their effective consumption price and $\mathcal{D}_t^L$ collects relevant retail and union distributions. The active configuration has no remittance block. The full source retains the population, retailer and union terms explicitly.

Aggregate consumption is $C_t = C_t^O + C_t^L$. The targeted-transfer experiment sends the marginal transfer entirely to constrained households; it does not change the initial share of constrained households or reallocate the existing transfer stock. General transfers reach both groups and are partly saved by optimizing households.

The home constrained-household share is forty percent in both calibrations. Planning and income-decline factors are each 0.95, corresponding to the inherited twenty-year annual horizons. They are structural priors, not estimates from country household microdata. Incidence and shock size are separate assumptions in the targeted/general-transfer comparison.

4 Production, capital and nominal adjustment

4.1 Private production and utilized capital

For sector $s \in \{T, N\}$, utilized capital and effective labor enter a CES technology. An abbreviated active source equation is

$$Z_{s,t} = AA_{s,t}\left[(1-\alpha_{s,U})^{1/\xi_s}K_{s,t}^{(\xi_s-1)/\xi_s} + \alpha_{s,U}^{1/\xi_s}(TECHFAC\, A_{s,t}U_{s,t})^{(\xi_s-1)/\xi_s}\right]^{\xi_s/(\xi_s-1)}. \tag{6}$$

AA is the level-productivity shifter and A a labor-augmenting component. The productivity experiment shocks the common AA innovation in both sectors. The oil-input block is inactive. Utilization satisfies $K_{s,t} = u_{s,t}\mathcal{K}_{s,t}$, with utilization costs and factor-demand conditions determining the operating intensity of capital.

The factor-substitution elasticity in (6) differs from the home/import and foreign-supplier elasticities. These parameters govern separate margins. Conflating them would attribute a change in productive input substitution to a change in export demand.

4.2 Private investment and installation

Installed capital follows

$$\mathcal{K}_{s,t} g_t^A g_t^N = (1 - \delta_{s,t})\mathcal{K}_{s,t-1} + I_{s,t-1} S_{I,t-1}^{acc}, \qquad \delta_{s,t} = \bar{\delta}_s + NWKSHK_{s,t}. \tag{7}$$

Investment takes a period to enter installed capital. A capital-destruction shock changes effective depreciation, not simply the valuation of an unchanged stock. The real investment adjustment cost is

$$\mathcal{G}_{I,s,t} = \frac{\phi_I}{2} I_{s,t} \left(S_{I,t} \frac{I_{s,t}}{I_{s,t-1}} - 1 \right)^2. \tag{8}$$

The capital-producer optimality condition links $Q_{s,t}$ to the investment-good price and present and future marginal adjustment costs. Anticipated demand, financing and productivity therefore affect investment before installation is complete.

4.3 Public capital

Public capital enters the domestic final-output aggregation block:

$$Z_t^D = Y_t^A (K_{1,t}^G)^{\alpha_{G1}} (K_{2,t}^G)^{\alpha_{G2}} SCALEFAC, \tag{9}$$

$$K_{1,t}^G g_t^A g_t^N = (1 - \delta_{G1}) K_{1,t-1}^G + G_{t-1}^{inv}, \tag{10}$$

$$K_{2,t}^G g_t^A g_t^N = (1 - \delta_{G2}) K_{2,t-1}^G + G_{t-1}^{cons}. \tag{11}$$

The loaded infrastructure output elasticity is 0.1; the second stock's output elasticity is zero. SCALEFAC normalizes initial public capital consistently with the final-output level. Government investment thus has a purchases channel and a lagged productive-services channel. Government consumption has a direct purchases channel without the same productive effect.

These elasticities do not measure project selection, procurement quality or implementation delays. Applying the model to a particular infrastructure program requires that additional mapping rather than an assumption that all recorded government investment is equally productive.

4.4 Prices and wages

Monopolistically competitive producers, wage setters and distributors face quadratic nominal adjustment costs. A representative producer-price cost has the source form

$$\mathcal{G}_{P,s,t} = \frac{\phi_{P,s}}{2} Z_{s,t} \left(\frac{\Pi_{s,t}}{\Pi_{s,t-1}^{1-\zeta}} - (\Pi_t^*)^{\zeta} \right)^2. \tag{12}$$

Pricing optimality balances markup deviations against current and expected future marginal adjustment costs. Wage, consumption, investment and bilateral import prices have their own

coefficients and normalization terms. Equation (12) is the cost expression; the full pricing first-order conditions are retained in the catalog.

The delivered ζ is zero, so lagged inflation enters the cost benchmark. The wage adjustment coefficient is 216; tradable, nontradable and investment-good producer-price coefficients are 108. Retail consumption and bilateral import-price coefficients differ. These are cost parameters, not Calvo non-adjustment probabilities or measured price durations. The same nominal-adjustment profile is imposed in every included region.

5 Entrepreneurial finance and country risk

5.1 Balance sheets and default

Entrepreneurs finance capital with net worth and debt:

$$B^e_{s,t} = Q_{s,t}\mathcal{K}_{s,t}g^A_t g^N_t - NW_{s,t}. \tag{13}$$

Capital returns and the financing contract jointly determine leverage, the default threshold and monitoring costs. With standardized threshold $z_{s,t}$, dispersion $\sigma_{s,t}$ and standard-normal distribution function Φ,

$$\bar{\omega}_{s,t} = \exp(z_{s,t}\sigma_{s,t} - \sigma^2_{s,t}/2), \tag{14}$$

$$PD_{s,t} = \Phi(z_{s,t}), \qquad H_{s,t} = \Phi(z_{s,t} - \sigma_{s,t}), \tag{15}$$

$$\mathcal{G}_{s,t} = H_{s,t} + \bar{\omega}_{s,t}[1 - \Phi(z_{s,t})]. \tag{16}$$

The lender zero-profit condition and entrepreneur return condition determine z. Raising dispersion is therefore not equivalent to imposing an additive loan spread.

Suppressing the regional index, net worth obeys

$$\begin{aligned} NW_{s,t} = {} & \frac{R^{realized}_{t-1}}{g^A_t g^N_t} NW_{s,t-1} + \left[R^k_{s,t-1,realized}(1 - \mu_s H_{s,t}) - R^{realized}_{t-1}\right] Q_{s,t-1}\mathcal{K}_{s,t} \\ & - P_{s,t}(DIV_{s,t} + NWYSHK_{s,t}). \end{aligned} \tag{17}$$

Realized returns on inherited capital differ from expected returns on new capital. Dividends follow the inherited net-worth rebuilding rule. Bankruptcy resource costs, enterprise distributions and capital-producer income enter household and resource accounts through separate source equations.

Baseline default is eight percent in each sector, a model prior rather than an observed country default rate. The financial figures use contemporaneous NORMCDF probabilities. The source's ZZ_BUST reporting variable leads these by one period; the paper does not mix the two timings.

5.2 Three corporate shocks

The dispersion, or Ziggy, shock raises σ in both sectors by one sixth of its initial value, with persistence 0.6. Operating-income-loss innovations raise NWYSHK, normalized by initial sector net worth. They reduce net worth through (17) and enter sector resource-clearing equations. Capital-destruction innovations raise effective depreciation in (7). Each loss-ratio test uses a one-percent innovation relative to the source net-worth normalization.

These disturbances need not produce identical consumption or investment signs. An operating-resource loss differs from more dispersed firm outcomes and from destruction of installed capital. Dividend rules, real returns, fiscal feedback and household income respond differently. Their results are reported separately rather than hidden under a generic financial-shock label.

5.3 Policy rates, financing and international parity

Let Ω_t be the country premium and $\widetilde{\Omega}_t$ its inherited smoothing object. The source distinguishes the policy rate from the financing rate:

$$I_t = I_t^{MP} \frac{\Omega_t}{\widetilde{\Omega}_t^{1-\delta_I} \widetilde{\Omega}_{t-1}^{\delta_I}}, \tag{18}$$

$$I_t = R_t \Pi_{t+1}^{C}. \tag{19}$$

The international parity condition for a non-numeraire region is

$$I_{r,t} = EPS_{r,t+1} I_{US,t} \frac{RISKPREM_{r,t}}{RISKPREM_{US,t}}, \qquad RISKPREM_{r,t} = FXPREM_{r,t} \Omega_{r,t}. \tag{20}$$

The exchange-premium component retains the external-balance closure. A one-hundred-basis-point country-premium shock is therefore not an assumption that every borrowing rate rises exactly that amount. Policy, expectations, premium smoothing and exchange rates determine the outcome jointly.

The premium deviation is $\Delta\Omega_t = 0.01\rho^{t-1}$ for $\rho = 0.2$ or 0.6. The loaded operational autoregressive coefficients are zero, so the audit supplies the equivalent known innovation sequence. No separate inflation-expectations or credibility wedge is introduced.

6 Trade targets, adjustment speed and aggregation

6.1 Home goods versus imports

Consumption and investment distributors combine domestic goods and imported final aggregates. A representative relation is

$$Z_t = \left[\alpha_H^{1/\xi} Y_{H,t}^{(\xi-1)/\xi} + (1-\alpha_H)^{1/\xi} \{ Y_{F,t}(1-\mathcal{G}_{F,t}) \}^{(\xi-1)/\xi} \right]^{\xi/(\xi-1)}. \tag{21}$$

Intermediate distributors have a corresponding home/import margin with productivity-related share terms. The elasticities XI_C, XI_I and XI_T govern consumption, investment and intermediate substitution between domestic goods and the import aggregate. PHI_FC, PHI_FI and PHI_FT govern changes in import intensity. They do not govern switching between two foreign suppliers.

Imports can fall because absorption falls or because import intensity falls within an absorption category. Supplier composition and valuation add another margin. These are jointly endogenous responses. Export growth divided by depreciation is not an estimate of one of the structural elasticities.

6.2 Bilateral suppliers

For final imports bought by r from j,

$$P^F_{D,r,t} = \left[\sum_{j \neq r} \zeta^D_{rj} P^{1-\eta_{D,r}}_{D,rj,t}\right]^{1/(1-\eta_{D,r})}, \tag{22}$$

$$Y^*_{D,rj,t} = \zeta^D_{rj} Y^F_{D,r,t} (P_{D,rj,t}/P^F_{D,r,t})^{-\eta_{D,r}}. \tag{23}$$

The consumption and investment splits satisfy the same relative-price relation. Intermediate target demands use the normalized productivity-dependent bias

$$b^T_{rj,t} = \frac{\zeta^T_{rj}(A_{T,j,t}AA_{T,j,t})^{\beta_r}}{\sum_{k \neq r} \zeta^T_{rk}(A_{T,k,t}AA_{T,k,t})^{\beta_r}}, \tag{24}$$

where $\beta_r = BALSAM_r$. Supplier elasticities $\eta_D = XI_DM$ and $\eta_T = XI_TM$ are distinct from the home/import elasticities.

Define $s_{rj,t} = \widehat{Y}_{rj,t} - \widehat{Y}^F_{r,t}$. The original diagnostic law was

$$s_{rj,t} = \lambda_r s_{rj,t-1} + (1-\lambda_r) s^*_{rj,t}. \tag{25}$$

Retention of 0.8 closes one fifth of the remaining gap each year, a roughly three-year half-life under an unchanged target. The fast case has zero retention. The dotted-line case delays foreign buyers only; common slow sourcing delays every buyer. Within a model, long-run elasticities and steady weights remain unchanged.

Boehm, Levchenko and Pandalai-Nayar (2023) find smaller short-run than long-run tariff-induced trade responses and adjustment over several years. This motivates separating horizons. Their tariff experiment is not a country-risk experiment and does not estimate our retention coefficient. The speed remains a chosen research sensitivity.

6.3 The productivity aggregation correction

Intermediate aggregation changes its effective units when productivity-dependent trade biases change. With initial expenditure weights w_{rj}, define

$$h_{r,t} = \sum_{j \neq r} w_{rj} \widehat{b}^T_{rj,t}, \qquad c_{r,t} = -h_{r,t}/(\eta_{T,r} - 1). \tag{26}$$

The first-order CES identity is

$$\sum_{j \neq r} w_{rj} \widehat{Y}_{T,rj,t} = \widehat{Y}^F_{T,r,t} + c_{r,t}. \tag{27}$$

Simply delaying the full target can violate this identity. The corrected law is

$$s_{rj,t} = \lambda_r s_{rj,t-1} + (1-\lambda_r) s^*_{rj,t} + \lambda_r (c_{r,t} - c_{r,t-1}). \tag{28}$$

If weighted lagged shares sum to $c_{r,t-1}$ and weighted target shares sum to $c_{r,t}$, weighted summation of (28) yields $c_{r,t}$ exactly. Final imports have $c = 0$.

The extra term separates sourcing composition from the productivity-unit adjustment required by the CES system. In every non-productivity experiment here, autonomous A_T and AA_T

states remain at baseline, so the correction vanishes. Fiscal, country-risk and financial paths are unchanged. Corrected productivity paths replace the failed initial diagnostics, which remain in the computational record.

This is an explicit first-order law, not a fully optimized nonlinear adjustment technology or a nonlinear welfare result. Estimating its speed and deriving its nonlinear microfoundations remain separate tasks.

7 Fiscal and monetary closure

7.1 Government accounts and the residual instrument

Debt, the primary balance and interest costs satisfy

$$SUR_t = -\left[B_t - \frac{B_{t-1}}{\Pi_t^C g_t^A g_t^N}\right], \tag{29}$$

$$SUR_t = PS_t - IC_t, \qquad IC_t = \frac{(I_{t-1}-1)B_{t-1}}{\Pi_t^C g_t^A g_t^N}. \tag{30}$$

Effective labor, capital and consumption taxes enter revenue. Purchases include government consumption and investment. General transfers are the residual budget instrument in the loaded closure; targeted transfers are specified separately.

The rule targets the overall surplus relative to current GDP, with an output-gap term and inherited switches for tax, inflation and debt feedback. The home output-gap coefficient is 0.49 and direct debt-gap feedback is zero. At unchanged stationary output, the surplus implies

$$\bar{b} = -\bar{s}\,\frac{\bar{\Pi} g^A g^N}{\bar{\Pi} g^A g^N - 1}. \tag{31}$$

Zero extra debt-gap feedback does not mean the rule has no stationary debt implication. A deliberate permanent debt reduction nevertheless needs a new target and an explicit transition. Residual transfers are a net closure item, not a direct observation of social-benefit spending. This paper does not silently change that instrument to labor taxes or a discretionary consolidation package.

7.2 The policy rule used in the simulations

The audit replaces the original policy row with a common annual forecast-inflation rule. In log deviations,

$$\begin{aligned}\widehat{I}_{r,t}^{MP} - \widehat{I}_{r,t-1}^{MP} = \tfrac{1}{2}\Big[0.75(\widehat{\Pi}_{r,t}^{C} - \widehat{\Pi}_{r,t}^{*}) + 0.25(\widehat{\Pi}_{r,t+1}^{C} - \widehat{\Pi}_{r,t+1}^{*})\Big] \\ + \widehat{S}_{r,t}^{INT}.\end{aligned} \tag{32}$$

This is the row actually implemented. In annual frequency its inflation terms are current and next-year observations; they should not be described as quarterly leads four and eight without a timing conversion. Replacing the policy row does not change every occurrence of the original smoothing parameter in other equations, including financing-premium smoothing.

The euro area has one rate; other regions have their own rates and exchange rates. Country risk changes a financing wedge, not the inflation target. The monetary innovation is normalized as a one-percentage-point innovation in the linear policy equation, not an imposed one-year increase in the observed rate. Endogenous feedback and later policy decisions remain active.

7.3 Anticipated holds versus sequential decisions

For each fiscal shock the policy rate is endogenous, held at baseline for the first year, or held for the first two years. Policy innovations are solved jointly with private-sector behavior to satisfy the hold. Thereafter equation (32) applies without further discretionary innovations.

The core holds are announced initially. A known two-year hold differs from a one-year promise unexpectedly extended at the beginning of year two. The latter requires a revised information set and conditional solution. Fiscal figures in this paper do not label anticipated holds as surprise sequential decisions. The productivity experiment below does use sequential information revisions.

8 Calibration and empirical status

8.1 Home targets and structural parameters

Table 1 uses current loaded states, rather than copying an earlier paper's table. Values describe the model benchmark, not a new national-accounts release. Exports and imports are model goods-and-services exposures. Armenia's openness retains a structural re-export adjustment; Georgia's fiscal and external mappings include documented proxies.

Table 1: Domestic stationary fiscal and external ratios

Percent of GDP	Armenia	Georgia
Government consumption	10.66	12.90
Government investment	5.50	7.70
Government debt	48.00	36.10
Overall balance	-2.54	-1.91
Primary balance	0.25	0.19
Exports	55.24	52.19
Imports	55.00	51.73
Net foreign assets	-47.10	-89.00

Source and notes: Current operational states; percentages of annual GDP. Debt and NFA retain the source concepts. Rounding does not replace stored input precision.

Table 2: Selected home structural parameters

Parameter	Armenia	Georgia
Liquidity-constrained population share	0.40	0.40
Survival / planning factor	0.95	0.95
Income-decline factor	0.95	0.95
Risk aversion	2.00	2.00
Consumption persistence	0.40	0.40
Public-capital output elasticity	0.10	0.10
Investment adjustment parameter	1.00	1.00
Home/import consumption elasticity	0.75	1.50
Home/import investment elasticity	0.75	1.50
Home/import intermediate elasticity	1.50	1.50
Final supplier elasticity	1.50	1.50
Intermediate supplier elasticity	1.50	1.50
Wage adjustment parameter	216.00	216.00
Tradable price adjustment parameter	108.00	108.00
Fiscal output-gap coefficient	0.49	0.49
Fiscal debt-gap coefficient	0.00	0.00

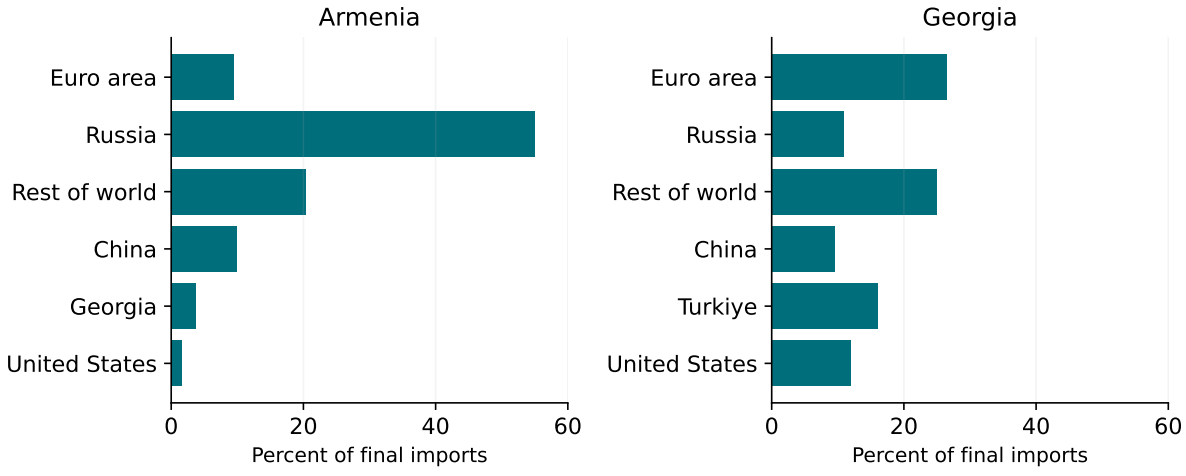
Source and notes: Loaded values. Nominal adjustment parameters are common across all regions. The annual planning and income-decline factors imply horizons of about twenty years.

Armenia's home consumption and investment elasticities are 0.75, while Georgia's are 1.5. Supplier elasticities are 1.5 in both. The timing tests retain these differences. Country contrasts therefore cannot be attributed solely to openness or sourcing speed, and the paper does not imply that the long-run calibrations are already identical.

8.2 Trade exposure and re-exports

Figure 1 displays solved home final-import expenditure shares. Russia dominates Armenia's identified supplier network. Georgia's network is more dispersed. Gross trade exposure is important, but it is not a value-added measure of dependence.

Figure 1: Home final-import supplier shares



Source and notes: Solved bilateral shares. Selected cells use EU27 proxies, common goods shares across uses and mirror-trade adjustments. These are calibration networks, not estimated transmission coefficients.

Re-export and transit refinements must reconcile domestic production, imported inputs, minimally transformed re-exports and domestic transport or wholesale margins. Multiplying the model's goods-and-services export ratio by a customs domestic-export percentage would not perform that reconciliation. No additional numerical re-export correction is installed here.

The residual world closes selected trade and expenditure accounts. Its behavioral parameters include generic priors. Category-specific partner weights and small bilateral cells are not independently estimated. An equilibrium residual, a dated observation and a behavioral prior carry different uncertainties and should not receive an undifferentiated empirical interpretation.

8.3 China's fiscal perimeter

The loaded benchmark separates government from enterprise investment in China. Government investment is 4.19 percent of GDP, an inherited research benchmark with empirical provenance still to be reconciled. A previous ownership-based split treated state-owned-enterprise investment as government investment. The repaired mapping reallocates spending between government and enterprises while preserving total investment.

This removes a problematic fiscal residual conditional on that benchmark. It does not certify the government investment, revenue, debt and transfer concepts against a single statistical perimeter. That reconciliation matters for international experiments because a large region's fiscal and capital assumptions affect the rest of the system. The regional tables in Appendix C expose these inputs rather than presenting only the home economy.

9 Numerical method, information and validation

9.1 Stationary calibration and dynamic solution

Each regional system has 4,931 calibration equations and 4,711 operational dynamic equations. These include accounting and reporting relations; the counts are not numbers of independently estimated behavioral equations. Calibration flips solve parameters and ratios jointly. The operational configuration restores the behavioral interpretation of the recovered parameters.

The supplied states come from the preceding nonlinear calibration workflow. The dynamic engine expands the operational source, checks the stationary equations and constructs sparse shift-specific Jacobians. The first-order system is

$$\sum_{k \in \mathcal{K}} J_k \Delta x_{t+k} + F \varepsilon_t = 0. \tag{33}$$

A Schur reduction eliminates static variables, and sparse factorization with refinement solves the stacked dynamic system. Forty- and eighty-year horizons impose zero deviations outside the solution window. The first twenty years are compared to assess terminal-horizon sensitivity.

The policy and sourcing changes enter the actual Jacobians. A known sequence implements shock persistence when the loaded shock process is white noise. Fixed-rate constraints are enforced by solving a small system for the required policy innovations. None of these operations relies on changing an assignment that the running model does not use.

9.2 Core numerical checks

Tests cover the stationary residual, stacked conditional equations, first-order CES aggregation, impact GDP expenditure accounting, fixed-rate constraints and horizon sensitivity. All seven destination responses are retained for every shock origin.

Table 3: Numerical consistency of the core audit

Model	Timing	Stationary	Linear	CES	GDP impact	Horizon (pp)
Armenia	Fast	2.7e-12	2.2e-13	1.8e-11	8.0e-10	0.0015
Armenia	Dotted	2.7e-12	5.6e-14	9.3e-12	7.9e-10	0.0023
Armenia	Common slow	2.7e-12	1.4e-13	6.5e-12	7.9e-10	0.0023
Georgia	Fast	5.9e-12	1.1e-13	2.8e-11	9.7e-10	0.0020
Georgia	Dotted	5.9e-12	1.5e-13	1.1e-11	6.9e-10	0.0027
Georgia	Common slow	5.9e-12	2.8e-13	1.1e-11	6.9e-10	0.0027

Source and notes: Maximum absolute errors. CES uses the corrected productivity-unit identity. The horizon column is the maximum first-twenty-year GDP difference in percentage points; the threshold is 0.01. Original failed and replacement productivity checks are retained.

Thresholds are 10^{-8} for stationary and linear residuals, 10^{-7} for quantity and GDP identities and 10^{-9} for fixed-rate constraints. The retained non-productivity quantity check is evaluated at horizon eighty; full equation residuals and impact GDP checks cover both horizons. Corrected productivity quantity checks cover both.

Passing establishes first-order numerical consistency of these experiments. It is not a global uniqueness proof, full rational-expectations determinacy analysis, nonlinear accuracy guarantee or empirical identification of the sourcing speed. The paper reports economic anomalies even when their equation residuals are small.

9.3 Five-year recognition of productivity persistence

Realized common sector technology is one percent above baseline in years one through ten. Full information makes that path known initially. Under gradual recognition, agents observe the full current increase but initially expect only one fifth to persist in subsequent years through year ten. Expected future productivity rises by another fifth at the beginning of each of years two through five; the terminal date remains year ten.

The initial perceived profile is one percent in year one and 0.2 percent thereafter through year ten. At year $k+1$, for $k = 1, \ldots, 4$, the current-year surprise is $1 - 0.2k$ percentage points and the future revision is 0.2 percentage points. By year five persistence is fully recognized. These vintages sum to the same realized technology path as full information.

Each news vintage is solved at its arrival-date information set. Shifted responses are added while preserving inherited states. Conditional equations are checked for every vintage. The realized sum is not incorrectly required to satisfy the initial perfect-foresight system with hindsight. This is a public belief-revision experiment; its fifths are not estimated posterior probabilities.

Table 4: Conditional validation of the recognition experiments

Model	Timing	Conditional residual	CES	Realized TFP	Horizon (pp)
Armenia	Fast	5.3e-14	2.8e-12	2.7e-13	0.0011
Armenia	Common slow	2.8e-14	1.6e-12	2.6e-13	0.0013
Georgia	Fast	6.3e-14	4.5e-12	2.7e-13	0.0013
Georgia	Common slow	1.9e-14	2.7e-12	2.6e-13	0.0016

Source and notes: Seven origins in each model and timing case; five news vintages per origin; forty- and eighty-year horizons. The realized productivity path is independently checked.

10 Fiscal experiments and economic properties

10.1 Comparable impulses and the experiment grid

The seven instruments are government consumption, government investment, targeted transfers, general transfers and labor-, capital- and consumption-tax reductions. The initial instrument cost is one percent of baseline GDP in each active year. Purchases use the initial government price; rate changes use the initial tax base. This does not impose an identical ex-post deficit after feedback.

The grid has seven origins, fourteen fiscal instrument/duration combinations, three monetary regimes and seven non-fiscal tests. Thus $7(14\times3+7)=343$ scenarios arise for each model/timing case. Two models and three timing specifications give 2,058 core scenarios at both horizons. Recognition adds twenty-eight realized productivity scenarios across two models, two timing cases and seven origins, each decomposed into five conditional news-vintage solutions at both horizons. Simultaneous financial paths are exact first-order sums.

10.2 Domestic fiscal responses

Tables 5 and 6 report two-year expansions with common slow sourcing. E is endogenous policy, $F1$ an initially announced one-year hold and $F2$ an initially announced two-year hold. GDP responses in both years and first-year CPI inflation are shown separately. One-year expansions appear in Appendix D.

Table 5: Armenia: two-year fiscal expansions

Instrument	Y_1^E	Y_2^E	Y_1^{F1}	Y_2^{F1}	Y_1^{F2}	Y_2^{F2}	π_1^E
Government consumption	0.62	0.58	0.65	0.63	0.74	0.74	0.02
Government investment	0.71	0.77	0.79	0.86	0.82	0.90	0.06
Targeted transfers	0.37	0.37	0.39	0.39	0.44	0.46	0.01
General transfers	0.17	0.17	0.17	0.17	0.19	0.20	0.00
Labor tax reduction	0.18	0.19	0.18	0.20	0.19	0.21	0.01
Capital tax reduction	0.27	0.31	0.31	0.36	0.38	0.44	0.02
Consumption tax reduction	0.28	0.29	0.30	0.31	0.33	0.36	-1.28

Source and notes: GDP percent deviations and CPI inflation percentage-point deviations. One percent of initial GDP is the instrument impulse in each of the first two years. All holds are anticipated initially. Common slow sourcing.

Table 6: Georgia: two-year fiscal expansions

Instrument	Y_1^E	Y_2^E	Y_1^{F1}	Y_2^{F1}	Y_1^{F2}	Y_2^{F2}	π_1^E
Government consumption	0.70	0.66	0.75	0.72	0.85	0.85	0.03
Government investment	0.80	0.85	0.88	0.94	0.92	1.00	0.06
Targeted transfers	0.41	0.41	0.44	0.44	0.50	0.53	0.01
General transfers	0.19	0.18	0.20	0.19	0.22	0.23	0.00
Labor tax reduction	0.21	0.22	0.21	0.23	0.22	0.25	0.01
Capital tax reduction	0.34	0.39	0.38	0.44	0.45	0.54	0.03
Consumption tax reduction	0.32	0.33	0.34	0.35	0.38	0.41	-1.29

Source and notes: Definitions as in Table 5. Numerical files retain unrounded values.

Government investment has the largest initial GDP response under the endogenous rule in both home economies, followed by government consumption. Its second-year response is larger than its first-year response as expenditure dynamics and capital services persist. The result reflects purchases and productive capacity, not an assumption that all private spending must be crowded in.

Targeted transfers exceed broad transfers in initial GDP impact. This accords with the current-resource constraint of their recipients. General transfers also reach optimizing households and are partly saved. The ranking is conditional on household incidence, the constrained share and the financing closure; it is not a universal transfer multiplier.

Tax cuts work differently. Labor taxes affect disposable income and work incentives, while capital taxes affect expected returns and investment. Consumption taxes change tax-inclusive consumer prices. Their direct CPI effect is much larger than the inflation response to other fiscal instruments. That CPI decline is not evidence of an equally large endogenous disinflation of producer costs or a lower inflation target.

10.3 Monetary accommodation and dynamics

Temporary nominal-rate holds change expected real returns and private spending. For many instruments the two-year hold raises initial and subsequent GDP effects relative to the endogenous rule. Fiscal announcements and financing are otherwise unchanged. The effect is not a universal scalar multiple: tax-inclusive inflation, investment valuation and transfer incidence affect the result differently.

The paired figures in Appendix F show GDP, consumption, investment and CPI inflation for all seven two-year expansions. Corresponding panels share scales across countries and instruments. This exposes the smaller broad-transfer effects rather than rescaling every panel to make all instruments appear equally strong.

10.4 Fiscal effects of sourcing speed

Table 7: First-year GDP and sourcing timing: two-year fiscal shocks

Instrument	AM fast	AM dotted	AM common	GE fast	GE dotted	GE common
Government consumption	0.56	0.62	0.62	0.64	0.70	0.70
Government investment	0.74	0.71	0.71	0.80	0.80	0.80
Targeted transfers	0.33	0.37	0.37	0.37	0.41	0.41
General transfers	0.14	0.17	0.17	0.16	0.19	0.19
Labor tax reduction	0.18	0.18	0.18	0.20	0.21	0.21
Capital tax reduction	0.29	0.27	0.27	0.35	0.34	0.34
Consumption tax reduction	0.25	0.28	0.28	0.28	0.32	0.32

Source and notes: Endogenous policy, percent responses. AM is Armenia and GE Georgia. Dotted delays foreign buyers; common delays all buyers. Within-model long-run parameters and steady weights are retained.

Slower sourcing changes import leakage, competitiveness and private expenditure jointly. It can retain more expenditure at home while delaying export reallocation, so it need not move every multiplier in the same direction. The purchases/broad-transfer ranking is informative in this benchmark, but its values require new tests if import content, incidence or financing changes.

11 Country risk and trade timing

11.1 Domestic transmission

With immediate foreign sourcing, the one-hundred-basis-point premium shock with persistence 0.2 initially raises GDP in both home economies despite weaker consumption and investment. Depreciation rapidly expands export market shares; import compression supports net exports. The original diagnosis found virtually no role for stronger foreign absorption in that initial export increase.

Under common slow sourcing, the first-year GDP response is approximately minus one tenth of a percent in each country. The export-volume increase falls from about nine tenths to about one fifth of a percent. Imports continue to fall because absorption and import intensity adjust. The result changes through the relative timing of demand and market shares, not through removing the external sector.

Figures 9 and 10 compare fast, foreign-only-slow and common-slow rules. The slow curves nearly coincide for some domestic quantities. The common rule nevertheless treats a shock originating abroad more symmetrically: every buyer faces the same sourcing retention coefficient.

11.2 Persistence and impact accounting

Greater persistence deepens the contraction. With persistence 0.6, first-year GDP falls by roughly three tenths of a percent rather than roughly one tenth under common slow sourcing. Depreciation, inflation and import compression change with the duration of financing stress; these are solved responses rather than imposed elasticities.

Table 8 separates impact expenditure contributions. A negative import change is subtracted and supports net exports. Consumption and investment drive the initial domestic-demand decline under country risk, while net exports offset much of it without reversing the GDP sign.

Table 8: Impact GDP expenditure contributions

Model	Shock	C	I	G	X	M (subtract)	GDP
Armenia	Country risk	-0.36	-0.21	0.00	0.10	-0.38	-0.09
Armenia	Ziggy	-0.09	-0.63	0.00	-0.02	-0.32	-0.42
Armenia	Income loss	0.17	-0.04	0.00	-0.01	0.08	0.04
Armenia	Capital loss	0.01	0.05	0.00	-0.01	0.04	0.01
Georgia	Country risk	-0.40	-0.20	0.00	0.10	-0.39	-0.12
Georgia	Ziggy	-0.12	-0.59	0.00	-0.01	-0.27	-0.45
Georgia	Income loss	0.14	-0.05	0.00	-0.01	0.05	0.02
Georgia	Capital loss	-0.00	0.04	0.00	-0.01	0.03	-0.00

Source and notes: Common slow sourcing. Contributions are percentage points of initial GDP at previous-price valuation. GDP equals C+I+G+X–M. M is shown before subtraction. Display rounding can obscure exact adding-up.

The decomposition also corrects a possible misunderstanding of the operating-income-loss experiment. Its exports fall and imports rise initially; consumption drives its small GDP increase. That is not a remaining export boom. A further arbitrary export-elasticity reduction cannot supply the missing household-income and financing explanation.

11.3 All shock origins

Appendix E reports own-region risk responses in every included origin at both persistence values. Large economies need not match the home response: their exposure, financial structure, expenditure composition and residual fiscal flows differ. The suite verifies accounting under those differences.

A country-risk innovation isolates one origin's financing wedge. A global financial scenario shocks several regions explicitly. A foreign response to an isolated shock does not mean the foreign region was itself directly shocked. These distinctions matter when domestic vulnerability and international transmission are assessed.

12 Corporate shocks and international co-movement

12.1 Dispersion, investment and default

Dispersion stress lowers home GDP, consumption and investment under common slow sourcing. Initial investment falls about four percent; GDP falls by less than one half of a percent. Net worth falls and the required real capital return rises, providing a financial-accelerator account of the contraction.

The benchmark amplitude also raises initial sector default probabilities from the inherited eight-percent baseline to about fifteen percent. The calculation is first order. A small equation residual does not validate crisis-scale distributional nonlinearities. Historical stress scenarios should choose amplitudes against spreads, balance-sheet losses and plausible default paths, separately from these mechanism tests.

The financial figures show GDP, consumption, investment, real required capital returns, default and net worth. The return and default panels use the arithmetic mean of the two sectors. Those model objects are not measured market loan yields or independently estimated aggregate country

default rates.

12.2 Income and capital losses

Operating-income losses weaken investment but initially raise home consumption. Consumption more than offsets part of the investment and trade deterioration in Table 8; GDP falls subsequently. Such a path cannot be presented as a conventional financial-tightening recession without explaining household behavior.

The source income-loss variable drains entrepreneurial net worth and enters sector resource constraints. Household claims on corporate and capital-producer income, bankruptcy resource costs, endogenous real rates and residual transfers also remain active. Accounting identifies the spending increase; it does not by itself identify which channel causes it. A completed causal attribution would require additional controlled mechanism tests. This paper reports the unresolved interpretation explicitly.

Capital destruction raises depreciation and can induce replacement investment. Armenia's small initial GDP increase contrasts with Georgia's close-to-zero, slightly negative unrounded response; both subsequently contract. Replacement investment is a distinct response from tighter finance suppressing new capital formation. A single generic financial-shock description would hide that distinction.

12.3 Individual-origin spillovers and common stress

Table 9 reports separate dispersion shocks in each region. Foreign values are initial-GDP-weighted means over unshocked regions. Consumption and investment entries are averages of regional percentage responses, not chain-weighted world demand aggregates.

Table 9: Separate dispersion shocks: domestic and foreign responses

System	Origin	Home Y	Home C	Home I	Foreign Y	Foreign C	Foreign I
Armenia	Armenia	-0.42	-0.13	-3.99	-0.0001	-0.0001	-0.0002
Armenia	Euro area	-0.72	-0.30	-4.09	-0.0565	-0.0256	-0.0525
Armenia	Russia	-0.58	-0.25	-3.11	-0.0058	-0.0026	-0.0053
Armenia	Rest of world	-0.52	-0.20	-2.91	-0.0797	-0.0394	-0.0838
Armenia	China	-1.39	-0.66	-3.83	-0.0653	-0.0246	-0.0591
Armenia	Georgia	-0.45	-0.18	-4.31	-0.0002	-0.0001	-0.0002
Armenia	United States	-0.60	-0.24	-3.36	-0.0428	-0.0198	-0.0402
Georgia	Georgia	-0.45	-0.18	-4.31	-0.0002	-0.0001	-0.0002
Georgia	Euro area	-0.72	-0.30	-4.08	-0.0569	-0.0260	-0.0532
Georgia	Russia	-0.57	-0.24	-3.03	-0.0058	-0.0025	-0.0052
Georgia	Rest of world	-0.51	-0.20	-2.90	-0.0769	-0.0381	-0.0812
Georgia	China	-1.41	-0.67	-3.87	-0.0664	-0.0251	-0.0601
Georgia	Turkiye	-1.03	-0.50	-3.61	-0.0057	-0.0024	-0.0057
Georgia	United States	-0.60	-0.24	-3.38	-0.0432	-0.0200	-0.0407

Source and notes: Year one, percent, common slow sourcing. Foreign weights exclude the origin and sum to one. Four decimals preserve small foreign responses. Transmission includes all active model links; a pure-trade channel is not separately identified.

A small home economy has little effect on the foreign mean, while large regions have larger external effects. The transmission includes trade, exchange rates, interest rates and active asset-accounting

links. Labeling it pure trade would require another channel-shutdown experiment.

Table 10 adds equal normalized disturbances in all regions. At first order the joint response is exactly the sum of separately solved origins. Foreign-origin dispersion stress adds materially to the home contraction, and home consumption and investment fall more strongly together.

Table 10: Home demand under separate and simultaneous financial shocks

Model	Shock	Home variable	Home shock	Foreign shocks	Joint shock
Armenia	Ziggy	GDP	-0.42	-0.45	-0.86
Armenia	Ziggy	Consumption	-0.13	-0.24	-0.37
Armenia	Ziggy	Investment	-3.99	-0.64	-4.63
Armenia	Income loss	GDP	0.04	0.04	0.08
Armenia	Income loss	Consumption	0.25	-0.06	0.20
Armenia	Income loss	Investment	-0.27	-0.08	-0.36
Georgia	Ziggy	GDP	-0.45	-0.36	-0.81
Georgia	Ziggy	Consumption	-0.18	-0.21	-0.39
Georgia	Ziggy	Investment	-4.31	-0.53	-4.84
Georgia	Income loss	GDP	0.02	0.04	0.07
Georgia	Income loss	Consumption	0.21	-0.05	0.16
Georgia	Income loss	Investment	-0.38	-0.05	-0.43

Source and notes: Year one, common slow sourcing. Foreign shocks sum the six other origins' effects on the home economy. Joint equals home plus foreign. These are deterministic simultaneous innovations, not estimates of a covariance matrix or unconditional demand correlations.

This is a coherent scenario mechanism for international co-movement. It does not estimate historical shock correlations, variance shares or stochastic consumption/investment correlations. Those require data, a stochastic process and identification. Common shocks should not be invoked to hide an unexplained individual-shock response.

13 Productivity and five-year recognition

A one-percent common productivity increase lasts ten years and is then removed. Under full information, households and firms react immediately to future income and returns. Consumption, investment, prices and trade can adjust before future production occurs. Capital installation and balance sheets propagate the effects.

Slow sourcing moderates immediate trade reallocation and changes the initial GDP response. The productivity-unit correction is essential: solving altered demand rows without it can leave a failed CES quantity identity. Equation (28) repairs the aggregation while leaving non-productivity paths unchanged.

Five-year recognition reduces the initial expansion with the same realized technology path. In Armenia, initial GDP rises about one tenth of a percent under recognition versus about one half under full information. Georgia rises about one fifth instead of nearly nine tenths. Year-two GDP also rises less. This isolates knowledge about persistence, not a gradual implementation of actual technology.

Table 11: Productivity persistence and recognition in every origin

System	Shock origin	Full Y_1	Learn Y_1	Full Y_2	Learn Y_2
Armenia	Armenia	0.56	0.10	1.16	0.43
Armenia	Euro area	1.07	0.15	1.84	0.61
Armenia	Russia	1.04	0.15	1.78	0.62
Armenia	Rest of world	0.98	0.18	1.68	0.64
Armenia	China	1.45	0.13	2.42	0.68
Armenia	Georgia	0.85	0.18	1.56	0.61
Armenia	United States	1.05	0.15	1.79	0.61
Georgia	Georgia	0.85	0.18	1.56	0.60
Georgia	Euro area	1.07	0.15	1.84	0.60
Georgia	Russia	1.03	0.15	1.75	0.62
Georgia	Rest of world	0.98	0.18	1.67	0.63
Georgia	China	1.46	0.13	2.43	0.68
Georgia	Turkiye	1.10	0.07	2.01	0.57
Georgia	United States	1.06	0.15	1.79	0.61

Source and notes: Own-region GDP percent responses, common slow sourcing. Realized technology rises one percent for ten years in both columns. Learn denotes the specified five-year recognition schedule, not an estimated Bayesian posterior.

The productivity figures compare fast and slow sourcing with full information, and slow sourcing with gradual recognition. Information timing and trade timing are separate assumptions. Neither an export elasticity nor an aggregate import cost substitutes for specifying what firms and households expect about future productivity.

14 Monetary properties and cross-shock comparison

Tables 12 and 13 collect the home non-fiscal results. The monetary innovation contracts GDP and inflation. Its large effect relative to the risk shock reflects an innovation in a rate-change rule, not an imposed one-year level increase followed by an automatic return of the observed rate to baseline. Expectations and subsequent policy remain endogenous. The complete rate and inflation paths must be assessed before interpreting it as a conventional one-period rate multiplier.

Table 12: Armenia: home non-fiscal properties

Shock	Y_1	Y_2	π_1	X_1	M_1
Country risk, persistence 0.2	-0.09	-0.12	0.17	0.19	-0.69
Country risk, persistence 0.6	-0.27	-0.30	0.28	0.31	-1.32
Dispersion (Ziggy)	-0.42	-0.44	-0.04	-0.03	-0.58
Operating-income loss	0.04	-0.07	0.02	-0.03	0.14
Capital destruction	0.01	-0.01	0.00	-0.02	0.07
Ten-year productivity increase	0.56	1.16	-0.02	0.41	-0.30
Monetary policy innovation	-1.79	-2.23	-0.97	-0.75	-0.74

Source and notes: Common slow sourcing, endogenous policy. GDP and trade volumes are percent deviations; CPI inflation is in percentage points. Productivity uses full information. The monetary innovation is normalized in the policy equation.

Table 13: Georgia: home non-fiscal properties

Shock	Y_1	Y_2	π_1	X_1	M_1
Country risk, persistence 0.2	-0.12	-0.15	0.12	0.19	-0.75
Country risk, persistence 0.6	-0.31	-0.34	0.21	0.33	-1.44
Dispersion (Ziggy)	-0.45	-0.50	-0.04	-0.02	-0.52
Operating-income loss	0.02	-0.08	0.02	-0.02	0.10
Capital destruction	-0.00	-0.02	0.01	-0.02	0.06
Ten-year productivity increase	0.85	1.56	-0.13	0.40	-0.19
Monetary policy innovation	-2.05	-2.51	-0.78	-0.71	-0.49

Source and notes: Definitions as in Table 12. Minus zero denotes a small negative unrounded value, not an exact zero restriction.

A permanent inflation-target reduction from three to two percent changes the stationary environment and requires explicit expectations, fiscal valuation and terminal conditions. A temporary rate innovation or a tax-induced CPI reduction cannot stand in for that transition. The paper documents the monetary block and temporary innovation without claiming a completed permanent disinflation experiment.

15 Empirical refinement and policy use

Fiscal composition requires an appropriate mapping of import content, constrained households and productive capital. Financing-risk analysis requires meaningful premium processes, balance-sheet losses, spreads and default targets. Productivity analysis needs both a production mechanism and an information assumption. A consistent structural system organizes these questions but does not answer all of them through a single parameter choice.

Historical narrative work should compare depreciation episodes with foreign demand, spare capacity, investment, imported inputs, restrictions and re-export changes. It should assess exports and imports jointly rather than target one GDP sign. Country services, value-added content, category-specific partner shares and transit margins are priorities for empirical refinement. The sourcing speed remains a research sensitivity until that work disciplines it.

The financial priorities are equally concrete. The dispersion test generates a coherent contraction but a substantial default increase. The income-loss test still needs a controlled explanation of its consumption response. A smaller dispersion shift combined with an income loss may become a useful scenario, but it is not calibrated merely because it produces a desirable recession path.

Temporary fiscal experiments do not establish permanent debt-strategy effects. The surplus target, transfer closure, productive capital and expected monetary path must be specified for a transition. Similarly, a surprise extension of a policy hold is not its anticipated counterpart. Here the fiscal holds are anticipated while productivity recognition is sequential.

Prudent risk management calls for comprehensive treatment of policy composition, household incidence, foreign conditions and financing risks; consistency of budgets, resources and external accounts; and explicit coordination of policy assumptions. Model accounting provides consistency, while empirical evidence and scenario design provide plausibility. Both are needed for a policy judgment.

16 Conclusions

The two seven-region systems document the mechanisms, calibration and policy assumptions relevant to Armenia and Georgia. Results distinguish shock origin, fiscal duration, monetary announcement, sourcing speed and information.

Common slow sourcing moderates export-market-share adjustment and reverses the positive initial home GDP response to country risk. Productivity-dependent import units require a correction to preserve first-order CES accounting. Government purchases, targeted support and tax reductions have different demand, supply and distributional effects. Dispersion shocks contract demand; operating-income and capital losses retain separate and partly unresolved interpretations. Gradual recognition of persistence produces a smaller initial expansion under the same realized productivity increase.

Numerical checks pass. Empirical priorities remain fiscal and trade coverage, sourcing speed, financing and default amplitudes, and household responses to income loss.

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A Equation and implementation map

The main text suppresses regional and sector indices where possible. This map links economic objects to the executable source. The publication supplement contains numbered lists of all 4,711 expanded original operational equations for each regional mapping. The lists describe the original operational model. The runtime policy and sourcing replacements in equations (32) and (28) must also be applied to reproduce the reported dynamics.

Economic object	Source symbols	Role
Optimizing consumption	C_OLG, MPC, MPCINV, TW	Consumption from wealth and the forward-looking spending propensity.
Household resources	FW, HW, OTHW	Inherited assets, labor-income wealth and other distributions.
Constrained consumption	C_LIQ, TRANSFER_LIQ	Current-resource budget and marginal transfer incidence.
Private capital	KKT, KKN, IT, IN, QT, QN	Lagged installation, utilization and capital valuation.
Public capital	KG1, KG2, GOVINV	Infrastructure accumulation and output services.
Corporate finance	NWT, NWN, BT, BN	Sector net worth, debt and leverage.
Firm risk	ZIGGY_T, ZIGGY_N, NORMCDF	Dispersion, thresholds and contemporaneous default probabilities.
Financing returns	RETKT, RETKN, ZZ_EQPT, ZZ_EQPN	Required capital returns and expected real premia.
Capital destruction	NWKSHK_T, NWKSHK_N	Extra depreciation, normalized by initial sector net worth.
Operating-resource loss	NWYSHK_T, NWYSHK_N	Net-worth drains and sector resource terms.
Home/import substitution	YCF, YIF, YTF, XI_C, XI_I, XI_T	Aggregate import intensity by use category.
Foreign sourcing	YCM, YIM, YDM, YTM, XI_DM, XI_TM	Bilateral supplier demand and relative-price targets.
Productivity trade bias	ZETA_T, ZZETA_T, BALSAM	Normalized intermediate supplier bias.
Policy and country risk	INTMP, INT, GBPREM, GBPREMSMOOTH	Policy, financing and premium smoothing.
Government accounts	GOVSUR, PRIMSUR, B, INTCOST	Overall and primary balances, debt and interest.
Fiscal closure	XX_GOVSUR, XX_TRANSFER, DAMP_GDPGAP	Surplus targeting, residual transfers and cyclicality.
External accounts	F, F_RAT, NFA_RAT, E, EPS	Assets, valuation and international parity.
Real-activity reporting	GROWTH_FISH, EXPORTS_LASP, IMPORTS_PAAS	Chain quantities and expenditure valuation.

Calibration flips recover selected parameters from ratios and targets; the operational system restores their behavioral role. Inactive oil, sovereign-fund and remittance source branches are not active channels merely because the general model code contains them.

B Measurement and exact experiment conventions

B.1 GDP and expenditure accounting

The source constructs Laspeyres and Paasche real-GDP growth from consumption, enterprise investment, government purchases, exports and imports. Fisher growth is their geometric mean. The reported first-order level response is

$$y_t^{resp} = 100 \sum_{u=1}^{t} \frac{\Delta GROWTH_FISH_u}{\overline{GROWTH_FISH}}. \tag{34}$$

It is a linear approximation to a chain-weighted index, not a response of nominal GDP. At impact,

$$y_1^{resp} = c_1^{contrib} + i_1^{contrib} + g_1^{contrib} + x_1^{contrib} - m_1^{contrib}, \tag{35}$$

where previous-price components are divided by initial GDP. Later previous-price perturbations are not automatically exact contributions to the chained GDP level, so the displayed decomposition is limited to year one.

B.2 Trade quantities, exchange rates and returns

For nominal trade object V and source Laspeyres/Paasche valuation components,

$$v_t^{resp} = \frac{100}{\bar{V}} \sum_{u=1}^{t} \frac{1}{2} \left[(\Delta V_u^L - \Delta V_{u-1}) + (\Delta V_u - \Delta V_u^P) \right]. \tag{36}$$

The initial deviation is zero. This keeps a volume response distinct from a change in trade values.

Real effective depreciation cumulates proportional deviations in REERDEP; positive means depreciation. CPI and policy panels use $100\Delta PIE_CONS$ and $100\Delta INTMP$ at annual frequency. They follow the audit's factor-level percentage-point convention rather than a separate exact log-rate transformation. ZZ_RETKT and ZZ_RETKN already express annual log returns in percentage units; they are not multiplied by another hundred. The displayed net-worth response is the proportional change in the sum of sector net worth.

B.3 Fiscal and corporate shock sizes

Purchases are scaled to one percent of initial GDP at the initial government price and accompanied by a minus-one-percentage-point surplus-target innovation. Tax reductions use $\Delta\tau = -\bar{Y}/(100\overline{TAXBASE})$ with the corresponding surplus-target easing. General transfers use the easing under the residual-transfer closure. Targeted transfers direct the marginal amount to constrained households with consistent budget financing.

The innovation profile is one in year one for a one-year shock, and one in each of the first two years for a two-year shock. Tax bases, private expenditure, trade, capital and the ex-post balance

remain endogenous. A two-year interest hold with a one-year fiscal shock is deliberately a different duration combination.

Dispersion innovations are $\bar{\sigma}/6$ in each sector with a geometric 0.6 profile. Income and capital loss ratio innovations are 0.01 in each sector in year one. The income ratio is $P_s NWYSHK_s/\overline{NW_s}$; the capital ratio is $Q_s NWKSHK_s \mathcal{K}_s/\overline{NW_s}$. They are not one percent of GDP. Country-premium innovations instead target a one-hundred-basis-point gross-premium deviation with the stated persistence.

C Every region's stationary calibration

GDP shares are percentages of model-world GDP; other ratios use the respective region's GDP. The tables expose inherited observations, proxies, priors and solved quantities rather than creating a newly verified empirical data set.

Table 15: Armenia-centered system: regional ratios

Region	GDP share	G-cons.	G-inv.	Debt	Exports	Imports	NFA
Armenia	0.02	10.66	5.50	48.00	55.24	55.00	-47.10
Euro area	14.87	21.68	3.46	86.60	24.94	25.00	10.90
Russia	1.96	18.90	2.80	20.30	17.37	17.59	43.38
Rest of world	40.12	17.10	3.20	87.90	17.50	17.44	-12.92
China	16.77	16.70	4.19	56.30	16.92	17.00	16.40
Georgia	0.03	12.90	7.70	36.10	52.19	51.73	-89.00
United States	26.24	17.10	3.20	87.90	12.43	12.43	0.00

Source and notes: Current loaded states and model GDP weights. The residual world's selected quantities solve as closure items.

Table 16: Georgia-centered system: regional ratios

Region	GDP share	G-cons.	G-inv.	Debt	Exports	Imports	NFA
Georgia	0.03	12.90	7.70	36.10	52.19	51.73	-89.00
Euro area	14.87	21.68	3.46	86.60	24.94	25.00	10.90
Russia	1.96	18.90	2.80	20.30	17.37	17.59	43.38
Rest of world	38.92	17.10	3.20	87.90	17.80	17.74	-12.54
China	16.77	16.70	4.19	56.30	16.92	17.00	16.40
Turkiye	1.22	14.46	3.00	23.60	27.43	27.30	-25.80
United States	26.24	17.10	3.20	87.90	12.43	12.43	0.00

Source and notes: Definitions as in Table 15. R7 is Turkiye here and Georgia in the Armenia-centered system.

D One-year fiscal experiments

E denotes endogenous policy, $F1$ a known first-year hold and $F2$ a known two-year hold. All holds are announced initially, including the second year when the fiscal impulse lasts only one year.

Table 17: Armenia: one-year fiscal expansions

Instrument	Y_1^E	Y_2^E	Y_1^{F1}	Y_2^{F1}	Y_1^{F2}	Y_2^{F2}	π_1^E
Government consumption	0.59	0.02	0.62	0.05	0.66	0.10	0.02
Government investment	0.65	0.14	0.69	0.18	0.65	0.13	0.04
Targeted transfers	0.28	0.08	0.29	0.10	0.31	0.13	0.01
General transfers	0.12	0.04	0.13	0.05	0.13	0.06	0.00
Labor tax reduction	0.12	0.05	0.13	0.05	0.13	0.06	0.00
Capital tax reduction	0.13	0.15	0.15	0.17	0.18	0.22	0.01
Consumption tax reduction	0.21	0.07	0.22	0.08	0.24	0.11	-1.28

Source and notes: Common slow sourcing. GDP percent responses in years one and two; first-year CPI inflation under endogenous policy in percentage points.

Table 18: Georgia: one-year fiscal expansions

Instrument	Y_1^E	Y_2^E	Y_1^{F1}	Y_2^{F1}	Y_1^{F2}	Y_2^{F2}	π_1^E
Government consumption	0.68	0.02	0.71	0.07	0.76	0.13	0.03
Government investment	0.74	0.14	0.77	0.19	0.75	0.16	0.04
Targeted transfers	0.31	0.09	0.33	0.12	0.36	0.15	0.01
General transfers	0.14	0.04	0.14	0.05	0.15	0.07	0.00
Labor tax reduction	0.14	0.06	0.15	0.06	0.15	0.07	0.00
Capital tax reduction	0.16	0.19	0.18	0.22	0.22	0.27	0.01
Consumption tax reduction	0.24	0.08	0.25	0.10	0.27	0.12	-1.30

Source and notes: Definitions as in Table 17. The initial instrument cost is one percent of GDP.

E Country-risk experiments in all origins

These tables show the response in the shocked region. Detailed files retain every other destination response. Fast, dotted and common-slow specifications vary sourcing timing while retaining each model's long-run parameters.

Table 19: All-origin country risk: persistence 0.2

System	Origin	Fast Y_1	Dotted Y_1	Slow Y_1	Slow Y_2	Slow π_1
Armenia	Armenia	0.32	-0.09	-0.09	-0.12	0.17
Armenia	Euro area	-0.11	-0.25	-0.25	-0.27	0.04
Armenia	Russia	-0.11	-0.25	-0.25	-0.18	0.01
Armenia	Rest of world	-0.23	-0.27	-0.27	-0.25	0.03
Armenia	China	-0.37	-0.49	-0.49	-0.41	0.00
Armenia	Georgia	0.25	-0.11	-0.12	-0.15	0.12
Armenia	United States	-0.26	-0.34	-0.34	-0.31	0.00
Georgia	Georgia	0.25	-0.12	-0.12	-0.15	0.12
Georgia	Euro area	-0.11	-0.25	-0.25	-0.27	0.04
Georgia	Russia	-0.10	-0.24	-0.24	-0.17	0.01
Georgia	Rest of world	-0.22	-0.27	-0.27	-0.25	0.03
Georgia	China	-0.37	-0.50	-0.50	-0.42	0.00
Georgia	Turkiye	-0.11	-0.36	-0.36	-0.30	0.05
Georgia	United States	-0.26	-0.35	-0.35	-0.32	0.00

Source and notes: One-hundred-basis-point initial premium innovation. GDP percent responses and CPI inflation percentage-point responses; the premium profile is known initially.

Table 20: All-origin country risk: persistence 0.6

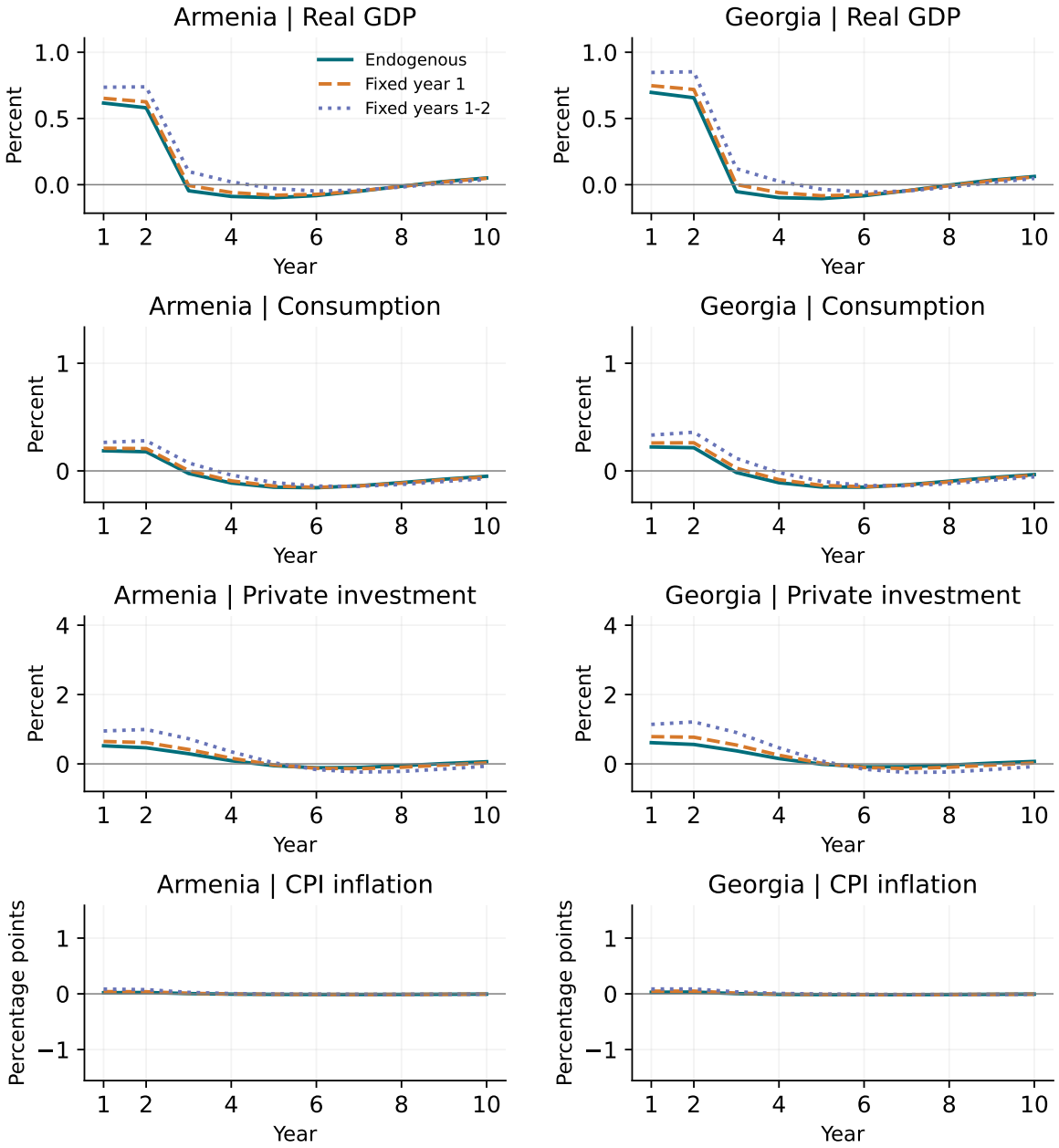
System	Origin	Fast Y_1	Dotted Y_1	Slow Y_1	Slow Y_2	Slow π_1
Armenia	Armenia	0.41	-0.27	-0.27	-0.30	0.28
Armenia	Euro area	-0.26	-0.52	-0.52	-0.58	0.06
Armenia	Russia	-0.25	-0.52	-0.53	-0.51	0.01
Armenia	Rest of world	-0.47	-0.55	-0.55	-0.58	0.04
Armenia	China	-0.74	-0.98	-0.98	-0.98	-0.01
Armenia	Georgia	0.31	-0.29	-0.31	-0.34	0.20
Armenia	United States	-0.51	-0.67	-0.67	-0.71	0.00
Georgia	Georgia	0.31	-0.31	-0.31	-0.34	0.21
Georgia	Euro area	-0.26	-0.52	-0.52	-0.58	0.06
Georgia	Russia	-0.24	-0.51	-0.52	-0.50	0.01
Georgia	Rest of world	-0.45	-0.54	-0.54	-0.57	0.04
Georgia	China	-0.75	-0.99	-0.99	-0.99	-0.01
Georgia	Turkiye	-0.29	-0.76	-0.76	-0.75	0.08
Georgia	United States	-0.51	-0.68	-0.68	-0.72	0.00

Source and notes: Definitions as in Table 19. Only persistence changes. A same-name region can differ between separately calibrated systems.

F Dynamic figures

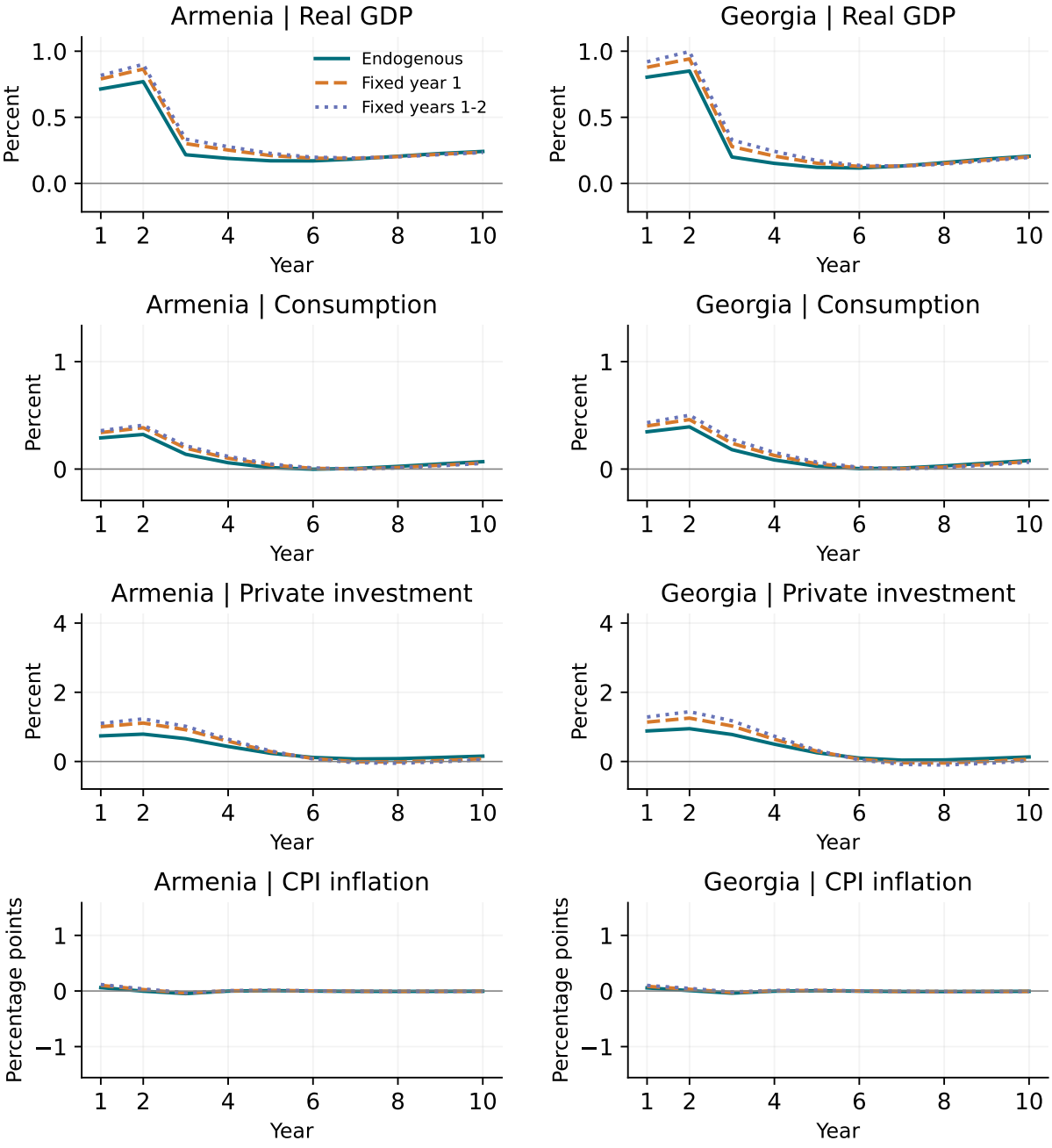
Years are annual. Figures show baseline deviations unless levels are explicitly marked. Fiscal scales are common across countries and instruments for each variable. Risk, financial and productivity figures use matching country scales within each experiment family. No dual axes are used.

Figure 2: Government consumption: two-year expansion



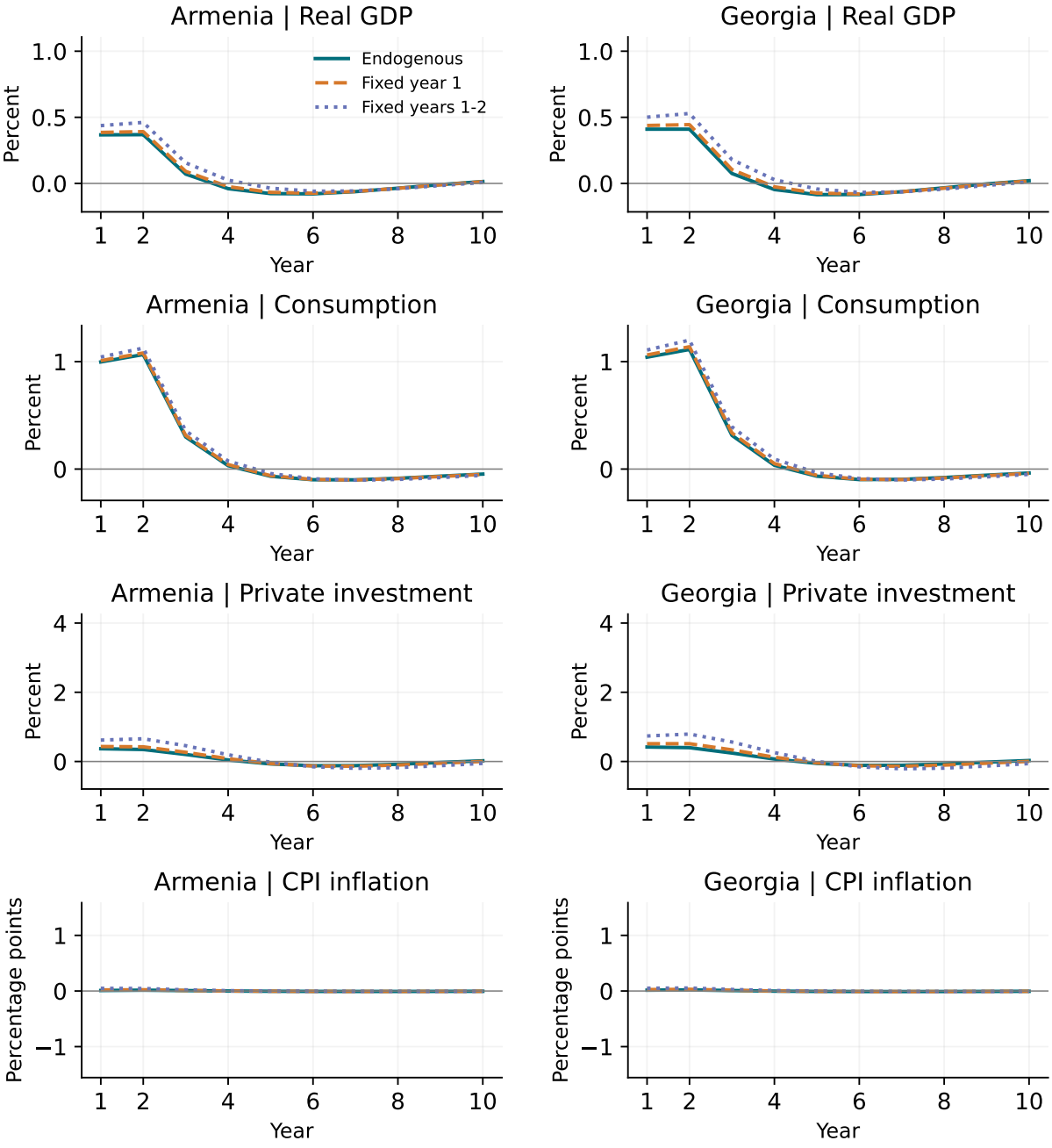
Source and notes: One percent of initial GDP in each of the first two years. Common slow sourcing; holds are anticipated initially. Inflation panels are percentage-point deviations.

Figure 3: Government investment: two-year expansion



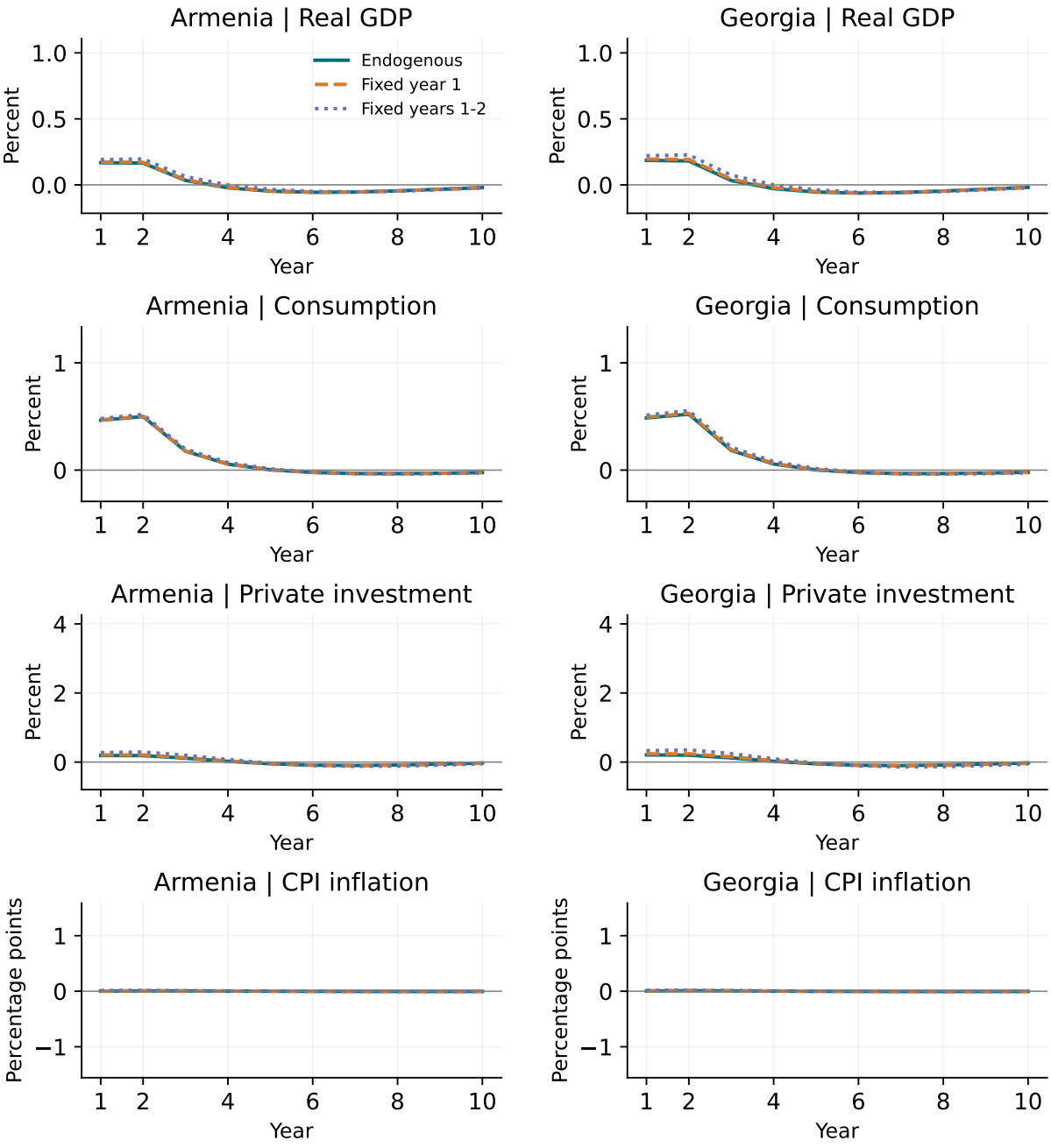
Source and notes: Definitions as in Figure 2. Public capital is installed with the source lag; its output elasticity is 0.1.

Figure 4: Targeted transfers: two-year expansion



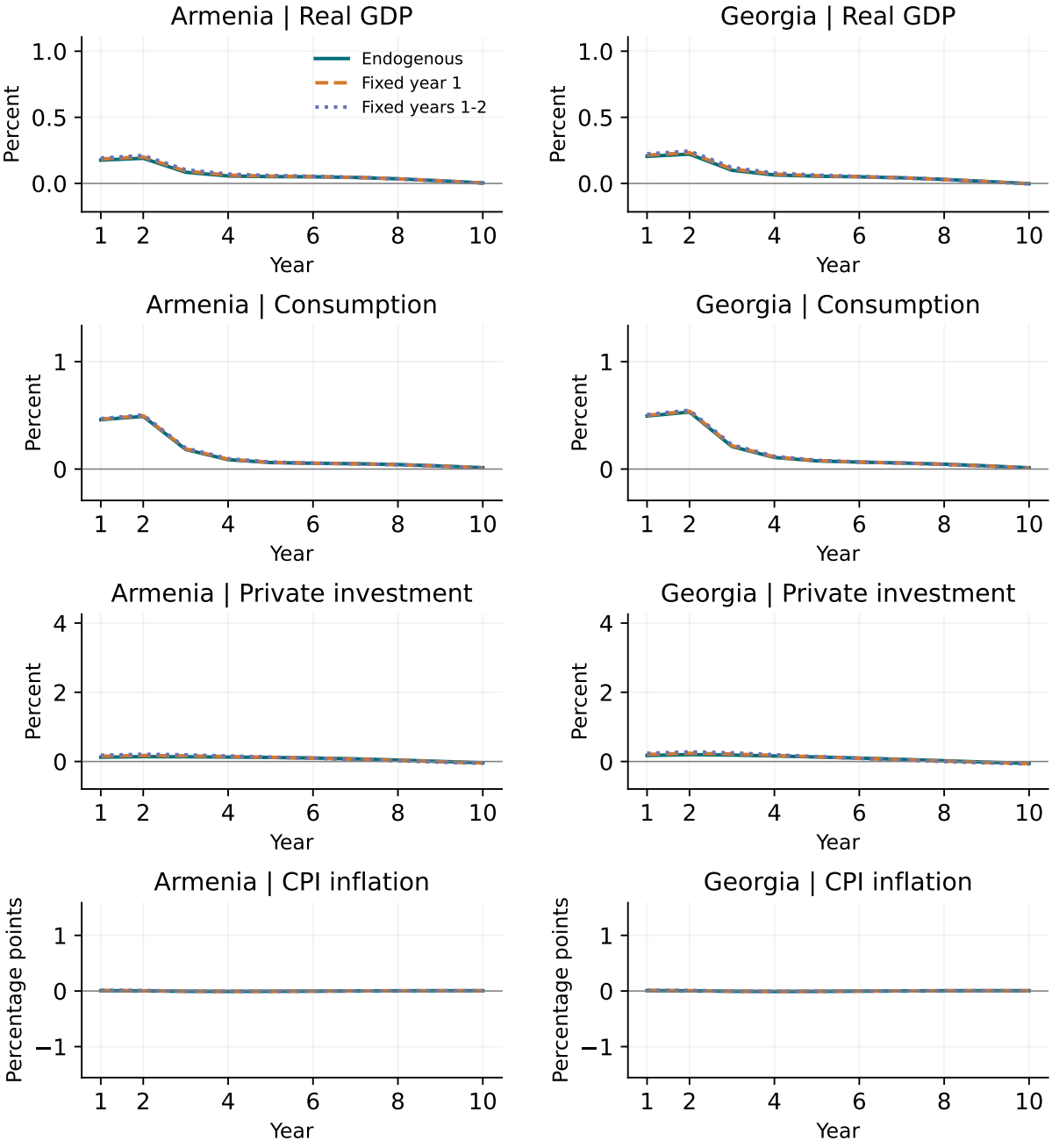
Source and notes: The marginal transfer reaches constrained households without changing their initial population share. Other definitions as in Figure 2.

Figure 5: General transfers: two-year expansion



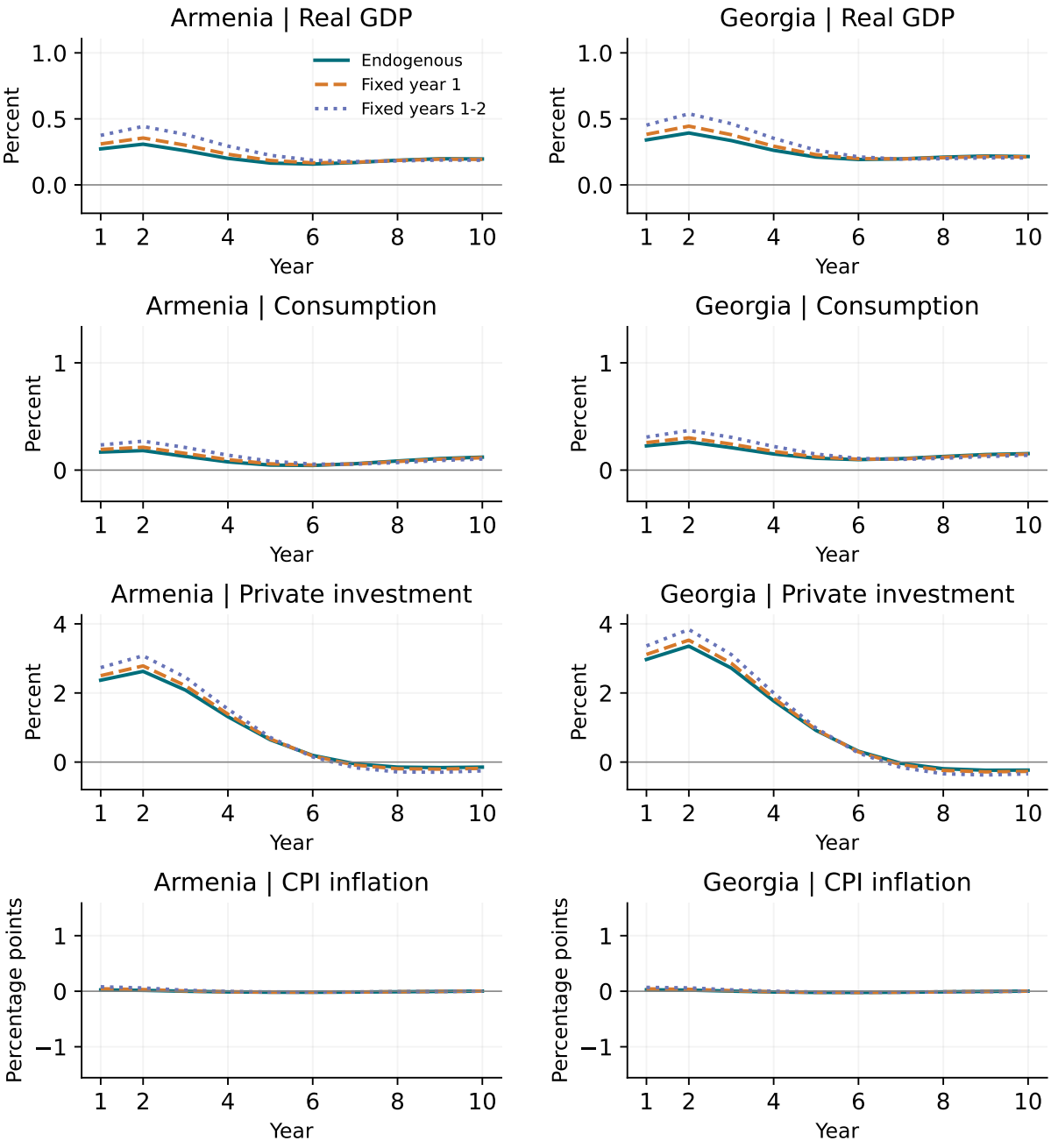
Source and notes: Broad transfers use the inherited fiscal closure. Optimizing and constrained households differ in spending behavior. Other definitions as in Figure 2.

Figure 6: Labor-tax reduction: two-year expansion



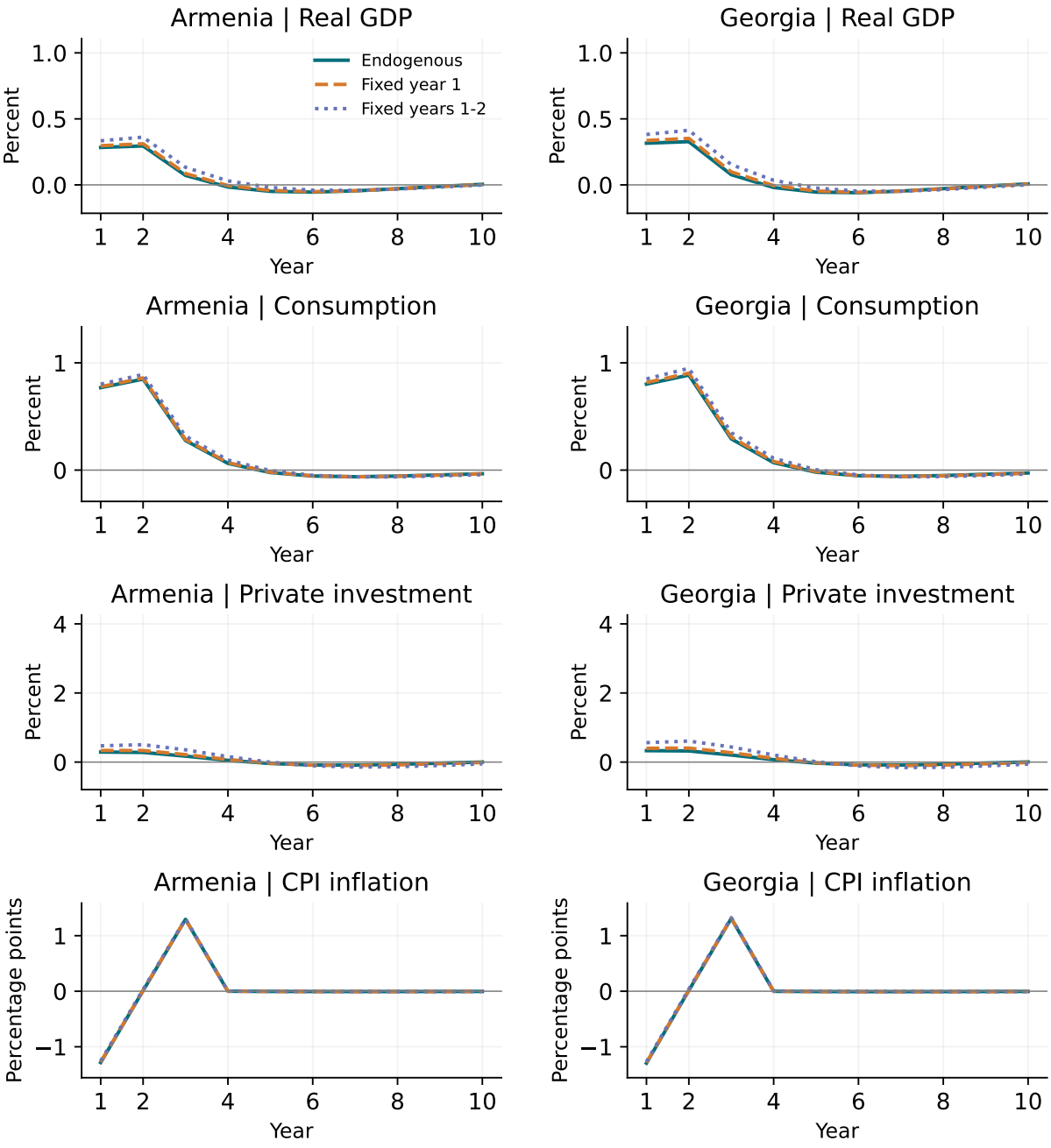
Source and notes: The rate innovation is normalized by the initial labor-tax base. Other definitions as in Figure 2.

Figure 7: Capital-tax reduction: two-year expansion



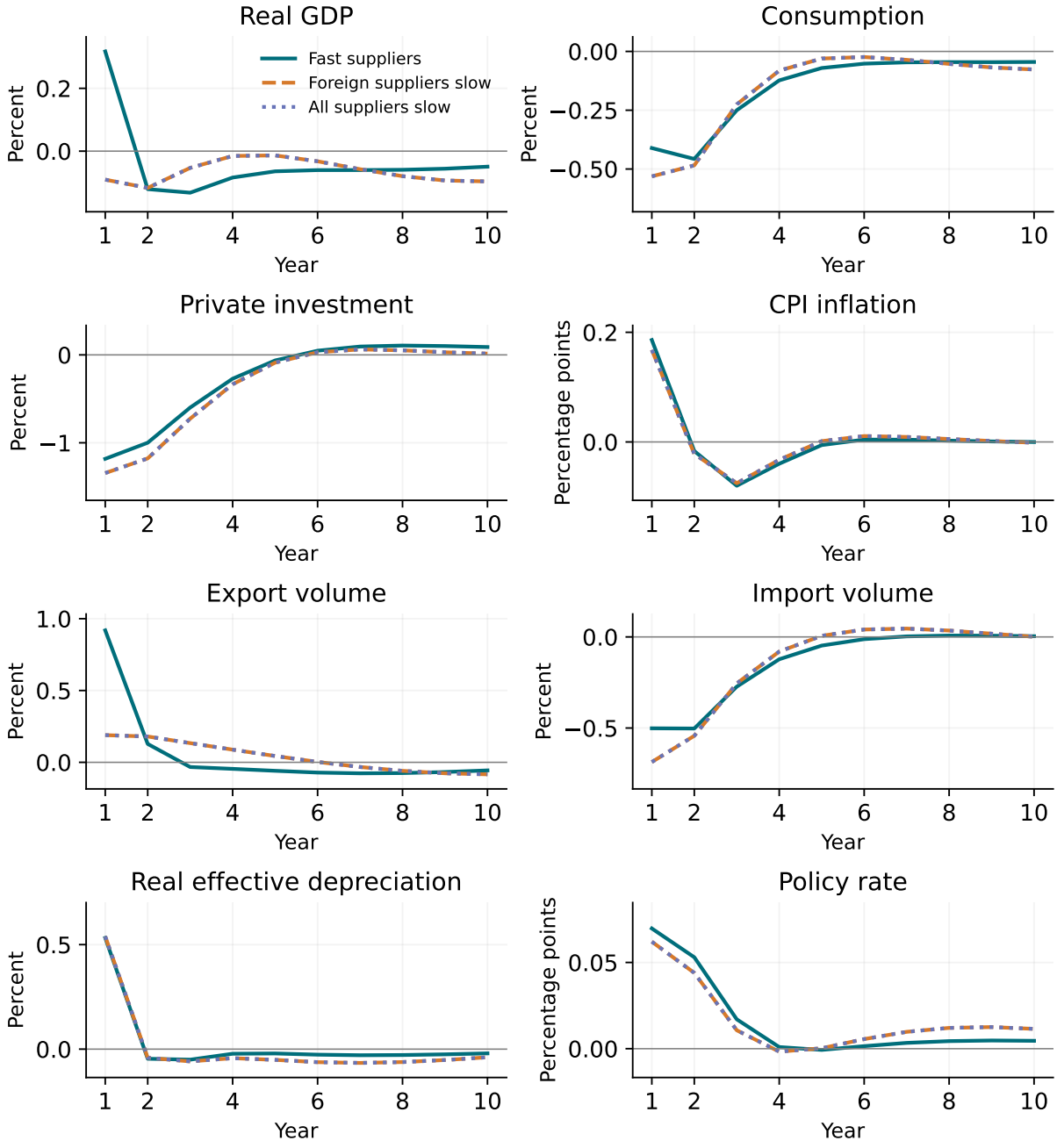
Source and notes: The tax-base normalization differs from that of labor and consumption taxes. Investment responds to expected after-tax returns and adjustment costs. Other definitions as in Figure 2.

Figure 8: Consumption-tax reduction: two-year expansion



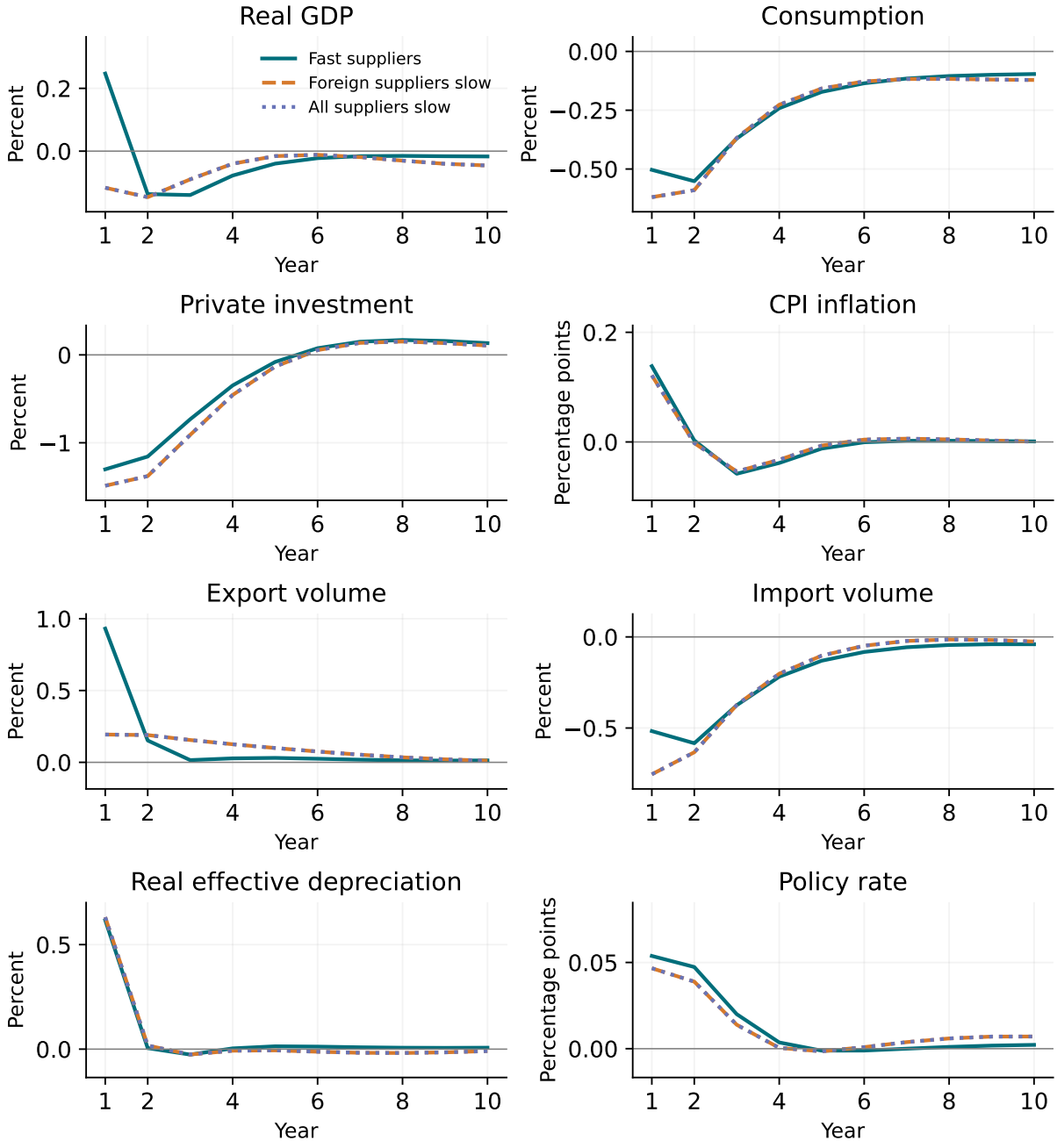
Source and notes: The tax-inclusive CPI includes the direct tax-price change. This is not an inflation-target reduction. Other definitions as in Figure 2.

Figure 9: Armenia: country risk and trade timing



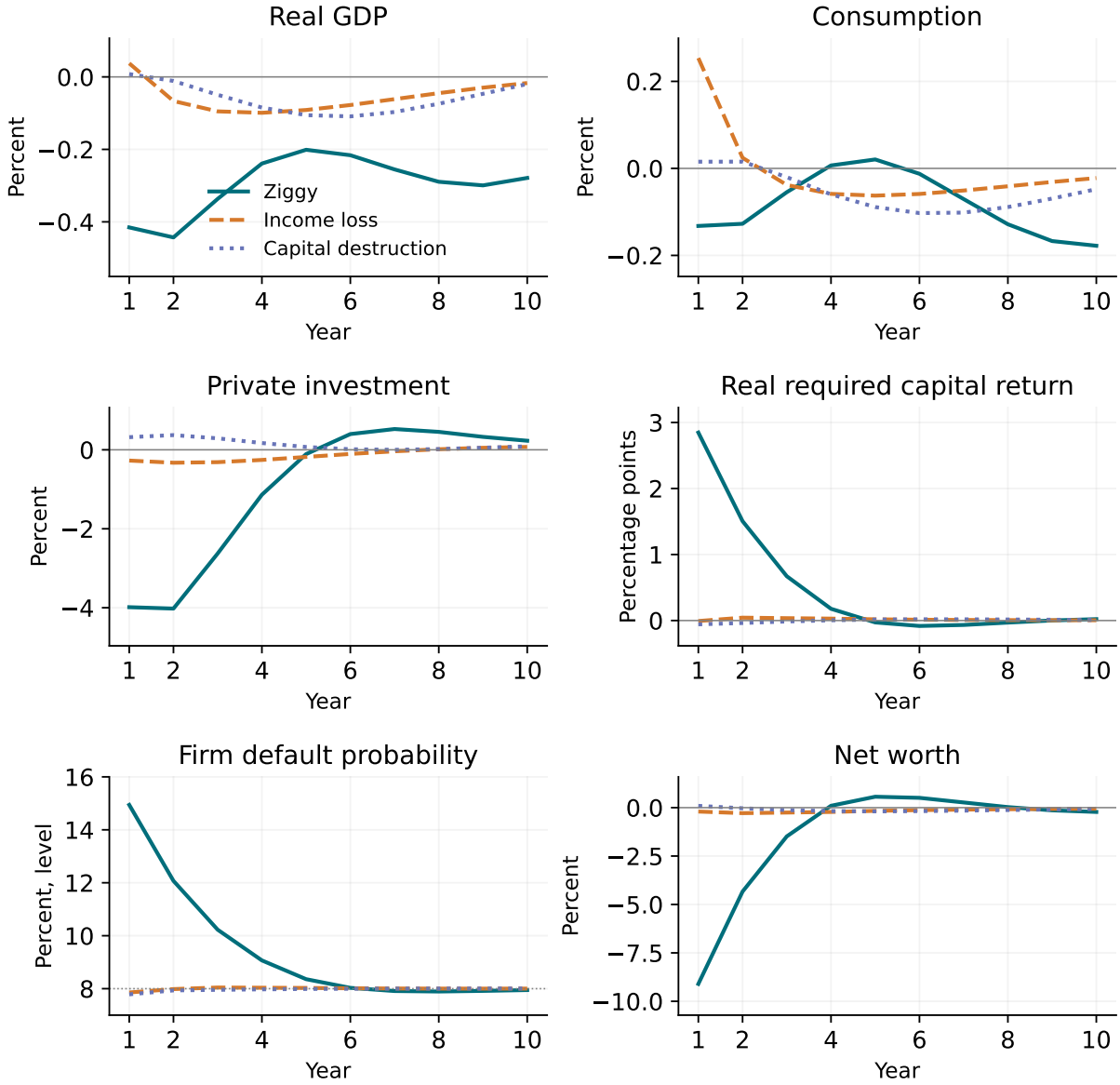
Source and notes: One-hundred-basis-point premium shock, persistence 0.2, endogenous policy. Positive real effective depreciation means depreciation. Trade volumes are chain-Fisher quantities. The slow curves overlap where the domestic-buyer margin is small.

Figure 10: Georgia: country risk and trade timing



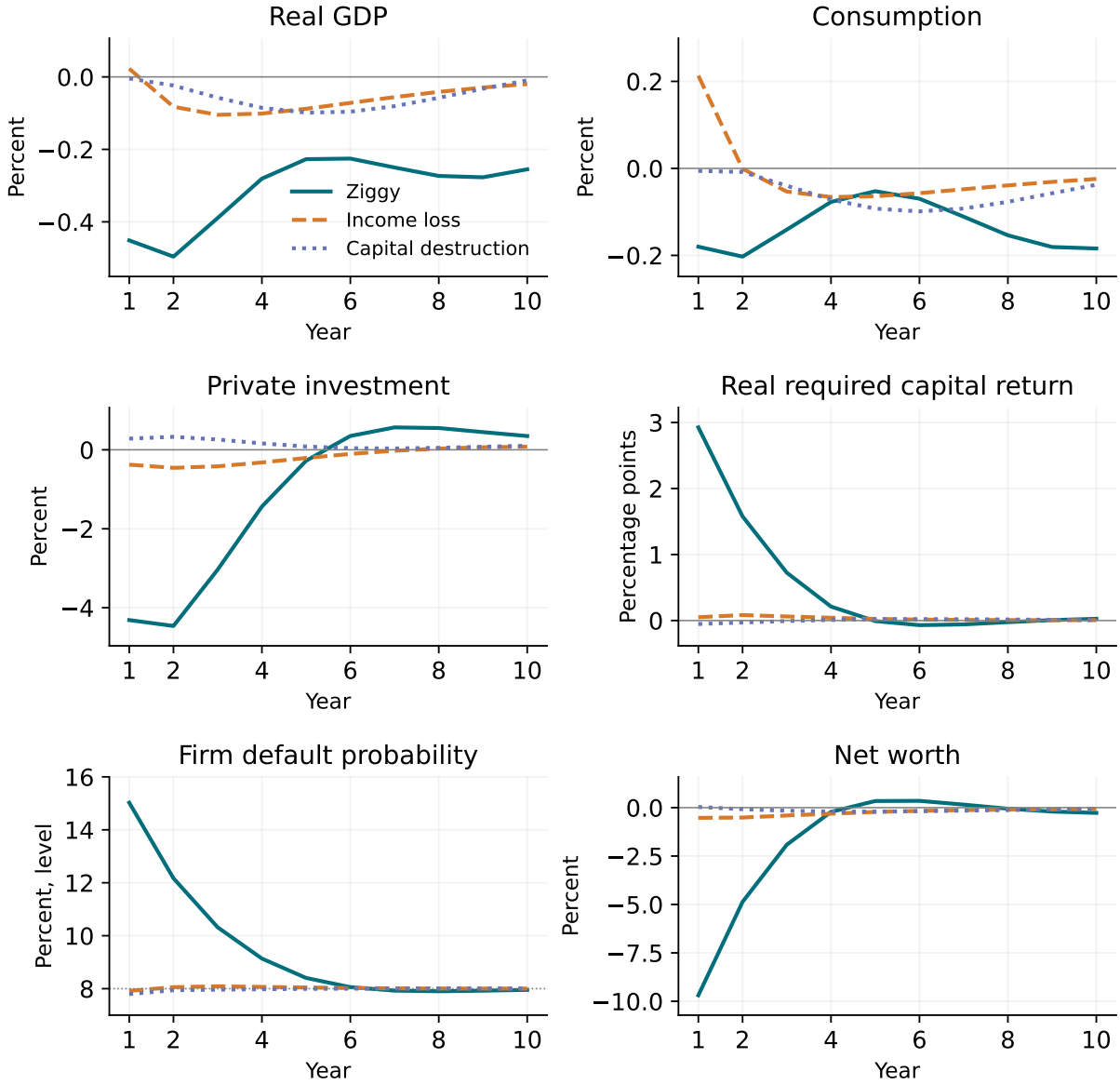
Source and notes: Definitions as in Figure 9; corresponding vertical scales are identical across the two country figures.

Figure 11: Armenia: three corporate financial disturbances



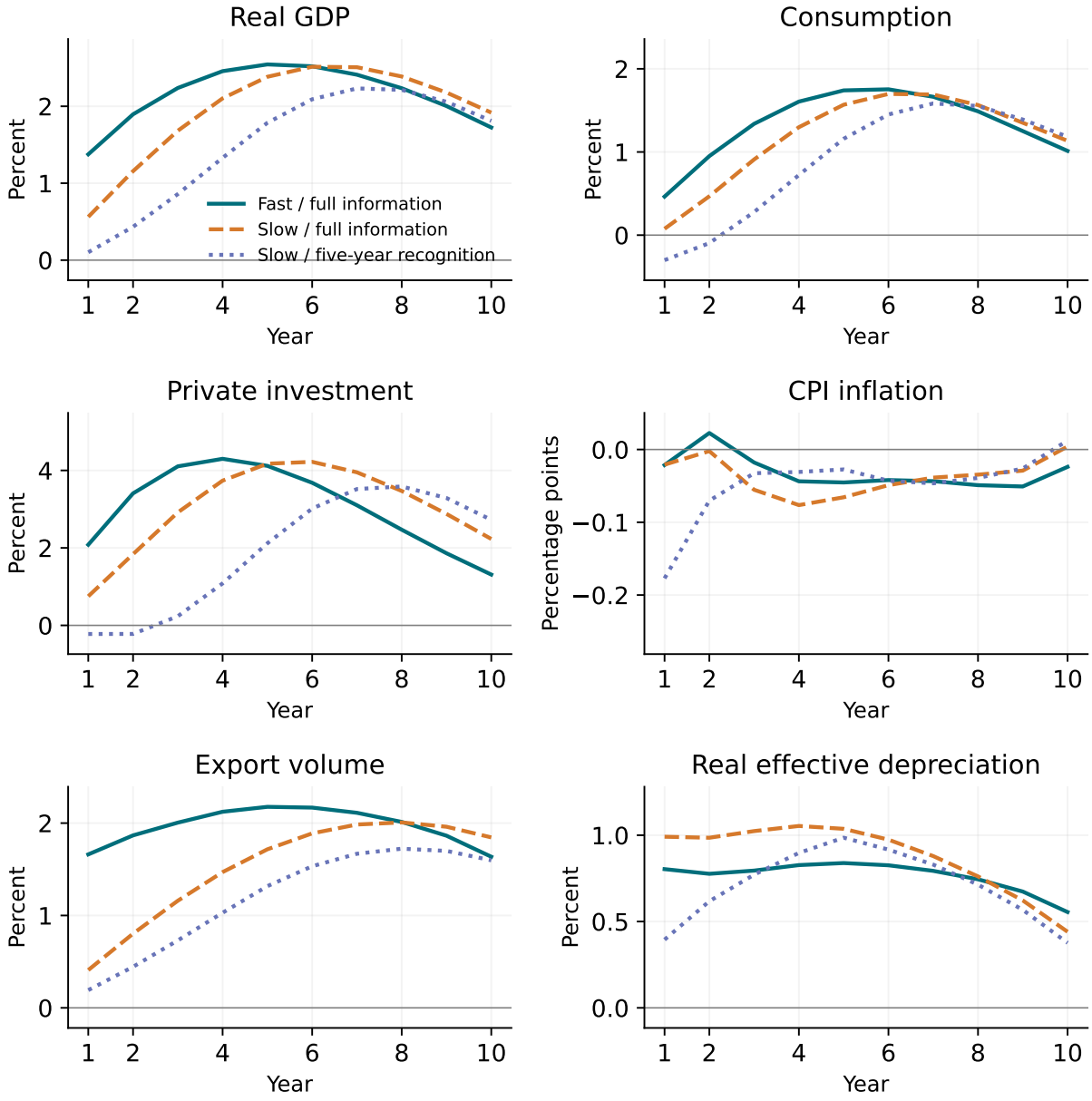
Source and notes: Common slow sourcing. Real required capital return is the mean sector log-return change in percentage points. Default is the mean contemporaneous sector probability in percent, around an eight-percent baseline. Other panels are percent deviations. Model returns and default probabilities are not observed market series.

Figure 12: Georgia: three corporate financial disturbances



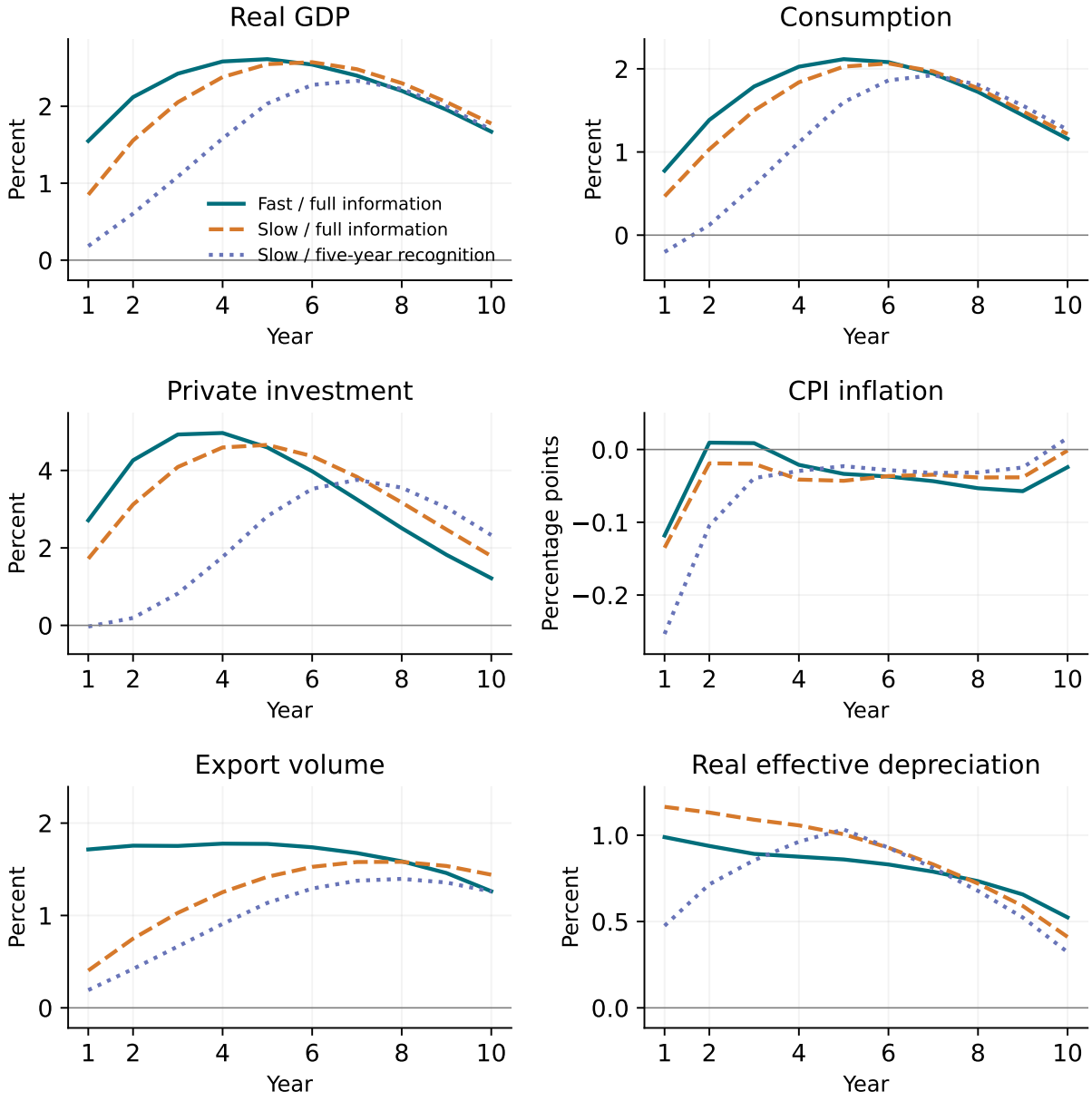
Source and notes: Definitions as in Figure 11. Shock normalizations differ across dispersion, income loss and capital destruction; they are not equal welfare losses.

Figure 13: Armenia: productivity persistence and recognition



Source and notes: Actual common productivity rises one percent in years one through ten. Full-information cases know this initially. Recognition observes current technology and revises future persistence over five years. Actual technology is not phased in.

Figure 14: Georgia: productivity persistence and recognition



Source and notes: Definitions as in Figure 13. Corresponding country scales match.

G Reproducibility and the publication boundary

The publication source contains the LaTeX document, figures, tables, asset-generation program, expanded original operational equation lists, all-origin summary and numerical diagnostics. The supplement also preserves the model source, current operational states, parameter values, simulation drivers and learning outputs. Detailed core response paths remain in the larger property-audit release or can be regenerated from the drivers.

The sequence is to check stationary states; run the core audit; correct productivity aggregation and replace those productivity paths; solve the news-vintage recognition experiment; generate assets; and compile the paper. Table rounding occurs only at presentation. File hashes identify the numerical evidence.

Runtime changes are implemented by the setup functions in `run_trade_diagnostics.py` and `repair_productivity_validation.py`, including policy and sourcing replacements. The original equation lists alone do not encode those changes. Learning is checked at each arrival-date information set. Solving the final realized technology path under perfect foresight instead reproduces a different experiment.

The documented boundary includes temporary fiscal shocks, anticipated holds, two risk persistence values, three corporate disturbances, ten-year productivity, five-year recognition, a temporary policy innovation and deterministic common financial stress. It excludes permanent debt and three-to-two-percent inflation-target transitions, Bayesian learning, an estimated international covariance process and nonlinear crisis solutions. These boundaries allow future extensions to be evaluated against an explicit benchmark.