INTERNATIONAL MONETARY FUND

Closing the Gap

A LIC's Policy Options Under an Aid Shock

Dawit Tessema and Sotima Jocelyn Koussere

WP/26/151

2026
JUL

WORKING PAPER

 WP/26/151

IMF Working Paper
Strategy, Policy and Review Department

Closing the Gap: A LIC's Policy Options Under an Aid Shock
Prepared by Dawit Tessema and Sotima Jocelyn Koussere*

Authorized for distribution by Eugenio Cerutti
July 2026

ABSTRACT: This paper uses a structural model calibrated to an aid-dependent economy to analytically explore the macroeconomic and distributional effects of a permanent aid cut under three alternative policy responses: non-concessional borrowing, domestic revenue mobilization, and uncompensated spending cuts. We find that a borrowing-only response leads to unsustainable debt and highly regressive outcomes. An uncompensated cut results in economic stagnation, higher poverty, and adverse inequality. Within the model, a strategy combining moderate borrowing with ambitious domestic revenue mobilization, while painful in the medium term, produces the most favorable path to fiscal sustainability and moderates the rise in poverty and inequality. These findings are analytical and model-based; they illustrate the trade-offs inherent in fiscal adjustment under aid dependence rather than prescribing specific policy actions.

RECOMMENDED CITATION: Tessema, Dawit and Sotima Jocelyn Koussere. 2026. Closing the Gap: A LIC's Policy Options Under an Aid Shock. IMF Working Paper No. 26/151. International Monetary Fund.

JEL Classification Numbers:	C53, E62, H63, O11
Keywords:	Aid Dependence; Fiscal Adjustment; Domestic Revenue Mobilization; Distributional Analysis
Author's E-Mail Address:	DTessema@imf.org, JKoussere@imf.org

* "The authors would like to thank Daehaeng Kim, Christian Ebek, Bozena Radzewicz-Bak, other reviewers of earlier versions of the paper and participants of SPRMS seminar for helpful comments. While the paper discusses a model calibrated to Liberia as a representative highly aid-dependent low-income country, the analysis is analytical and does not constitute country-specific policy recommendations.

Contents

1 Introduction

Many low-income countries remain heavily dependent on foreign aid to finance public spending and investment. A sudden and permanent reduction in grant inflows would create a substantial financing gap and pose serious macroeconomic risks. This paper uses a structural model calibrated to an aid-dependent economy, Liberia, to analytically explore the macroeconomic and distributional effects of such a shock under alternative fiscal policy responses. Liberia provides a useful calibration case because of its extreme aid dependence, limited debt-carrying capacity, and the availability of recent household survey data for distributional analysis. The findings are model-based and illustrate general trade-offs inherent in fiscal adjustment under aid dependence; they are not intended as country-specific policy recommendations.

Liberia's economy is highly aid-dependent, with foreign assistance financing a large share of public spending and investment. Between 2010 and 2022, net foreign aid received by Liberia was equivalent to 22 percent of GNI, far above the 11 percent average for low-income countries and 3 percent for sub-Saharan African countries (The World Bank, 2025). Grants alone have recently averaged 6–14 percent of GDP or roughly one-third of government revenues (IMF, 2024) and help to fund critical infrastructure, education, and social programs. This heavy reliance on external aid means that a sudden cessation of grant inflows would create a substantial financing gap and pose serious macroeconomic risks. Liberia's overall fiscal deficit would increase to nearly double digits without grants[1], which implies that absent donor support, the authorities would need to cut spending by an equivalent magnitude or find alternative financing to maintain development spending. Such an abrupt shock could jeopardize growth and poverty reduction gains. By 2024 the extreme poverty rate had already fallen to 26.4 percent from 40.9 percent in 2022 amid favorable economic conditions, particularly easing inflation (The World Bank, 2024), which fiscal retrenchment could likely worsen.

At the same time, Liberia faces tight concessional financing constraints and limited capacity to absorb debt shocks.[2]. Over 90 percent of Liberia's external public debt stock is on concessional terms, reflecting past efforts to rely on low-cost loans and grants (IMF, 2024). The Fund's assessment underscores that Liberia's fiscal position can only remain sustainable if it continues to receive aid and highly concessional funds; turning to non-concessional borrowing would quickly escalate debt service burdens and undermine fiscal stability. The authorities are therefore essentially constrained to

[1] In FY2023 and FY2024, the overall fiscal balance was around -7.1 percent and -2.8 percent of GDP including grants, but -13.8 percent and -8.3 percent excluding grants (IMF, 2024).

[2] The IMF's latest debt sustainability analysis (DSA) assesses Liberia at high risk of overall public debt distress, with public debt ∼58 percent of GDP in 2024 and little space to accommodate additional shocks (IMF, 2024)

a fiscal deficit that can be financed by available donor support and a limited drawdown of reserves. Under these conditions, a permanent aid cutoff forces extremely difficult choices between unsustainable borrowing, drastic expenditure cuts, or ambitious domestic revenue mobilization measures, each with significant macroeconomic and distributional implications.

To explore these trade-offs analytically, this paper employs a structural model calibrated to Liberia to simulate a 3 percent of GDP permanent aid cut in Liberia under various fiscal policy responses. It compares a baseline with continued aid against three policy response scenarios in the event of an aid cut: (i) replacing lost grants with non-concessional financing, (ii) gradually implementing domestic revenue mobilization (DRM) to offset the aid loss, and (iii) making no offsetting fiscal effort, leading to uncompensated cuts to public spending. Each scenario is analyzed to capture both medium-term adjustment dynamics and long-run structural outcomes. The DRM scenario does not assume that the full revenue gain is achieved on impact; rather, the reform package is phased in over roughly ten years, with borrowing used only as a temporary bridge during the transition.

We pay particular attention to fiscal sustainability, debt dynamics, and income distribution (poverty and inequality), drawing on methodologies for distributional analysis that combine aggregate growth projections with household survey data. Distributional impacts are quantified using quadratic growth-incidence curves matching simulated growth rates for the bottom 80 percent and overall economy to derive decile-level income changes and Gini coefficients. Because this mapping from macro aggregates to decile-level outcomes relies on a small number of distributional assumptions, we treat the medium term horizon as the paper's main quantitative distributional benchmark. Very-long-run distributional comparisons are more uncertain and are supplemented by sensitivity analysis in appendix A.2. This approach allows us to infer how different fiscal adjustment strategies following an aid loss would affect various income groups, providing a unique view of equity implications alongside macro-aggregates. The model is calibrated to Liberia's empirical context using data from various sources; the results illustrate the analytical properties of each policy response within the modeling framework.

The model-based analysis finds that the effects of a permanent aid cut hinge critically on the policy response adopted. If the gap is filled entirely with non-concessional borrowing, public investment resumes, but higher debt service soon forces sharper fiscal adjustment, including GST hikes and transfer cuts. By year five, real GDP is about 0.8 percent below the baseline, private investment is crowded out, and unemployment edges up. The distributional consequences are regressive, with the Gini rising to about 0.45 (from 0.35), bottom-decile income growth slows to about 4.4 percent compared with 8.1 percent in the baseline, and the top decile gains roughly 1.9 percent annually, partly reflecting interest income on domestic debt. If the government does not compensate for lost grants and scales back development spending one for one, the macro-social costs are larger. By year five, GDP is about 1.4 percent lower and formal output about 1.2 percent lower than baseline, private investment remains subdued, real wages stagnate, the Gini approaches about 0.59 at 20 years, median income growth turns roughly 1 percentage point negative relative to baseline, and bottom-decile growth is about 4.0 percentage points lower. These patterns are consistent with a negative structural transformation induced by persistent underinvestment in human and physical capital.

In contrast, the DRM strategy, where the gap is temporarily bridged with non-concessional borrowing while broad-based domestic revenue mobilization is phased in, spreads the adjustment over time and across taxpayers. The medium term is still contractionary, with consumption about 3.1 percent lower and GDP about 0.7 percent lower by year five, but revenues build to roughly 13 percent of 2025 GDP over a ten-year horizon, debt stabilizes, and economic activity, wages, and sectoral output recover. The equity impact is materially less severe: the Gini rises only to about 0.42, and improves to roughly 0.32 across steady states, bottom-decile growth falls by about 1 percentage point rather than 2 to 3 points as under non-concessional only financing, and top-decile gains are smaller. Ranking the options, absent aid, DRM is the clear second best since it preserves core public investment where there are significant gaps, restores debt sustainability without locking in high debt service, and moderates the rise in inequality. This approach outperforms both the nonconcessional-financing-only response, which front loads continuity but back loads painful and regressive adjustment, and uncompensated cuts, which deliver the deepest macroeconomic and welfare losses.

The remainder of the paper is organized as follows. Section 2 sets up a stylized LIC model with informality and segmented labor markets and calibrates it to Liberia, defining the macro-distributional metrics (growth, debt, poverty, Gini, and growth-incidence) used throughout. Section 4 establishes the counterfactual in which grants are maintained and development spending proceeds as envisaged in the 2025–2030 National Development Plan, providing benchmark macro paths. Section 5 evaluates replacing grants with non-concessional borrowing, detailing implications for debt dynamics, private-credit crowding out, and the distribution of gains and losses across households. Section 6 analyzes a strategy that temporarily bridges with non-concessional financing while pivoting to domestic revenue mobilization via base broadening and compliance improvements, quantifying both macro effects and growth incidence across the income distribution. Section 7 considers an uncompensated aid cut that forces reductions in development spending, tracing consequences for growth, capital accumulation, poverty, and inequality relative to the baseline. Section 8 summarizes the model-based findings.

2 Model Framework

We incorporate the stylized facts discussed above into a model of a LIC economy and calibrate it. The following sections investigate how fiscal policy can stimulate growth in the formal economy through investments in education and infrastructure. The results demonstrate that even in the face of costly development financing, fiscal adjustments following these investments can be moderate if accompanied by an tax base expansion.

Following Buffie et al. (2022), we use a three sector open economy model of a LIC with various types of public debt, tax and expenditure variables[3]. The model features a composite traded good alongside two non-traded goods with the traded good serving as the numeraire. The subscripts x, j, and n denote the tradables sector, the informal non-tradables sector, and the formal non-tradables sector, respectively. For simplicity, we refer to the x sector as agriculture. All quantity variables, except for labor and land, are adjusted for long-term growth by detrending with $(1+\mathfrak{g})^t$, where $\mathfrak{g}$ represents the exogenous growth rate of per capita income.

2.1 The private sector

Production q across all three sectors follows Cobb-Douglas production functions.

$$q_{j,t} = a_j z_{t-1}^{\psi_j} k_{j,t-1}^{\alpha_j} S_{j,t}^{\theta_j} (e_{b,t} L_{j,t})^{(1-\alpha_j-\theta_j)}. \tag{1}$$

$$q_{x,t} = a_x z_{t-1}^{\psi_x} k_{x,t-1}^{\alpha_x} S_{x,t}^{\theta_x} H^{\chi} (e_{b,t} L_{x,t})^{1-\alpha_x-\theta_x-\chi}, \tag{2}$$

$$q_{n,t} = a_n z_{t-1}^{\psi_n} k_{n,t-1}^{\alpha_n} S_{n,t}^{\theta_n} (e_{n,t} e_{b,t} L_{n,t})^{(1-\alpha_n-\theta_n)}, \tag{3}$$

All sectors use capital (k), low-skill labor (L), high-skill labor (S), and public infrastructure (z) that serves as a productivity-enhancing public good. Additionally, sector (x) utilizes a sector-specific factor, such as land or a natural resource (H). The human capital of low-skill labor is augmented by the quality and quantity of primary education (e_b), and in the formal sector, the productivity of low-skill labor is further influenced by efficiency wage considerations through work effort (e_n). The economy features two types of educational capital: basic education capital (S_b) and upper-level

[3]For a complete treatment of model and calibration, see Buffie et al. (2022)

education capital (S_u). The creation of physical capital (k), infrastructure (z), and educational capital (S_b, S_u) all involve combining imported machinery (a_{im}) with formal and informal sector inputs a_{in} and a_{ij}, $\forall i \in \{k, z, S_b, S_u\}$. It should be highlighted that this structure might diverge from the dual economy perspective on informality, which perceives the formal and informal economies as largely separate entities producing distinct products, utilizing different labor, capital, and entrepreneurial inputs, and catering to separate customer bases. (Lewis, 1954; La Porta and Shleifer, 2014).

Competitive firms in sectors x, n and j maximize profits by selecting each input until its marginal value product equals its price.

$$(1-\alpha_x-\theta_x-\chi)\frac{q_{x,t}}{L_{x,t}} = w_{x,t}, \quad \theta_x\frac{q_{x,t}}{S_{x,t}} = w_{s,t}, \quad \alpha_x\frac{q_{x,t}}{k_{x,t-1}} = r_{x,t}, \quad \chi\frac{q_{x,t}}{H} = r_{h,t} \tag{4}$$

$$P_{n,t}(1-\alpha_n-\theta_n)\frac{q_{n,t}}{L_{n,t}} = w_{n,t}, \quad P_{n,t}\theta_n\frac{q_{n,t}}{S_{n,t}} = w_{s,t}, \quad P_{n,t}\alpha_n\frac{q_{n,t}}{k_{n,t-1}} = r_{n,t} \tag{5}$$

$$P_{j,t}(1-\alpha_j-\theta j)\frac{q_{j,t}}{L_{j,t}} = w_{j,t}, \quad P_{j,t}\theta_j\frac{q_{j,t}}{S_{j,t}} = w_{s,t}, \quad \text{and} \quad P_{j,t}\alpha_j\frac{q_{j,t}}{k_{j,t-1}} = r_{j,t} \tag{6}$$

The model differentiates between saving households and liquidity constrained households on the demand side, both with preferences over goods x, j, n and m − the imported good (*see Figure A.1 for a depiction of the preference structure*). Capital owners, skilled, and low-skill labor in the formal sector form the saving class. Their income includes net-of-tax earnings from factors, returns from financial assets like foreign and domestic bonds, and allocated shares of remittances, agricultural land rents, and government transfers. This saving household invests in physical capital, foreign bonds, both involving adjustment costs, and domestic government bonds. The model is a real-sector framework and does not include banks or financial intermediaries. In practice, government bonds may be held by banks, but the underlying income ultimately accrues to asset-holding households through bank profits and financial returns. The saving household in the model therefore stands in for the broader group of asset holders, which is sufficient for the question this paper addresses: how the burden of fiscal adjustment is distributed between those who hold financial assets and those who do not. With the ability to save and borrow, they aim to maximize a standard iso-elastic utility function [7] subject to [8], $\forall\ \mathfrak{q} = j, n, x$ and $(1+\mathfrak{g})k_{\mathfrak{q},t} = i_{\mathfrak{q},t} + (1-\delta)k_{\mathfrak{q},t-1}$.

$$V = \sum_{t=0}^{\infty} \beta^t \frac{{c_{2,t}}^{1-1/\tau}}{1-1/\tau} \tag{7}$$

$$\begin{aligned} P_t b_t - b_{f,t} &= (1-f_w)(w_{n,t}L_{n,t} + w_{s,t}S_{t-1}) + \sum_{\mathfrak{q}=j,n,x} [r_{\mathfrak{q},t} - f_{\mathfrak{q}}(r_{\mathfrak{q},t} - \delta P_{\mathfrak{q},t})]k_{\mathfrak{q},t-1} \\ &+(1-f_h)(1-\sigma)r_{h,t}H + (1-a_t)\mathcal{T}_t - \frac{1+r_f}{1+g}b_{f,t-1} + \frac{1+r_{t-1}}{1+g}P_t b_{t-1} \\ &-P_{k,t}\sum_{\mathfrak{q}=j,n,x}(i_{\mathfrak{q},t} + \mathbb{AC}_{\mathfrak{q},t}) - \frac{\eta}{2}(b_{f,t} - \bar{b}_f)^2 - P_{c,t}c_{2,t} - \mu_t z_{t-1}, \end{aligned} \tag{8}$$

Liquidity constrained households include the unemployed, low-skill workers in agriculture and informal sectors. They consume their entire income each period, comprised of net-of-tax labor income, agricultural land rents, and their share of government transfers. We refer to members of this group as the *'ex ante poor'*, as individuals can move in and out of this group.

$$V^* = \sum_{t=0}^{\infty} \beta^t \frac{{c_{1,t}}^{1-1/\tau}}{1-1/\tau} \tag{9}$$

$$P_{c,t}c_{1,t} = (1-f_{wx})(w_{x,t}L_{x,t} + \sigma r_h H) + (1-f_{wj})w_{j,t}L_{j,t} + a_t\mathcal{T}_t, \tag{10}$$

The work effort of low-skill labor in the formal sector $(e_{n,t})$ is influenced by own wage, the informal sector wage, and the unemployment rate $\mathfrak{u}$ [4]. Workers tend to exert more effort when receiving higher real wages and when the lower wages in the informal sector, coupled with high unemployment, make them value their employment more. Formal sector firms understand this relationship between real wage and labor productivity, optimizing both wages (w_n) and labor levels (L_n) to maximize profits, adhering to the Solow condition [12].

$$e_{n,t} = g_0 + g_1 \ln\left(\frac{w_{n,t}}{P_t}\right) - g_2 \ln\left(\frac{w_{j,t}}{P_t}\right) + g_3\mathfrak{u}_t, \tag{11}$$

$$g_1 = \frac{\partial e_{n,t}}{\partial(w_{n,t}/P_t)}\left(\frac{w_{n,t}/P_t}{e_{n,t}}\right) = 1. \tag{12}$$

In the informal sector and agriculture, dominated by self-employment and family-run operations, efficiency wage considerations are absent, leading to an integrated labor market with flexible wages. The total labor supply remains fixed at $\bar{L}_{xj}$, with job seekers transitioning freely between these sectors. Two main factors – public investment in upper-level education $(i_{u,t})$, which upgrades some low-skill workers to high-skill $\bar{L}_t = \bar{L}_0 - (S_t - S_0)$, and new formal sector job openings – affect the distribution of low-skill labor. A portion Δ_{xj} of these new high-skill workers comes from low-skill workers in agriculture and the informal sector. Additionally, a ξ percent of formal sector jobs go to workers from the combined agriculture and informal sectors. Thus, low-skill labor in the x, j sector is defined

[4] $\mathfrak{u} = \frac{\bar{L}_t - L_{n,t} - L_{j,t} - L_{x,t}}{\bar{L}_t}$

as:

$$\bar{L}_{xj,t} = L_{x,t} + L_{j,t} = L_{x,0} + L_{j,0} - \Delta_{xj}(S_t - S_0) - \xi(L_{n,t} - L_{n,0}) \tag{13}$$

2.2 The public sector

Public sector investment in infrastructure (i_z) and basic and upper-level education ($i_s \equiv i_b + i_u$) increases the stock of physical (z) and human capital (S_b, S_u) as in [1] and [2]. While human capital investment is assumed to take long to payoff, infrastructure investments are assumed to be shovel ready. Fixed input-output coefficients connect increases in education capital to the supply of high-skill labor S and the productivity of low-skill labor e_b.

$$(1+g)\tilde{z}_t = i_{z,t} + (1-\delta_{z,t})\tilde{z}_{t-1}. \tag{1}$$

$$S_{b,t} = i_{b,t-6} + (1-\delta_b)S_{b,t-1} \quad \text{and} \quad S_{u,t} = i_{u.t-8} + (1-\delta_u)S_{u,t-1}. \tag{2}$$

$$S_t = S_0 + \phi_1(S_{u,t-1} - S_{u,0}) \quad \text{and} \quad e_{b,t} = 1 + \phi_2(S_{b,t-1} - S_{b,0}). \tag{3}$$

The government's expenditures include debt service, infrastructure investment $\mathbb{I}_z$ (considering cost overruns)[5], maintenance $\mathfrak{m}$, transfers $\mathcal{T}$, and total education investment i_s. In the simulations, government transfers serve as a stylized social-protection instrument. The model therefore does include a social-protection channel, although not in the form of a detailed cash-transfer program with administrative targeting rules. Its revenues come from infrastructure user fees μz, consumption VAT, and sector-specific taxes on wages and profits $\mathfrak{q}$, with $\mathfrak{q} = j, n, x$. When expenditures exceed revenues, the deficit is financed through domestic, external commercial, or concessional borrowing (Δb, Δd_c, Δd), as shown in the equation [4], where $\Delta b_t = b_t - b_{t-1}$, $\Delta d_{c,t} = d_{c,t} - d_{c,t-1}$, and $\Delta d_t = d_t - d_{t-1}$ indicate changes in respective debts. The interest rates on concessional (d) and commercial debt (dc) are denoted by r_d and r_{dc}.

$$\begin{aligned} P_t\Delta b_t + \Delta d_{c,t} + \Delta d_t \quad = \quad & \frac{r_d - \mathfrak{g}}{1+\mathfrak{g}}d_{t-1} + \frac{r_{dc} - \mathfrak{g}}{1+\mathfrak{g}}dc_{t-1} + \frac{r_{t-1} - \mathfrak{g}}{1+\mathfrak{g}}P_t b_{t-1} + P_{z,t}(\mathbb{I}_{z,t} + \mathfrak{m}_t) \\ & + \mathcal{T}_t + P_{s,t}i_{s,t} - \mu_t z_{t-1} - h_t(P_{n,t}c_{n,t} + g_j P_{j,t}c_{j,t} + g_x c_{x,t} + g_m c_{m,t}) \\ & - \sum_{\mathfrak{q}=j,n,x} [f_{\mathfrak{q},t}(r_{\mathfrak{q},t} - \delta P_{k,t})k_{\mathfrak{q},t-1} + f_{w\mathfrak{q},t}w_{\mathfrak{q},t}L_{\mathfrak{q},t}] - f_{w,t}w_{s,t}S_t - f_{h,t}r_{h,t}H \end{aligned} \tag{4}$$

[5] The term $P_{z,t}\mathbb{I}_{z,t}$, where $\mathbb{I}_{z,t} = \mathcal{H}_t(i_{z,t} - i_{z,0}) + i_{z,0}$, points to the frequent cost overruns in ambitious public investment programs in LICs due to challenges like poor planning and weak oversight. The new investment adjustment factor $\mathcal{H}_t = \left(1 + \frac{i_{z,t}}{\tilde{z}_{t-1}} - \delta_z - \mathfrak{g}\right)^{\phi}$, with $\phi \geq 0$, reflects the severity of absorptive capacity constraints in the public sector.

Policy makers accept all concessional loans offered by official creditors, with the schedule for borrowing and amortization of these loans fixed, making Δd_t predetermined in the analysis. This sets the *ex-ante* financing gap ($\mathfrak{Gap}$) as in [5]. The financing of any shortfall between expenditures and revenues, considering fixed initial levels of transfers and taxes ($\mathcal{T}_0$ and h_0), is achieved through [6] and [7], where $\lambda_{dc} \in [0, 1]$ proportionally divides the borrowing between domestic and external commercial sources.

$$
\begin{aligned}
\mathfrak{Gap}_t \quad = \quad & \frac{1 + r_{d,t}}{1 + \mathfrak{g}} d_{t-1} - d_t + \frac{r_{dc} - \mathfrak{g}}{1 + \mathfrak{g}} dc_{t-1} + \frac{r_{t-1} - \mathfrak{g}}{1 + \mathfrak{g}} P_t b_{t-1} + P_{z,t}(\mathbb{I}_{z,t} + \mathfrak{m}_t) \\
& + \mathcal{T}_0 + P_{s,t} i_{s,t} - \mu_t z_{t-1} - h_0 (P_{n,t} c_{n,t} + g_j P_{j,t} c_{j,t} + g_x c_{x,t} + g_m c_{m,t}) \\
& - \sum_{\mathfrak{q}=j,n,x} [f_{\mathfrak{q},t}(r_{\mathfrak{q},t} - \delta P_{k,t}) k_{\mathfrak{q},t-1} + f_{w\mathfrak{q},t} w_{\mathfrak{q},t} L_{\mathfrak{q},t}] - f_{w,t} w_{s,t} S_t - f_{h,t} r_{h,t} H.
\end{aligned}
\tag{5}
$$

$$
P_t \Delta b_t = (1 - \lambda_{dc})[\mathfrak{Gap}_t + \mathcal{T}_t - \mathcal{T}_0 - (h_t - h_0)(P_{n,t} c_{n,t} + g_j P_{j,t} c_{j,t} + g_x c_{x,t} + g_m c_{m,t})] \tag{6}
$$

$$
\Delta d_{c,t} = \lambda_{dc}[\mathfrak{Gap}_t + \mathcal{T}_t - \mathcal{T}_0 - (h_t - h_0)(P_{n,t} c_{n,t} + g_j P_{j,t} c_{j,t} + g_x c_{x,t} + g_m c_{m,t})] \tag{7}
$$

Debt sustainability necessitates adjustments in VAT and transfers to cover the entire financing gap. Policymakers distribute the adjustment burden, net windfall when $\mathfrak{Gap} < 0$, between tax increases and spending cuts, targeting long-run values for VAT and transfers as in [8]. These targeted adjustments, alongside the management of domestic and external commercial debt, are essential to prevent unsustainable debt growth, guided by policymakers' preferences and the socio-political constraints on fiscal policy changes.

$$
h_t^{\text{target}} = h_0 + (1 - \lambda) \frac{\mathfrak{Gap}_t}{P_{n,t} c_{n,t} + g_j P_{j,t} c_{j,t} + g_x c_{x,t} + g_m c_{m,t}} \text{ and } \mathcal{T}_t^{\text{target}} = \mathcal{T}_0 - \lambda \mathfrak{Gap}_t \tag{8}
$$

2.3 Market Clearing Conditions

Flexible wages and prices equate demand to supply in the market for skilled labour, the market for low-skill labour in sector $x - j$, and the markets for the two non-traded goods:

$$
S_t = S_{x,t} + S_{n,t} + S_{j,t} \tag{1}
$$

$$
\bar{L}_{xj,t} = L_{x,t} + L_{n,t} \tag{2}
$$

$$
q_{n,t} = c_{n,t} + a_{kn} \sum_{\mathfrak{q}=j,n,x} (i_{\mathfrak{q},t} + \mathbb{AC}_{\mathfrak{q},t}) + a_{zn}(\mathbb{I}_{z,t} + \mathfrak{m}_t) + a_{sn} i_{s,t} \tag{3}
$$

$$q_{j,t} = c_{j,t} + a_{kj} \sum_{\mathfrak{q}=j,n,x} (i_{\mathfrak{q},t} + \mathbb{AC}_{\mathfrak{q},t}) + a_{zj}(\mathbb{I}_{z,t} + \mathfrak{m}_t) + a_{sj} i_{s,t} \tag{4}$$

The model is closed by the accounting identity that growth in the country's net foreign debt equals the current account deficit. Adding the public and private budget constraints produces

$$\Delta d_t + \Delta dc_t + \Delta b_{f,t} = \frac{r_d - \mathfrak{g}}{1+\mathfrak{g}} d_{t-1} + \frac{r_{dc} - \mathfrak{g}}{1+\mathfrak{g}} dc_{t-1} + \frac{r_f - \mathfrak{g}}{1+\mathfrak{g}} b_{f,t-1} + \frac{\eta}{2}(b_{f,t} - \bar{b}_f)^2 \tag{5}$$

$$+P_{z,t}(\mathbb{I}_{z,t} + \mathfrak{m}_t) + P_{s,t} i_{s,t} + P_t(c_{1,t} + c_{2,t}) \tag{6}$$

$$+P_{k,t} \sum_{\mathfrak{q}=j,n,x} (i_{\mathfrak{q},t} + \mathbb{AC}_{\mathfrak{q},t}) - P_{n,t} q_{n,t} - P_{j,t} q_{j,t} - q_{x,t} \tag{7}$$

In DIG-Labor, like most other neoclassical general equilibrium models, the concept of the long run is defined by convergence properties rather than calendar time. Consequently, it is appropriate to distinguish between a 10-year period, during which most short- and medium-term adjustments in capital accumulation, labor reallocation, and income distribution occur, and a 50-year very long run. This very long run represents the new steady state or balanced growth path once the effects of reforms and shocks have fully manifested. This is consistent with the literature demonstrating that convergence toward steady state in neoclassical general equilibrium models is gradual, implying long half-lives (Barro and Sala-i Martin, 1992; Acemoglu, 2009). The distributional analysis framework does not impose any formal constraints on the definition of the long run, thereby providing flexibility to interpret horizons of 10 years as pertinent for transitional analysis and 50 years as indicative of the fully realized steady-state equilibrium. At the same time, the mapping from macro aggregates to decile-level outcomes is calibrated from a limited set of distributional moments, and the growth differentials across deciles that hold at a given point in time may not persist unchanged over five decades as households adjust their behavior and policies evolve. We therefore place greater weight on the medium term results in the main text and treat very-long-run distributional comparisons more cautiously. The appendix presents sensitivity analysis under alternative specifications, varying growth damping assumptions, and empirical bounding of long-run Gini values.

3 Distributional Assessments

Our goal is to use a small set of macroeconomic outputs from our model to generate a plausible profile of income growth by decile of the population. The approach involves three main steps: (1) specify a functional form for the growth incidence curve $g(p)$, (2) determine the parameters of this function using aggregate constraints (total growth and bottom-80 percent growth) and initial distribution data, and (3) impose additional economic-theory constraints to ensure the profile is realistic (obeying properties of Lorenz curves and heavy-tailed income distributions). Finally, given the $g(p)$, we compute the implied new income distribution and Gini coefficient.

3.1 Quadratic Growth Incidence Curve

We choose a quadratic functional form for the anonymous growth incidence curve:[6], where p represents the population percentile (with $p = 0$ at the poorest and $p = 1$ at the richest).

$$g(p) = \alpha + \beta p + \gamma p^2, \qquad 0 \leq p \leq 1 \tag{1}$$

This functional form can approximate common growth profiles observed in empirical studies. For example, a roughly linear increasing GIC implies upper income quantiles benefit more than lower ones while a U-shaped curve implies middle income quantiles gain the least. Higher-order polynomials or piecewise functions could offer more flexibility, but with the risk of overfitting without sufficient constraints. We find a quadratic GIC to be a good compromise for flexibility. We do not claim that this is the only possible specification. Rather, it is a transparent and parsimonious choice that allows us to compare scenarios on a common footing. In Appendix A.2, we also consider a piecewise-linear, log-linear and square-root linear GICs, perturbed initial income shares, and bounded long-run assumptions on the Gini as robustness checks.

Since we will apply this $g(p)$ in discrete terms (by decile), one can think equivalently that each decile $i = 1, \ldots, 10$ is assigned a growth rate g_i based on the p within that decile. A simple choice is to let p be the midpoint of the decile's population range, e.g. $p = 0.05$ for the first decile, $p = 0.15$ for the second, …, up to $p = 0.95$ for the tenth decile. Thus, $g_1 = \alpha + \beta(0.05) + \gamma(0.05)^2$, $g_2 = \alpha + \beta(0.15) + \gamma(0.15)^2$, and so forth. These g_i represent the assumed income growth rate for the average person in decile i. We will later weight these by initial incomes to enforce consistency with aggregate growth.

3.2 Using Aggregate Constraints to Solve for GIC Parameters

We have three unknown parameters (α, β, γ) in the GIC. To pin them down, we use information from the model scenarios: specifically, the growth rate of output (denoted G_y) and the income growth of the bottom $\bar{y}$ percent, $(G_{\bar{y}})$, where $\bar{y} = \frac{L_{x,t}+L_{j,t}+L_{u,t}}{L}$. These will yield two equations. A third condition

[6] An *anonymous* GIC compares two snapshots of the income distribution without tracking the identities of individuals between periods. This is appropriate since we lack panel data on individuals. We only compare distributional snapshots. A quadratic GIC is flexible enough to take various shapes (increasing, decreasing, concave or convex) with just three parameters, and is smooth and continuous.

will come from an economic constraint (discussed in the next subsection), but let us first formalize the two aggregate constraints.

Let $s_i^{(0)}$ be the initial income share of decile i (so $\sum_{i=1}^{10} s_i^{(0)} = 1$). Let g_i be income growth for decile i as given by our GIC function at that decile for any one year. After one year, decile i's income share $s_i^{(1)}$ will change, but for small growth rates one can approximate the change in share as proportional to $(1+g_i)$. More exactly, the total income of decile i after the growth period would be $s_i^{(0)} \times (1+g_i) \times Y_0$, where Y_0 is initial total income. The sum of incomes after growth is $Y_1 = Y_0 \sum_{i=1}^{10} s_i^{(0)}(1+g_i)$. By definition, $1 + G_y = Y_1/Y_0$. Therefore:

$$\sum_{i=1}^{10} s_i^{(0)}(1+g_i) = 1 + G_y, \tag{1}$$

which implies that the weighted average of growth rates across deciles (weighted by their income share) equals the overall growth. If G_y is small, this simplifies to $\sum_i s_i^{(0)} g_i \approx G_y$. Equation (1) is exact for the discrete case as written. We can rewrite it as $\sum_i s_i^{(0)} g_i = G_y$ (since $\sum_i s_i^{(0)} = 1$ and distributing). Substituting $g_i = \alpha + \beta p_i + \gamma p_i^2$ (with p_i the percentile midpoint of decile i), this is a linear equation in α, β, γ. It implies that the GIC parameters must be such that the area under the GIC weighted by the initial Lorenz weights equals G_y.

Next, consider the bottom $\bar{y}$ percent of the population (deciles 1 through x). Their total income initially is $\sum_{i=1}^{x} s_i^{(0)} \times Y_0$. After growth, the bottom $\bar{y}$ percent total income is $\sum_{i=1}^{x} s_i^{(0)}(1+g_i)Y_0$. We define $1 + G_{\bar{y}}$ as the factor by which bottom-$\bar{y}$ percent total income grows: $(1+G_{\bar{y}}) \sum_{i=1}^{x} s_i^{(0)} Y_0 = \sum_{i=1}^{x} s_i^{(0)}(1+g_i)Y_0$. Canceling Y_0 and expanding, we get:

$$\sum_{i=1}^{x} s_i^{(0)}(1+g_i) = (1+G_{\bar{y}}) \sum_{i=1}^{x} s_i^{(0)}. \tag{2}$$

Again, since $\sum_{i=1}^{x} s_i^{(0)}$ is just the initial income share of bottom 80 (denote it $S_{\bar{y}}^{(0)}$), we can simplify (2) to $\sum_{i=1}^{x} s_i^{(0)} g_i = S_{\bar{y}}^{(0)}, G_{\bar{y}}$. This implies that the aggregate income growth accruing to the bottom $\bar{y}$ percent (left-hand side) corresponds to the bottom $\bar{y}$'s share of total income times their specific growth rate. Given $G_{\bar{y}}$ from our model scenarios, this becomes our second linear equation in α, β, γ. Additional information or assumptions are needed to pin down a unique curve, since we now have two linear equations from (1) and (2) and three unknowns.

3.3 Pareto Tail and Lorenz Convexity

To resolve the indeterminacy, we impose two constraints on the shape of the GIC. First is the *Pareto premium constraint*. Empirical income distributions tend to have a heavy upper tail that is well-approximated by a Pareto distribution beyond some high percentile (often the top 5 percent or 1 percent). A key property of Pareto-distributed top incomes is that wealth and income concentrate further at the top during growth spells unless specific redistributive forces counteract this (Benhabib and Bisin, 2018).

To reflect this, we require that the GIC be non-decreasing at high percentiles. In practice, we impose that the top decile's income growth is not lower than the ninth decile's growth (i.e. $g_{10} \geq g_9$), and similarly that the slope of $g(p)$ as $p \to 1$ is non-negative. For our quadratic $g(p)$, $g'(p) = \beta + 2\gamma p$; at $p = 1$ this is $\beta + 2\gamma$. The Pareto constraint can be stated as $\beta + 2\gamma \geq 0$, ensuring the curve is not sloping downward at the 100th percentile.[7] In the script, this constraint influences the choice of the free parameter by essentially rotating the curve until $g_{10} = g_9$ if initially the unconstrained solution had $g_{10} < g_9$.

Second is the *Lorenz convexity constraint*. The Lorenz curve plots cumulative income share against cumulative population and is by definition a convex function (Atkinson, 1970; Gastwirth, 1972).This convexity is equivalent to requiring that the distribution of income remains ordered without any reshuffling that would make a lower income decile suddenly richer than a higher decile in terms of share. In our GIC, an extreme inversion could theoretically occur if a poorer decile had an extraordinarily high growth rate compared to a slightly richer decile; that could make the poorer decile overtake the richer in absolute income. While such crossing is theoretically possible if a policy targeted the very poor exclusively, it is generally not observed in smooth aggregate scenarios and would violate the normal convexity of Lorenz curves which assume initial ordering by income persists in cumulative terms (Atkinson, 1970; Kakwani and Podder, 1973).

To enforce Lorenz convexity, we ensure that the cumulative income shares with income growth remain increasing. For example, if decile 1 grows much faster than decile 2, it might increase its share enough to overtake decile 2's share. To avoid any pathological outcome, we adjust γ such that growth rates do not increase too sharply for the lowest deciles relative to those just above them. In practice, a sufficient condition for Lorenz convexity is that $g(p)$ itself is a non-decreasing function of p when

[7] If the initial distribution data include a very large share for the top 10 percent, it may even be appropriate to impose a strictly increasing condition $g_{10} > g_9$, indicating the top 1 percent or 0.1 percent get an outsized gain. But we use the weak inequality as a minimal condition for heavy-tail consistency.

$G_{\bar{y}} > G_y$ (*declining inequality*), or *non-increasing* if $G_{\bar{y}} < G_y$ (*rising inequality*). We check final decile shares after applying g_i: the share of decile i should remain less than or equal to the share of decile $i+1$. If a violation is detected, the curvature γ is adjusted to correct whatever might have made the lowest deciles jump too much.

We are left with one parameter undetermined by the linear system γ. We choose γ to satisfy the Pareto tail condition with equality, unless the unconstrained solution already meets it. This yields a unique $g(p)$ that satisfies both aggregate constraints and has $g_{10} = g_9$, which tends to automatically satisfy Lorenz convexity for intermediate deciles if γ is not extreme. If further adjustment is needed for Lorenz convexity, we fine-tune γ marginally. The result is a GIC that yields a smooth growth distribution resembling empirical patterns of distributional change.

Mathematically, one could solve α, β from the two linear constraints in terms of γ:

$$\sum_{i=1}^{10} s_i^{(0)}(\alpha + \beta p_i + \gamma p_i^2) = G_y$$

$$\sum_{i=1}^{x} s_i^{(0)}(\alpha + \beta p_i + \gamma p_i^2) = G_{\bar{y}}$$

$$\beta + 2\gamma = 0$$

This yields closed-form solutions of α, β, γ. In more complex implementations, one might solve it numerically especially if additional piecewise conditions apply.

3.4 Projecting Decile Incomes and Inequality Measures

Given $g(p)$ and decile growth rates $g_1, \ldots, g_{10}$, we can compute each decile's projected income and the resulting inequality indices. If $y_i^{(0)}$ is the initial average income of decile i, then the projected average income is $y_i^{(1)} = y_i^{(0)} \times (1 + g_i)$. The total income of decile i becomes $Y_i^{(1)} = Y_{\text{total}}^{(0)} \cdot s_i^{(0)} \cdot (1 + g_i)$, where $Y_{\text{total}}^{(0)}$ is initial total income (so that $Y_i^{(0)} = s_i^{(0)} Y_{\text{total}}^{(0)}$). The new share of decile i in total income is $s_i^{(1)} = \frac{s_i^{(0)}(1+g_i)}{\sum_{j=1}^{10} s_j^{(0)}(1+g_j)}$. By construction, $\sum_i s_i^{(1)} = 1$. We then derive the Lorenz curve from $s_i^{(1)}$. Assuming within each decile that income is uniformly distributed, the Lorenz curve between decile points is piecewise linear. The cumulative share for the bottom k deciles is $L_k^{(1)} = \sum_{i=1}^{k} s_i^{(1)}$. We can calculate the Gini coefficient from the Lorenz curve using $1 - 2\sum_{k=0}^{10}(L_k^{(1)} + L_{k-1}^{(1)}) \times 0.1/2$, where $L_0^{(1)} = 0$ and $L_{10}^{(1)} = 1$. This computes twice the area between the Lorenz curve and the line of equality by trapezoidal approximation using the decile points. In practice, since decile data are coarse, this yields an approximate Gini.

Since our GIC was constructed to preserve Lorenz convexity, the final shares $s_i^{(1)}$ will still be in ascending order ($s_1^{(1)} < s_2^{(1)} < \cdots < s_{10}^{(1)}$). This allows us to meaningfully compare Gini to initial starting point. The change in Gini then indicates whether inequality rose or fell in the scenario. Additionally, we compute poverty measures by specifying a poverty line and estimating how many deciles (or what fraction of population) fell below it in the baseline versus other scenarios.

4 Baseline

To establish a point of comparison, we first construct a baseline scenario with no aid interruption, in which Liberia continues to receive external grants at roughly the end-2024 level into the medium term. This scenario assumes that concessional financing remains available to sustain the government's development programs. In the baseline, the 2025 national budget's public investment plan, which entails a modest scale-up equivalent to about +0.5 percent of GDP each in education and infrastructure spending (relative to 2024), can be fully implemented thanks to ongoing grant support (MoFDP, 2025). The continued inflow of aid means the government does not need to resort to large fiscal adjustments; only modest policy adjustments are required to maintain debt sustainability over time. This reflects Liberia's current strategy of leveraging donor funds for capital investment while keeping domestic borrowing and tax hikes limited. This baseline is consistent with the country's medium-term economic potential under prudent policies.

At baseline, sustained public investment in human capital and infrastructure delivers broadly inclusive growth and progressive distributional outcomes (see Figure A.3). The government prioritizes expanding access to basic education and addressing critical infrastructure bottlenecks that constrain productivity. These investments raise productivity economy-wide, stimulate employment, and allow real wages to grow. The baseline scenario yields a modest long-run increase in real GDP of about 4.2 percent (*relative to a no-investment counterfactual*) and stabilizes unemployment around 4 percent. Private investment also gradually rises, as improved infrastructure and human capital encourage greater economic activity.

Productivity gains are concentrated in sectors employing lower-skilled and informal workers, mainly due to better education and training, which narrows the wage gap between informal and formal labor and between unskilled and skilled workers. With aid financing complementing development spending, the fiscal burden on domestic resources remains low and any necessary tax or transfer adjustments are mild, so household disposable incomes are not significantly squeezed by fiscal policy. In sum, the baseline envisions a virtuous cycle in which concessional external financing enables greater public investment that fosters inclusive economic growth and reinforces social stability.

The distributional trajectory in the baseline is notably progressive (see Figures A.7 and A.8). Our simulations indicate that sustained investment in education and infrastructure would cause income inequality to trend downwards over time. Starting from a Gini coefficient of about 0.35, the 2016 HIES benchmark (LISGIS, 2016), the Gini steadily declines to 0.31 after 10 years, and falls further to around 0.30 in the very long run (see Figure A.8). This initial benchmark should be interpreted as a pragmatic calibration anchor rather than a precise estimate of Liberia's 2025 income distribution. Since the 2016 HIES, Liberia has experienced major shocks, including the pandemic and subsequent food and inflation episodes, so the level and shape of current inequality are uncertain. The direction of the change is itself ambiguous: the pandemic likely increased inequality through unequal income losses, while subsequent food-price shocks may have compressed the distribution at the bottom. The paper's distributional results should therefore be read primarily as scenario comparisons around a common starting distribution, not as point forecasts conditional on a fully up-to-date household survey. This marginal decline in inequality is driven by relatively faster income growth at the bottom of the income distribution. Annualized income growth for the bottom two deciles in the baseline reaches about 8.1 percent and 4.7 percent, respectively, whereas the top deciles see much more modest gains with top decile income growth stagnant over the period (see Figure A.7).

These outcomes reflect the benefits of public investment. Improved access to education and basic services increases the productivity and earnings of the poorest households, while the expansion of skilled labor (through higher education investment) eventually dampens the skill premium that high-income workers enjoy. Overall, the baseline scenario demonstrates that with continued donor support and prudent fiscal management, Liberia can achieve moderately high growth, improve income distribution, and lower poverty, albeit marginally in the medium term (see Figure A.9). This scenario embodies the goals of Liberia's national development plans, including the Pro-Poor Agenda for Prosperity (PAPD), wherein external aid and concessional loans fund investments that catalyze job-creating growth and human development.[8]

[8] The PAPD notes that while financial access is relatively manageable, Liberia's key challenges stem from limited technology and knowledge. Despite rich natural capital, the country trails peers in human and produced capital, with inequality, infrastructure gaps, and poverty posing major constraints to growth.

5 Non-Concessional Financing

In the first aid-cut scenario, we assume that all grant aid is permanently cut starting in 2025, and the authorities respond by fully replacing lost financing with a combination of external commercial loans and domestic debt issuance. This scenario posits no significant domestic revenue mobilization or expenditure reform to offset the aid shortfall; instead, the authorities attempt to continue their public investment plans by relying on non-concessional financing. Such a response might resemble turning to bond markets or domestic banks to fund projects, an approach that some aid-dependent countries resort to when grants dry up. Examining this case is instructive, as it highlights the potential short-term benefits of maintaining spending, as well as the considerable medium- and long-term risks to debt sustainability and equity.

5.1 Macroeconomic Outcomes

In this scenario, the government initially manages to sustain public investment at the planned levels despite the aid cutoff, since the grants are replaced dollar-for-dollar by new debt. In the very short run, this provides a degree of continuity, as there is no abrupt collapse in public spending. However, our simulations show that this strategy delivers only temporary macroeconomic gains, while exacerbating long-run debt vulnerabilities. Substituting grants with expensive debt introduces heavy debt-servicing costs that soon crowd out the benefits of the investment. As external commercial borrowing and domestic bond issuance accumulate, the public debt stock rapidly increases in the medium term (Figure A.4b). The additional interest payments and amortization create mounting fiscal pressure forcing the government to implement sharper fiscal adjustments a few years into the scenario to stabilize debt. In particular, the government would need to raise indirect taxes and implement deep cuts in government transfers to contain debt (Figure A.4a). These measures are sharper than anything required in the baseline, and emerge as a consequence of non-concessional financing. The shifts from grant-financed development spending to market-based borrowing implies that debt servicing quickly consumes fiscal space, forcing painful adjustment measures.

In the medium term (first 5–10 years), the non-concessional borrowing choice induces sluggish economic activity. Although public investment projects continue (e.g., roads are built and schools are funded), providing some stimulus, negative factors dominate. Higher taxes depress consumption, government transfer cuts reduce households' income, and heavy domestic borrowing drives up interest rates, which crowds out private investment (*Figure A.4a*). An important caveat is that the model is a real-sector framework and does not include banks, financial markets, or currency substitution.

Liberia is highly dollarized and has a shallow domestic debt market, so the standard channel, where government borrowing pushes up domestic interest rates and crowds out private investment, may be weaker in practice than the model implies. By abstracting from financial-sector frictions, the model isolates the distributional question to how adjustment costs are shared between asset-holding and liquidity-constrained households, but it does not capture the full complexity of Liberia's financial landscape.

The results show that real GDP falls about 0.8 percent below baseline by year 5. Unemployment rises modestly as both the formal and informal sectors contract due to weaker aggregate demand and reduced fiscal resources to support those sectors. In contrast, the traditional sector experiences a slight uptick as some displaced peri-urban workers return to agriculture and targeted infrastructure improvements (e.g. farm-to-market roads) benefit farming communities. This agricultural boost, however, is not enough to offset overall losses. It merely reflects a shift of unskilled labor back to lower-productivity activities. Real wages in agriculture do rise faster than in other sectors but economy-wide employment and income still diminish compared to the no-aid-cut baseline.

The combination of fiscal tightening and expensive financing acts as a drag on growth. By year 5, aggregate consumption is lower, private investment slows, and output in the formal and non-agriculture informal sectors is depressed. These results are consistent with broader evidence that high public borrowing in a small economy can crowd out the private sector and dampen growth, especially when much of the borrowing is domestic, siphoning funds from local credit markets (Adam and Bevan, 2005; Agénor and Montiel, 2015). Interest rates on domestic government debt would likely rise in this scenario, providing attractive low-risk returns to lenders but increasing costs for private borrowers.

The public debt path in this scenario becomes precarious. The debt-to-GDP ratio climbs more rapidly due to the new loans, and debt service as a share of revenue spikes. By design, the government in this scenario does not undertake major tax base expansion, so the debt service must be met largely by expenditure cuts, and a limited increase in the GST. Liberia's limited space to absorb shocks in its debt metrics would be tested severely as a permanent aid loss is exactly the kind of shock that could push Liberia into debt distress if met solely with non-concessional borrowing.

In the medium term, the government is forced to initiate stringent fiscal consolidation to prevent an explosive debt path. The GST hike and transfer cuts are needed to bring the primary deficit in line with what available financing, now less grants, can cover. The deficit is constrained by what can be financed through domestic and market borrowing, and as those options become too costly, fiscal stance must be contractionary. Even with consolidation, debt remains higher and more vulnerable to shocks, increasing risk of a debt crisis. While Liberia's external debt is mostly concessional (IMF, 2024), shifting to non-concessional borrowing could quickly aggravate risks of fiscal sustainability. Any short-run gains in continuity of public investment are offset by the accumulation of debt and the subsequent need for harsh fiscal measures to restore fiscal sustainability.

5.2 Distributional Impacts

The burden of adjustment in the non-concessional financing scenario falls disproportionately on lower-income households, making the outcome regressive. There are several channels for this regressive impact. First, the indirect tax increase (GST) is borne by consumers and tends to be relatively harsher on poor households, who spend a larger share of their income on consumption. Second, the cuts to government transfers and subsidies directly reduce income or increase costs for many at the lower end of the income distribution. In our simulation, the bottom deciles see much slower income growth than under the baseline, as a result of these measures (see Figure A.7). Third, as noted, the contraction in employment particularly affects informal and unskilled workers; when overall demand falls, it is often the most vulnerable workers who lose jobs or see their earnings decline.

Meanwhile, upper-income households experience a relative advantage in this scenario. They are more likely to hold government bonds or have savings in domestic banks, so they benefit from higher interest yields as the government borrows more domestically. These interest earnings help offset the richer households' share of the GST increase (and they benefit less, proportionally, from subsidies so they are less hurt by their removal). The net result is that both inequality and poverty worsen significantly compared to the baseline (see, respectively, Figure A.8, and Figure A.9). We estimate that under this scenario, the Gini coefficient rises to about 0.45 (versus 0.35 baseline) in the medium term. Income growth for the poorest decile drops to roughly 4.4 percent annually (much lower than the 8 percent+ under baseline), while the top decile's income grows around 1.9 percent per year.

The policy response of higher consumption taxes and transfer cuts amplifies existing disparities. It hits disposable incomes at lower income deciles, while the upper end of the distribution not only better withstands the taxes but also gains new income from lending to the public sector. This pattern is consistent with general findings that fiscal adjustment measures can be regressive in the absence of targeted mitigation (Woo et al., 2017). This scenario shows that if Liberia were to address aid shortfalls through offsetting non-concessional borrowing and absorb the fiscal tightening that comes with it, it would likely reverse the progressive gains seen in the baseline, undermine poverty reduction efforts and could exacerbate social tensions, given the stark increase in inequality.

6 Domestic Revenue Mobilization

The second aid-cut scenario explores a more balanced policy response: the government uses initial borrowing to smooth the shock of the aid cutoff but concurrently implements an ambitious domestic revenue mobilization (DRM) strategy to replace aid inflows over time. In this scenario, the permanent aid reduction is partially offset in the medium term by external and domestic borrowing, complemented over the longer term by major increases in domestic revenue collection. The rationale is that raising substantial new revenue, through tax reforms, cannot be done immediately. It requires administrative capacity and gradual broadening of the tax base needing some interim deficit financing (debt) to maintain public investment in the early years.

However, unlike the previous scenario, here the government actively works to expand its tax base and improve revenue such that domestic revenues have risen enough to largely fill the gap left by lost aid. This strategy is consistent with policy advice frequently given to aid-dependent countries to develop domestic revenue sources to eventually wean off aid, while using borrowing carefully as a bridge (Gang and Khan, 1991; Pack and Pack, 1993; Bräutigam and Knack, 2004). In Liberia's case, the authorities have articulated a Domestic Revenue Mobilization Strategy (with support from IMF technical assistance) focusing on improving tax administration and scaling back generous exemptions. This scenario can be viewed as a stylized implementation of such a strategy in response to an aid shock. It is effectively a *"borrow-and-reform"* approach: borrow in the short run to avoid disrupting spending, and simultaneously push through tax reforms that increase revenues for the long run.

6.1 Macroeconomic Outcomes

During the first few years after the aid cut, this scenario resembles the previous scenario in that the government resorts to external commercial loans and domestic borrowing to keep public investment projects funded. This prevents an abrupt fiscal contraction immediately after aid is cut. However, the difference is that, from the outset, the government embarks on significant fiscal reforms aimed at boosting revenue. In our design, the government gradually implements a package of tax measures and new fees. In the medium term, these measures begin to bear fruit, partially replacing the need for debt. By year 5, although public debt has still increased, with borrowing unavoidable early on, its path stabilizes as domestic revenues rise. We assume that by year 10 and beyond, the revenue gains substantially reduce the financing gap. Quantitatively, the scenario targets an eventual increase in total tax revenue by about 13 pp of GDP (relative to 2025 GDP) once all measures are fully phased in. This is an extremely ambitious uplift – essentially doubling Liberia's tax-to-GDP ratio (which in recent years has been about 16 percent of GDP (IMF, 2024). Such a large increase would require broadening the tax net far into the informal sector and improving compliance. Our simulation acknowledges this by phasing the changes gradually. Accordingly, the scenario is not one in which Liberia instantaneously raises revenue by 13 percent of GDP; it is a paced reform path over roughly a decade, with the cumulative gain materializing only over time.

The DRM strategy in the scenario includes two major components. The first involves broadening the GST base in agriculture and the informal sector. The goal is to raise the efficiency of consumption tax collection (C-efficiency) by about 6.5 percentage points over ten years. Given that the informal sector constitutes roughly 39 percent of GDP and 60 percent of employment (The World Bank, 2023*a*), expanding taxation into this sector is challenging, but even partial success would significantly boost revenue. The second involves introducing infrastructure user fees to help fund maintenance and operations of public investments. The scenario assumes a phased implementation of user fees that eventually generate an additional 6.5 pp of GDP in revenue over ten years. This not only raises revenue but also improves efficiency by pricing the use of infrastructure. We recognize that both GST base broadening into the informal sector and infrastructure user fees can be regressive if poorly designed, since they fall on consumption and disproportionately affect lower-income households. In the model, government transfers partly offset this burden. The paper explores only a limited set of scenarios; other policy combinations such as better-targeted transfers, public financial management reforms, or removing inefficient subsidies could further ease the adjustment and deserve separate analysis.

Together, these measures are designed to gradually replace aid with domestic resources. The government still relies on non-concessional financing in the interim. The simulation results indicate that the DRM scenario still incurs a medium-term adjustment cost. By year 5, consumption is about 3.1 percent lower and real GDP 0.7 percent lower than baseline (see Figure A.5a). This mild contraction reflects that even though borrowing prevented an initial collapse, the required fiscal tightening (tax hikes and some spending restraint) to steer debt onto a sustainable path is still costly. Both formal and informal sector output fall slightly below baseline in the medium term, and growth of informal labor incomes lags (about 0.9 percent lower by year 10). While the economy still goes through an adjustment, it is less severe than in the borrowing-only scenario. The peak-to-trough decline is smaller because the pain is spread between some borrowing and some taxation, rather than falling entirely on one mechanism. There is also a timing element where debt financing early on delays part of the adjustment, avoiding a sudden shock.

Over the longer term, however, the benefits of the DRM strategy become evident. By design, once domestic revenue replaces foreign aid, the government can maintain public investment without accumulating debt. In our simulation, after about a decade the additional revenue begins to significantly reduce new borrowing needs. Public debt stabilizes and eventually declines as a share of GDP, containing debt-servicing costs (see Figure A.5b). Over the long term, the economy recovers and convergences back toward the baseline path. Consumption and investment rebound, and real GDP growth improves with a more sustainable fiscal outlook. The increased tax revenue helps self finance public investment programs. As the labor market absorbs the tax measures and as productivity gains from sustained investment materialize, sectoral outputs and real wages rise across the economy in the long run. However, the long-run outcome under this scenario is still worse than in the baseline indicating enduring scaring from the aid shock, though a smaller one than it would under a less proactive response.

From a fiscal sustainability perspective, this combined strategy offers a viable, if difficult, path. By broadening the tax base and raising revenues, Liberia can alleviate its need to borrow and lower future debt service burdens. This scenario confirms that pairing moderate borrowing with aggressive revenue measures can eventually restore a sustainable fiscal balance. However, the scenario's feasibility depends on strong political will and administrative reform. Achieving a 13 percentage point increase in the revenue-to-GDP ratio would be challenging as it likely entails deep reforms in tax administration. This scenario similarly requires the government to take challenging actions like raising the GST rate and cutting government transfers. In our framework, these adjustments are included as part of ensuring fiscal credibility in the early years of the DRM scenario. While these adjustments contribute to a contraction in consumption initially, the government prevents a debt spiral and gradually regains fiscal independence.

6.2 Distributional Impacts

This mixed financing approach leads to more moderate distributional effects compared to the borrowing-only scenario as the adjustment burden is spread more evenly across the population and over time. That said, all simulated aid-cut responses remain inferior to the no-aid-cut baseline; the ranking is about damage limitation rather than improvement over the baseline. However, there are still adverse impacts on lower-income households in the medium term, because base broadening will increase the cost of living for everyone, including the poor. The key difference is that the magnitude of the impact is smaller. The simulation results show the Gini coefficient rises to about 0.40 under this scenario, higher than the baseline (0.31) but about the same as the pure borrowing case (see Figure A.8a). Income growth for the bottom deciles still takes a hit. Over the medium term, we estimate the bottom two deciles see their income growth rates about 15.7 percentage points and 8.9 percentage points lower than in the baseline path. Over the medium term, top decile income growth in the DRM scenario is about 2 percent or roughly 1.5 percentage points above baseline income growth for the decile.

What explains this more equitable distribution? Primarily, by diversifying the fiscal response, the government avoids placing the entire adjustment load on consumption taxes and spending cuts. Instead, part of the burden is shifted to broader taxation, including potentially more direct or progressive taxes. For instance, the introduction of user fees can be somewhat progressive if designed properly. The result is that inequality still increases since fiscal contraction tends to hurt the poor more, but less so. Another way to view this is through long-run outcomes. Across steady states, the results suggest that the scenario with DRM continues to outperform the one without.

If we assume stable conditions after the initial adjustment period, inequality under the DRM scenario gradually improves, with the Gini falling to approximately 0.28 in the unconstrained projection. This long-run estimate is more plausible than the corresponding NCF or uncompensated-cut values because the DRM path brings the economy closer to the baseline, where the distributional assumptions are better grounded. Still, any long run Gini point estimates should be treated with caution. The sensitivity exercises in the appendix confirm that the DRM scenario's long-run Gini remains well below the other aid-cut responses under all specifications tested. For the borrowing-only case, we do not emphasize literal half-century Gini point estimates. The key finding is comparative: under persistent debt-service pressure, the borrowing-only response remains substantially more regressive than the DRM path, a result that holds across all the bounded sensitivity exercises reported in the appendix (see also Figure A.8b).

In our extended simulation, we see that once domestic revenues are up and debt is under control, the government in the DRM scenario can start reallocating some resources to government transfers again, gradually reversing some of the earlier inequality increases. Moreover, as the economy grows on a more stable foundation, incomes at the bottom start rising faster. We project bottom-decile income growth improves by 2–3 percentage points in the long run. In contrast, the borrowing-only strategy without DRM leaves the government perpetually struggling with high debt service, necessitating deeper and more distortionary adjustments that further hurt the poor. The simulation results show bottom decile income growth significantly lower by 8.6 percent relative to baseline. This stark divergence reinforces the policy message that combining fiscal adjustment with domestic revenue reforms leads to a considerably more equitable outcome over time than relying on borrowing alone. By widening the revenue base and maintaining investment, the DRM approach creates conditions for shared growth in the future, even though the short-term might still be painful for low-income groups. While neither scenario is as good for the poor as having no aid cut at all, prioritizing domestic revenue mobilization is decidedly less regressive and offers a path back toward improving both poverty and inequality, whereas the borrowing-only strategy entrenches a regressive income distribution (see Figure A.8b and Figure A.9b).

7 Uncompensated Aid Cut

Finally, we consider a worst-case scenario in which the aid cut is met with no compensatory financing. The government simply absorbs the shock by drastically cutting public investment and spending in line with the loss of aid. In this scenario, there is no access to additional concessional financing and domestic revenue efforts yield only minimal gains. The authorities are essentially forced to run a smaller budget with sustained reduction in development spending to match the permanent drop in external grants. While this is an extreme scenario, it is useful to examine because it shows the full impact of an aid withdrawal when no offsetting funds are to be found.

7.1 Macroeconomic Outcomes

The macroeconomic consequences of an uncompensated aid cut are severe and lasting. With grant revenues gone and no alternative financing, the government's budget constraint forces it to slash expenditures, especially capital investments to avoid unsustainable deficits. By assumption, key public investment projects in infrastructure, education, health, etc., are scaled back or halted to align spending with available financing.

Over the first five years, we project a cumulative contraction in the economy relative to the baseline. By year 5, real GDP is about 1.4 percent lower than it would have been with continued aid, and consumption growth is 2.7 percentage points lower (Figure A.6a). Formal sector output declines by more than 1 percent relative to baseline, reflecting the direct hit to the modern sector. Private investment also drops sharply and remains subdued throughout the projection period. As public investment often crowds in private investment by providing complementary infrastructure, scaling back public investment can trigger a vicious cycle where the private sector also retreats with entrepreneurs seeing fewer opportunities in an environment of deteriorating infrastructure and aggregate demand weakness.

Labor market conditions deteriorate as well. With public investment scaled back and a contracting private sector, job creation slows markedly. We find that real wage growth stagnates across all sectors, meaning workers see little to no income growth over time. Labor mobility declines, particularly in the informal sector, as workers find it harder to move from low-productivity rural work to higher-productivity urban or formal jobs. As a result, by year 10, income growth for workers in agriculture and other informal activities is around 2.3 percentage points lower than it would have been in the baseline. The overall effect is a broad-based economic stagnation with the government essentially in fiscal autarky, and private investment contracting. The cumulative effect is seen in lower future growth potential. By the end of our 20-year horizon, the level of GDP is significantly below the baseline path, and the economy's productive capacity has suffered.

An additional strain comes from the fact that existing debt obligations and essential maintenance still need to be paid out of a now-smaller budget (Figure A.6b). The government cannot simply abandon debt service without triggering default. Therefore, in the absence of new aid or concessional loans, a larger share of the meager revenues must go to servicing existing debt. Also, infrastructure that was built prior to the aid cut (roads, power plants, etc.) requires maintenance spending just to keep from falling apart. We assume that the government maintains basic recurrent expenditures to prevent degradation of the capital stock. These legacy costs eat up fiscal space, leaving very little room for new investments that improve growth. This leads to a low-level equilibrium for the economy typified by low investment, low productivity growth, and persistent poverty. The results illustrate a compounding cycle where low public spending leads to weak private sector response and stagnant or declining incomes, which further limits domestic revenue reinforcing low public spending. Breaking out of this cycle without external support would be exceedingly difficult.

7.2 Distributional Impacts

Unsurprisingly, this scenario produces the worst distributional outcomes of all, with a dramatic surge in inequality and poverty. With no compensatory measures, the full brunt of the aid cutoff is transmitted to households. Public investment in education would have disproportionately benefited lower-income groups. Similarly, rural roads, and clinics directly help poorer communities and also employ workers from those areas. When such investment is withdrawn, the poor lose not only services and infrastructure but also income opportunities. In the medium term, the Gini coefficient remains at 0.41 relative to 0.31 at baseline, but not significantly worse than the other scenarios, as the full extent of adverse impacts has not been built into the dynamics. Income growth in the bottom decile is 17.2 percentage points below the baseline, while income growth in the upper decile is about 1.5 percentage points above the baseline (see Figure A.7a). The impact on poverty headcount is also not significantly worse than in the other alternative scenarios in the medium term, while worse than the baseline. Poverty headcount levels in this scenario climbs to 44.4 percent, relative to 31.6 percent in the baseline and 33.9 percent in initial headcount (see Figure A.9a).

Over the long-run, the income distribution shifts leftward, leaving many worse off than in the baseline, but the bottom suffers relatively more (see Figure A.9b). We do not report literal long-run Gini point estimates for this scenario. The important finding is that the uncompensated-cut scenario produces the worst inequality and poverty outcomes of all the scenarios considered. The exact level of the 50-year Gini depends on assumptions about how growth differentials across deciles persist over time, and the appendix sensitivity exercises explore this in detail. More troubling, median income growth becomes negative by about 1.6 percentage point below baseline indicating that not just the poorest, but the average household is experiencing welfare losses in absolute terms. The income growth for the two lowest deciles is reduced by 10.6 and 8.1 percentage points, respectively, compared to the baseline. This large loss implies, for example, that instead of a poorest decile's income growing at 3.9 percent per year, it sees a contraction of about 6.7 percent.

The mechanism behind this shift can be described as a form of *negative structural transformation*. While structural transformation traditionally drives development by shifting labor from low-productivity sectors to higher-productivity ones and reduces poverty, here, the withdrawal of development spending sets off the reverse. Since education investment is cut, the supply of skilled labor diminishes over time. As infrastructure projects are reduced, job creation in modern sectors stalls, leaving fewer pathways for productivity improvement of low-skill labor. Historically, even small increases in education spending in Liberia have been linked to improved earnings for lower deciles (The World Bank, 2023*b*). Meanwhile, skilled workers face less competition and potentially enjoy higher wage premiums due to the scarcity of skilled labor. At the steady state, top decile income grows by about 7.7 percentage points, indicative of the premium to capital and labor. The results point to a widening wage gap between skilled and unskilled workers in the long run with less new public investment in human capital, further entrenching inequality.

Another perspective comes from examining fiscal policy's role in redistribution. In the baseline, fiscal policy, including aid-funded spending, helps redistribute resources or at least invests in broadly shared goods. In the worst-case scenario, it becomes neutral or even regressive because most resources go to debt service and essential costs. Fiscal contraction tends to weigh more heavily on the poor, as observed. Comparing policy responses shows this pattern clearly: in both borrowing-only and DRM scenarios, the combination of fiscal contraction and high-cost financing hurts lower deciles while benefiting upper deciles to some extent. In the uncompensated cut scenario, where spending cuts are maximized, the distributional impact is extreme. Even in milder cases, when aid cuts are offset by financing or partial revenue measures, similar dynamics appear: lower incomes decline while upper incomes may gain through interest earnings or lighter relative tax burdens. The difference is in degree. Over time, prolonged underinvestment compounds these disparities.

A permanent, uncompensated aid cut would push Liberia's economy into prolonged stagnation and extreme inequality. It vividly illustrates the importance of development aid in supporting not just growth, but inclusive growth. The loss of aid without any alternative creates a self-reinforcing downward spiral of low investment and widening disparities. This is arguably the most alarming outcome, underscoring why policymakers strive to avoid such scenarios at all costs, either by securing continued aid or, if that fails, by finding other financing or implementing reforms as in the previous scenarios.

8 Conclusion

The model-based analysis demonstrates that the choice of policy response determines whether an aid cut leads to a temporary setback or a deep, lasting regression within the modeling framework. Across all the robustness checks reported in the appendix, including an alternative GIC specification, perturbed initial distributions, and bounded long-run projections, a phased DRM strategy dominates both pure non-concessional borrowing and uncompensated cuts on both macroeconomic and distributional grounds. Within the model, the strategy adopted in response to a permanent aid cut shapes the economic and social outcomes. The simulations indicate that combining fiscal adjustment with phased domestic revenue mobilization produces the most favorable macroeconomic and distributional trajectory, supporting fiscal sustainability, and equity while reducing aid dependence over time.

Such a strategy would require reforms including improving tax collection, broadening the tax base, and rationalizing expenditure. In the model, social protection is captured through government transfers, so the recommendation to protect the poor during adjustment is consistent with the framework and amounts to preserving or retargeting those transfers during the transition. These efforts should be paired with measures to protect the poor during the transition, for instance, targeted social safety nets and maintaining critical pro-poor spending even as overall expenditure tightens.

The model indicates that heavy reliance on non-concessional borrowing is a high-risk path. While borrowing may prevent an immediate collapse in investment, it creates unsustainable debt and shifts adjustment costs into the future, likely in a more painful form. Like in most LICs limited borrowing space makes expensive debt particularly dangerous, as it would worsen inequality and fiscal strain. While the model results suggest that seeking additional concessional support and improving expenditure efficiency would impose fewer economic burdens, there are options we do not explore for instance, cutting wasteful spending, and improving public financial management may also generate credibility gains by improving tax compliance, lowering perceived waste, and making scarce fiscal resources more productive. These channels are important but are not fully modeled here. These options impose fewer economic burdens than commercial borrowing or sharp tax increases, as shown by comparative fiscal space analyses.

The simulations underscore that, within the model, maintaining investments in human capital and social protection helps contain rising inequality even under fiscal stress. The sequencing of adjustment also matters: the model suggests that rationalizing expenditure before reducing productive investments softens the distributional impact. More broadly, dollarization, weak monetary transmission, and banking-sector dynamics are all highly relevant in Liberia but lie outside the scope of this real-sector model. The analysis illustrates a broader point for aid-dependent economies: within the class of models considered, building fiscal resilience through stronger domestic revenue mobilization and careful debt management produces more favorable macroeconomic and distributional outcomes than either pure borrowing or uncompensated expenditure cuts. The model results are analytical and should be interpreted in light of the simplifying assumptions inherent in the framework, including the real-sector focus and the absence of banking, and monetary transmission channels noted above.

References

Acemoglu, D. (2009), *Introduction to Modern Economic Growth*, Princeton University Press, Princeton, NJ.

Adam, C. S. and Bevan, D. L. (2005), 'Fiscal deficits and growth in developing countries', *Journal of Public Economics* **89**(4), 571–597.

Agénor, P.-R. and Montiel, P. J. (2015), *Development Macroeconomics*, fourth edn, Princeton University Press.

Atkinson, A. B. (1970), 'On the measurement of inequality', *Journal of Economic Theory* **2**(3), 244–263.

Barro, R. J. and Sala-i Martin, X. (1992), 'Convergence', *Journal of Political Economy* **100**(2), 223–251.

Benhabib, J. and Bisin, A. (2018), 'Skewed wealth distributions: Theory and empirics', *Journal of Economic Literature* **56**(4), 1261–91.

Bräutigam, D. A. and Knack, S. (2004), 'Foreign aid, institutions, and governance in sub-saharan africa', *Economic Development and Cultural Change* **52**(2), 255–285.

Buffie, E., Adam, C., Zanna, F., Balma, L., Tessema, D. and Kpodar, K. (2022), 'Public Investment and Human Capital with Segmented Labor Markets', *Oxford Economic Papers* **76**(1), 162–186.

Gang, I. N. and Khan, H. A. (1991), 'Foreign aid, taxes and public investment', *Journal of Development Economics* **34**(1), 355–369.

Gastwirth, J. L. (1972), 'The estimation of the lorenz curve and gini index', *The Review of Economics and Statistics* pp. 306–316.

IMF (2024), Liberia: Request for a 40-Month Arrangement Under the Extended Credit Facility-Press Release; Staff Report; Staff Supplement; and Statement by the Executive Director for Liberia, IMF Staff Country Reports 2024/309, International Monetary Fund.

Kakwani, N. C. and Podder, N. (1973), 'On the Estimation of Lorenz Curves from Grouped Observations', *International Economic Review* **14**(2), 278–292.

Kennickell, A. (2024), 'Chasing the tail: A generalized pareto distribution approach to estimating wealth inequality', *The Review of Income and Wealth* **71**(1), e12696.

La Porta, R. and Shleifer, A. (2014), 'Informality and Development', *Journal of Economic Perspectives* **28**(3), 109–26.

Lewis, A. (1954), 'Economic Development with Unlimited Supplies of Labour', *The Manchester School* **22**(2), 139–191.

LISGIS (2016), Liberia - Household Income and Expenditure Survey 2016, Technical report, Liberia Institute of Statistics and Geo-Information Services, Monrovia, Liberia.

MoFDP (2025), 'Government of the Republic of Liberia National Budget for FY2025'.
URL: *https://www.mfdp.gov.lr/index.php/docs/the-national-budget*

Pack, H. and Pack, J. R. (1993), 'Foreign aid and the public sector', *Review of Economics and Statistics* **75**(2), 258–265.

Ravallion, M. and Chen, S. (2003), 'Measuring pro-poor growth', *Economics Letters* **78**(1), 93–99.

The World Bank (2023*a*), 'Liberia Country Economic Memorandum'.

The World Bank (2023*b*), Liberia Poverty Assessment: *Towards a more Inclusive Liberia*, Technical report, Liberia Institute of Statistics and Geo-Information Services, Washington, D.C.

The World Bank (2024), Macro Poverty Outlook for Liberia: October 2024, Technical Report 194115, World Bank.

The World Bank (2025), 'Net Official Development Assistance Datafrom World Bank Open Data'.
URL: *https://data.worldbank.org/indicator/DT.ODA.ODAT.GN.ZS*

Woo, J., Bova, E., Kinda, T. and Zhang, Y. S. (2017), 'Distributional consequences of fiscal adjustments: What do the data say?', *IMF Economic Review* **65**(2), 273–307.

A.1 Main Result Figures

Figure A.1: A three-tier CES preference structure

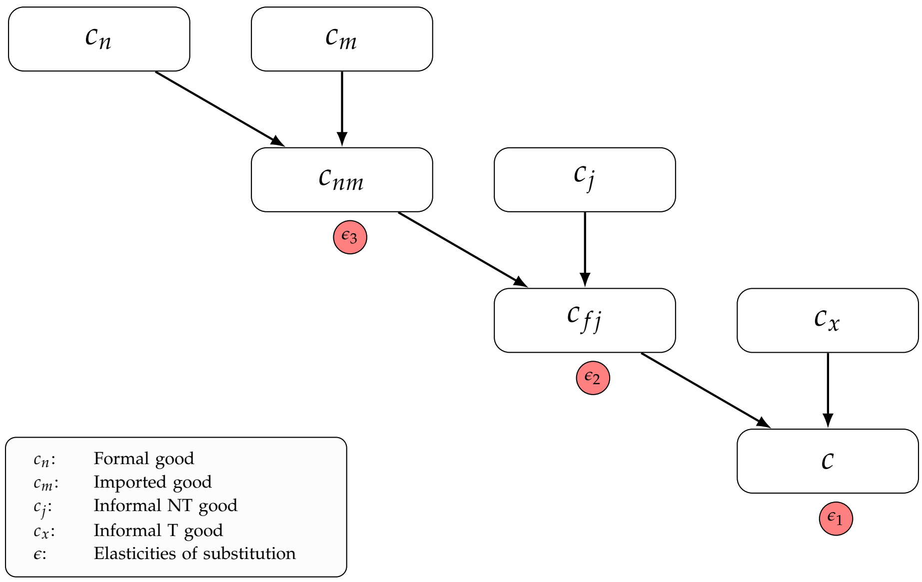


Figure A.2: Preference ordering possibilities

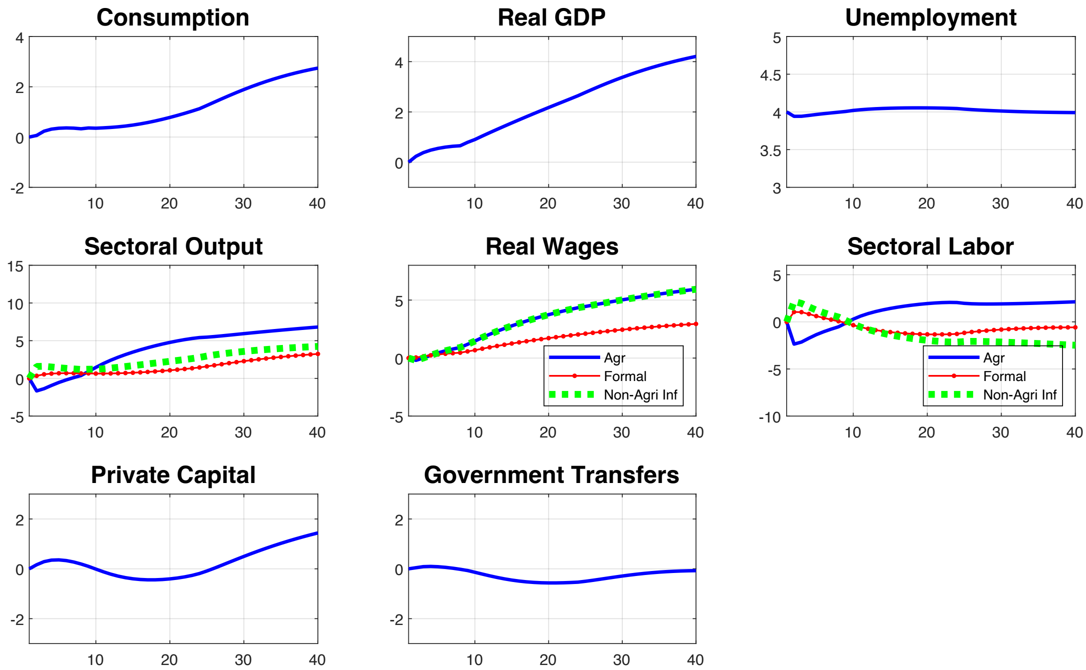
1. $f(f(f(c_m, c_n), c_x), c_j)$
2. $f(f(f(c_m, c_n), c_j), c_x)$
3. $f(f(f(c_m, c_x), c_n), c_j)$
4. $f(f(f(c_m, c_x), c_j), c_n)$
5. $f(f(f(c_m, c_j), c_n), c_x)$
6. $f(f(f(c_m, c_j), c_x), c_n)$
7. $f(f(f(c_n, c_x), c_m), c_j)$
8. $f(f(f(c_n, c_x), c_j), c_m)$
9. $f(f(f(c_n, c_j), c_m), c_x)$
10. $f(f(f(c_n, c_j), c_x), c_m)$
11. $f(f(f(c_x, c_j), c_m), c_n)$
12. $f(f(f(c_x, c_j), c_n), c_m)$

Table A.1: Calibration of the Model

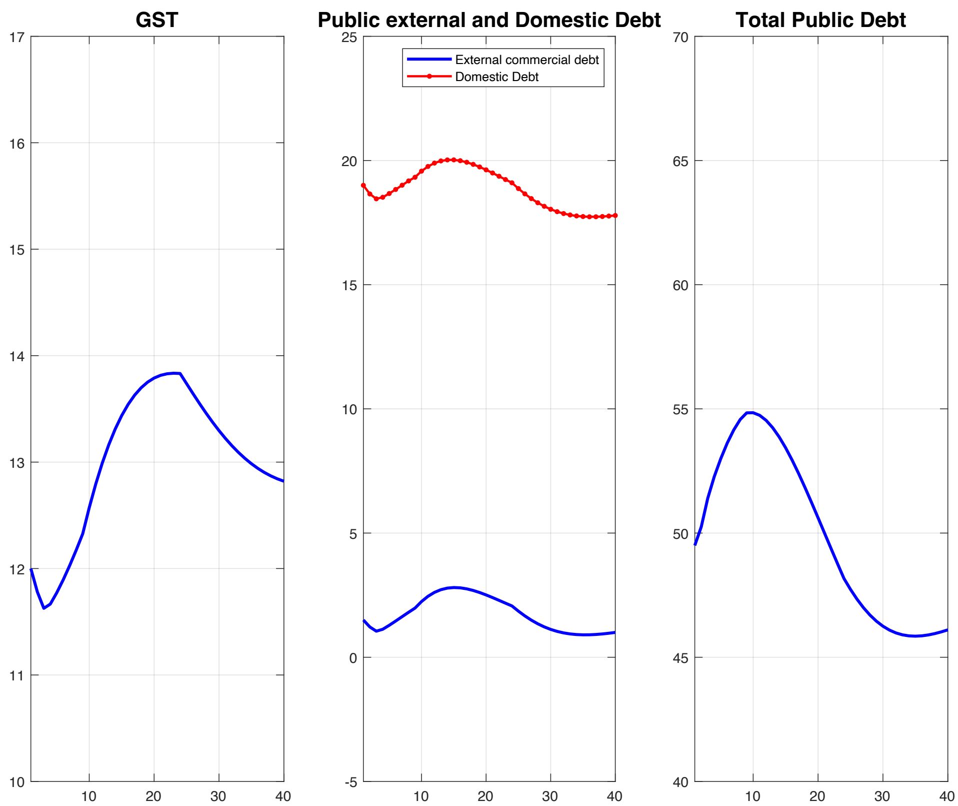
Parameter/Variable	Value in Base Case
Consumption shares (γ_m, γ_n, γ_j, γ_x)	$\gamma_n = 0.40$
	$\gamma_m = 0.10$
	$\gamma_j = 0.20$
	$\gamma_x = 0.30$
Intertemporal elasticity of substitution (τ)	0.40
Elasticity of substitution (good x and goods n, j, m) (ϵ_1)	0.5
Elasticity of substitution (formal and informal traded goods) (ϵ_2)	0.5
Elasticity of substitution (imported consumer good and formal good) (ϵ_3)	0.5
Wages (formal and informal sectors) (w_s, w_n, w_j)	$w_s = 3$
	$w_n = 1$
	$w_j = 0.6$
Factor shares in the formal sector (α_n, θ_n)	$\alpha_n = 0.50$
	$\theta_n = 0.30$
Factor shares in the informal sector (α_j, θ_j)	$\alpha_j = 0.20$
	$\theta_j = 0.20$
Factor shares in agriculture (χ, α_x, θ_x)	$\chi = 0.30$
	$\alpha_x = 0.20$
	$\theta_x = 0.05$
Depreciation rates (δ, δ_z, δ_b, δ_u)	$\delta = \delta_z = \delta_b = \delta_u = 0.05$
Real interest rate on concessional loans (r_d)	0.013
Real interest rate on external commercial debt (r_{dc})	0.06
Trend growth rate (g)	0.023
Ratio of user fees to recurrent costs (f)	0.5
Consumption VAT rates (h, g_j, g_x)	$h = 0.20$
	$g_j = 0.30$
	$g_x = 0.10$
Taxes on profits, wages, and land rents (f_n, f_j, f_x, f_w, f_{wj}, f_{wx}, f_h)	$f_n = 0.15$
	$f_j = 0.03$
	$f_x = 0.02$
	$f_w = 0.12$
	$f_{wj} = f_{wx} = f_h = 0.01$
Efficiency of public investment (s)	1
Absorptive capacity constraint (ϕ)	0
Return on infrastructure (R_z)	0.20
Real interest rate on domestic bonds (r)	0.10
Real interest rate on foreign loans held by the private sector (r_f)	0.10
Interest elasticity of private capital flows (Γ)	1
Ratio of maintenance spending to GDP ($P_z m/GDP$)	0.01644
Ratio of infrastructure investment to GDP ($P_z i_z/GDP$)	0.06
Ratios of investment in education to GDP ($P_s i_b/GDP$, $P_s i_u/GDP$)	$P_s i_b/GDP = 0.028$
	$P_s i_u/GDP = 0.012$
Ratio of private foreign loans and concessional and non-concessional public external debt (b_f, d, dc) to initial GDP	$b_f/GDP = 0$
	$d/GDP = 0.32$
	$dc/GDP = 0.06$
Q-elasticity of investment spending (Ω)	2.5
Return on maintenance relative to new investment in infrastructure (R_{mz})	1
Share of new high-skill workers drawn from low-skill workers in sector $x - j$ (Δ_{xj})	$\Delta_{xj} = 0.80$
Fraction of newly created/vacant formal sector jobs filled by workers from sector $x - j$ (ξ)	$\xi = 0.5$
Unemployment rate (u)	0.12
Elasticity of the real wage in the formal sector with respect to the unemployment rate (g_3)	$g_3 = 0.1$
Real informal sector wage (g_2)	$g_2 = 0.5$
Cost shares of nontraded inputs in the production of capital goods (α_{ij}, α_{in}, $i = s, z, k$)	$\alpha_{kj} = \alpha_{zj} = 0.35$
	$\alpha_{kn} = \alpha_{zn} = 0.15$
	$\alpha_{sj} = 0.60$
	$\alpha_{sn} = 0.20$
Returns to education (R_u, R_b)	$R_u = 0.30$
	$R_b = 0.30$
Ratio of elasticities of sectoral output with respect to the stock of infrastructure (ψ_n/ψ_x, ψ_j/ψ_x)	1
Long-run targets for domestic debt (b_{target}) and external commercial debt (dc_{target})	$b_{\text{target}} = b_0$
	$dc_{\text{target}} = dc_0$
Division of fiscal adjustment between expenditure cuts and tax increases (λ)	0.5
Residual financing of the fiscal gap (λ_{dc})	0.30

Figure A.3: Baseline: Macroeconomic dynamics under uninterrupted aid flows

a *Macro and Sectoral Dynamics*



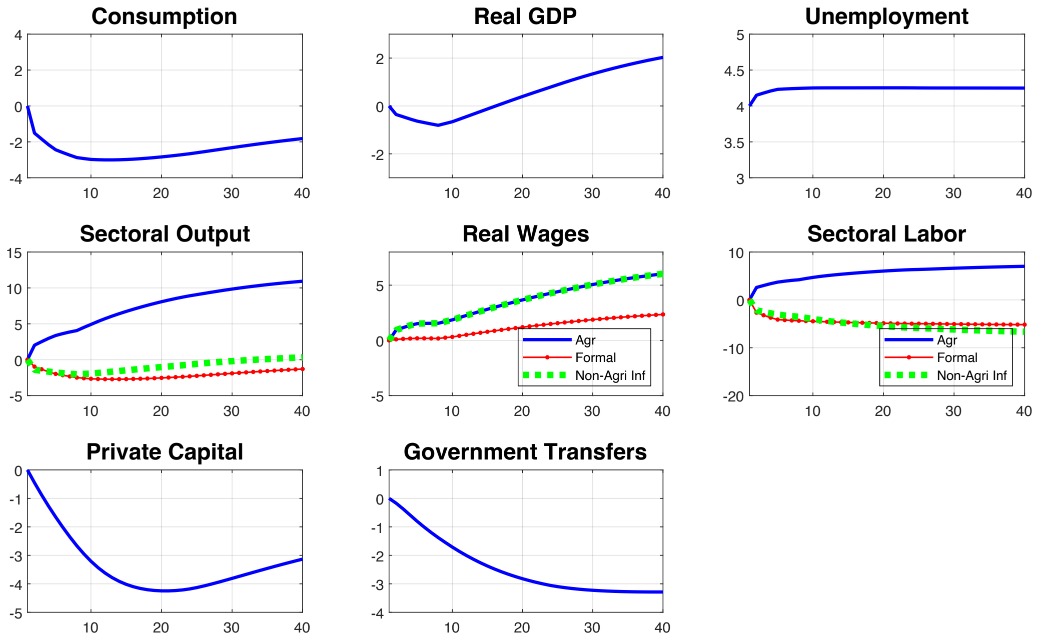
b *Fiscal Adjustment and Debt*



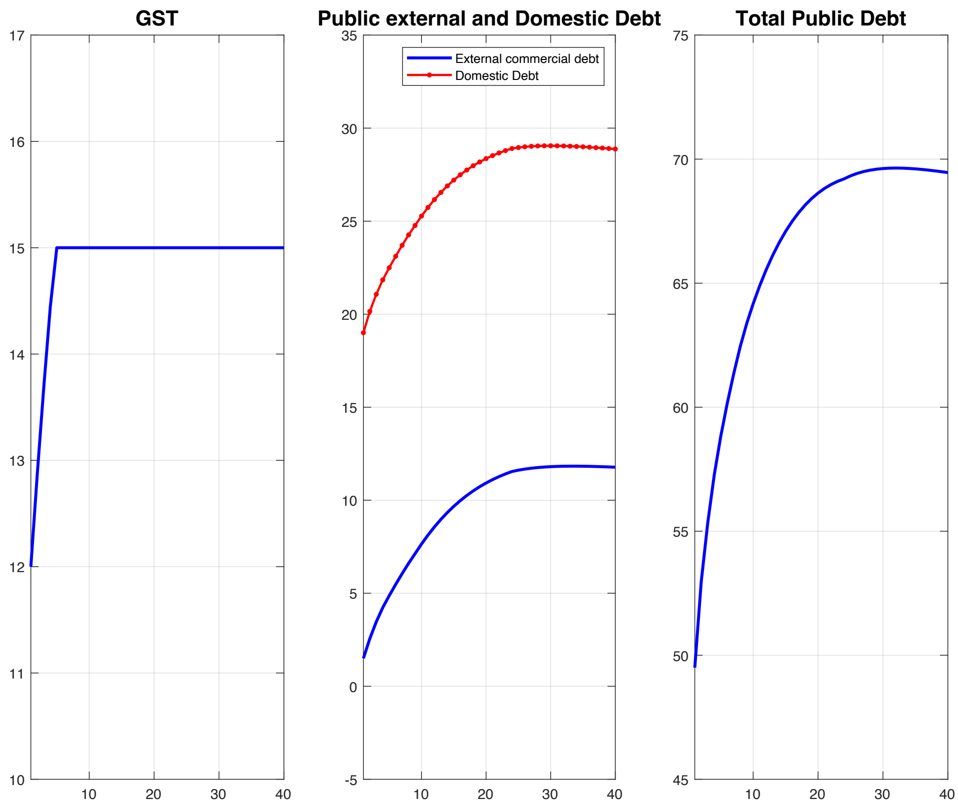
Notes: Unemployment and GST are in percent; debt variables in percent of GDP; all others as steady-state deviations.
Source: Authors' simulations.

Figure A.4: Macroeconomic dynamics under non-concessional financing

a Macro and Sectoral Dynamics



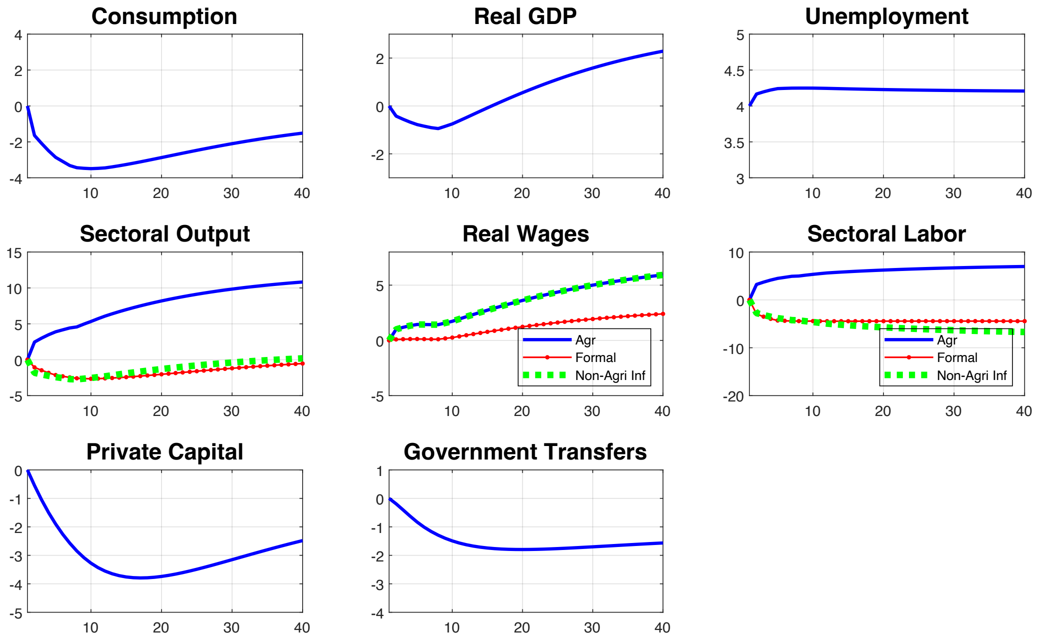
b Fiscal Adjustment and Debt



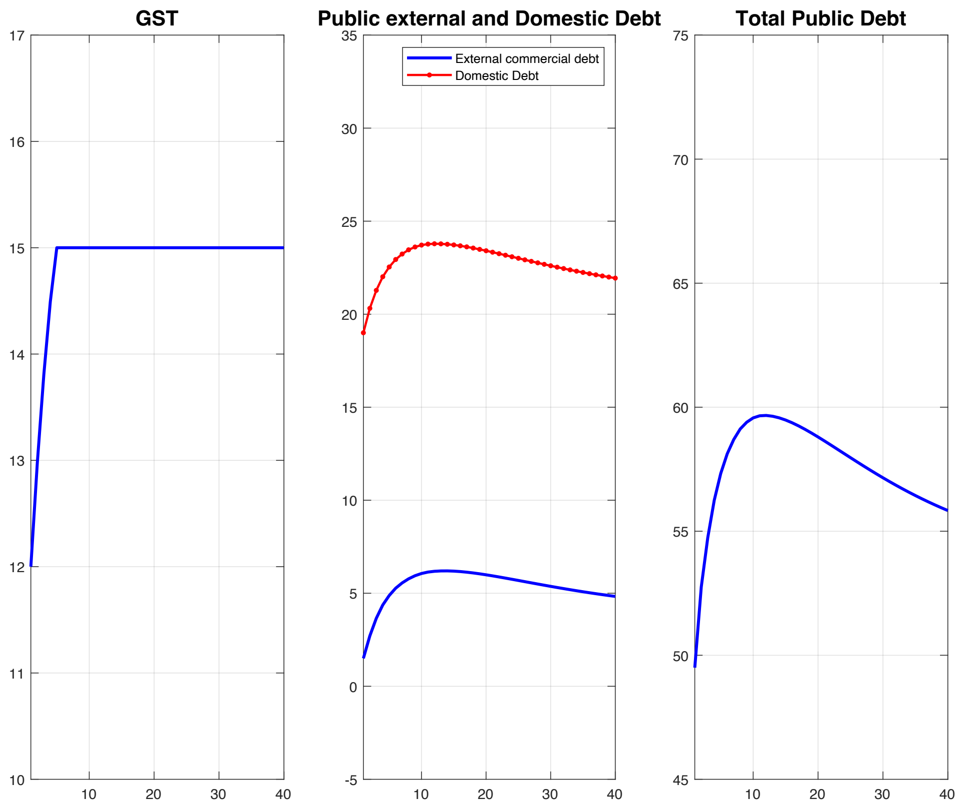
Notes: Unemployment and GST are in percent; debt variables in percent of GDP; all others as steady-state deviations.
Source: Authors' simulations.

Figure A.5: Macroeconomic dynamics under DRM

a *Macro and Sectoral Dynamics*



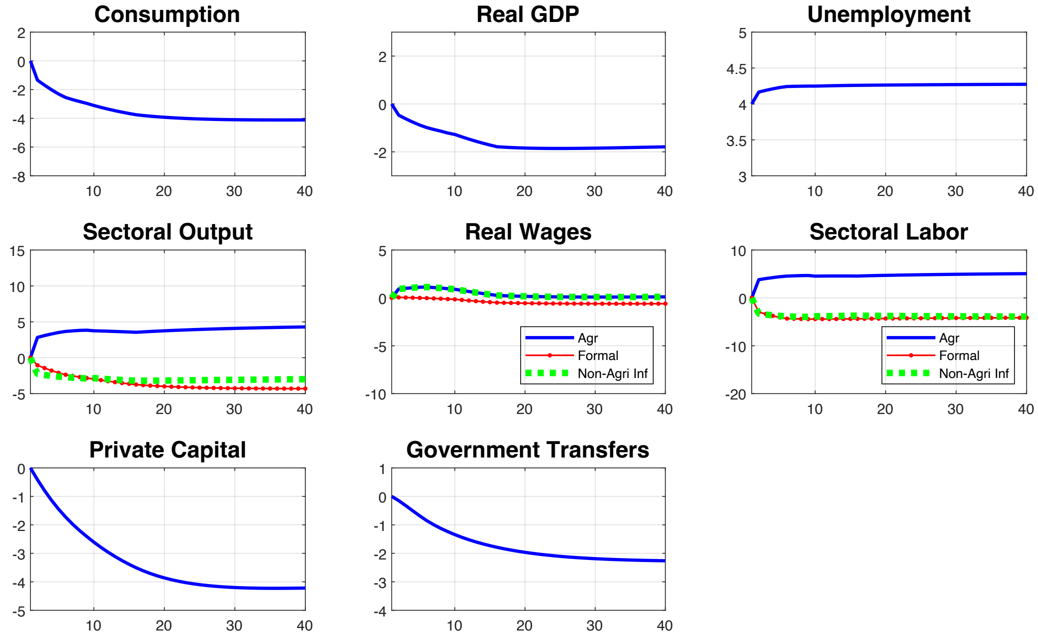
b *Fiscal Adjustment and Debt*



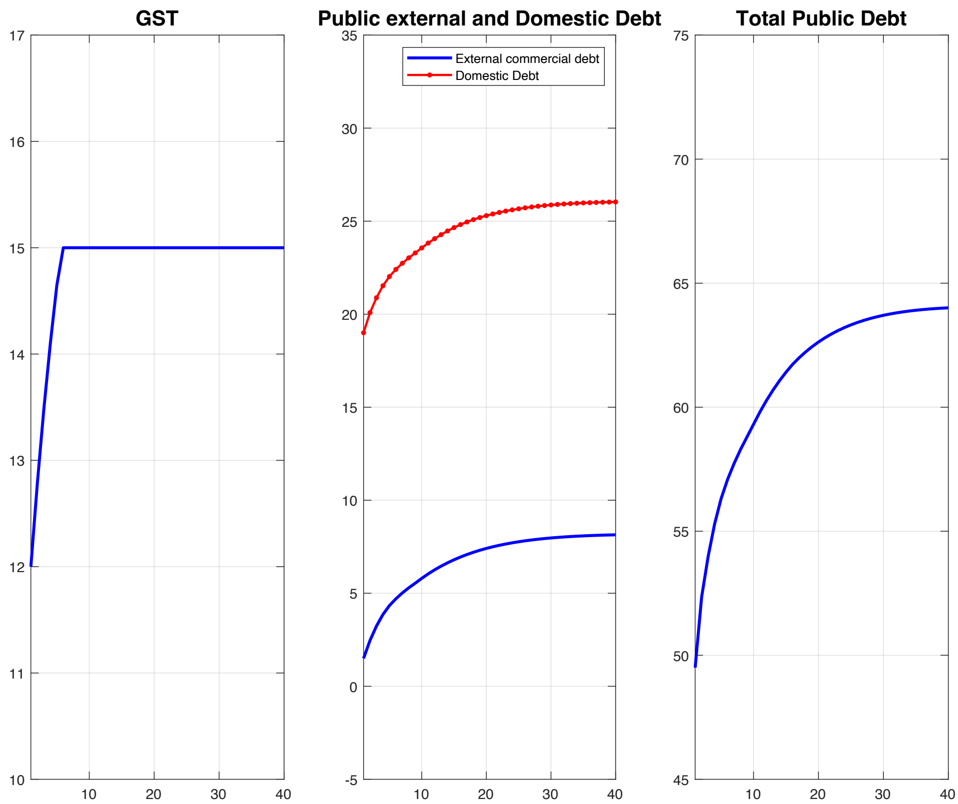
Notes: Unemployment and GST are in percent; debt variables in percent of GDP; all others as steady-state deviations.
Source: Authors' simulations.

Figure A.6: Macroeconomic dynamics under uncompensated cuts

a Macro and Sectoral Dynamics



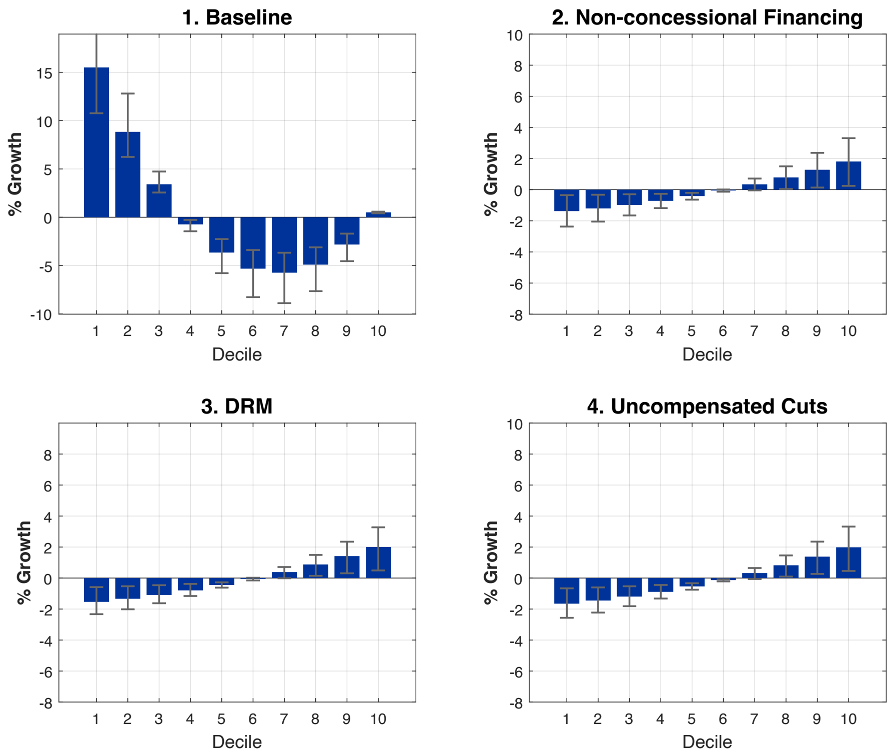
b Fiscal Adjustment and Debt



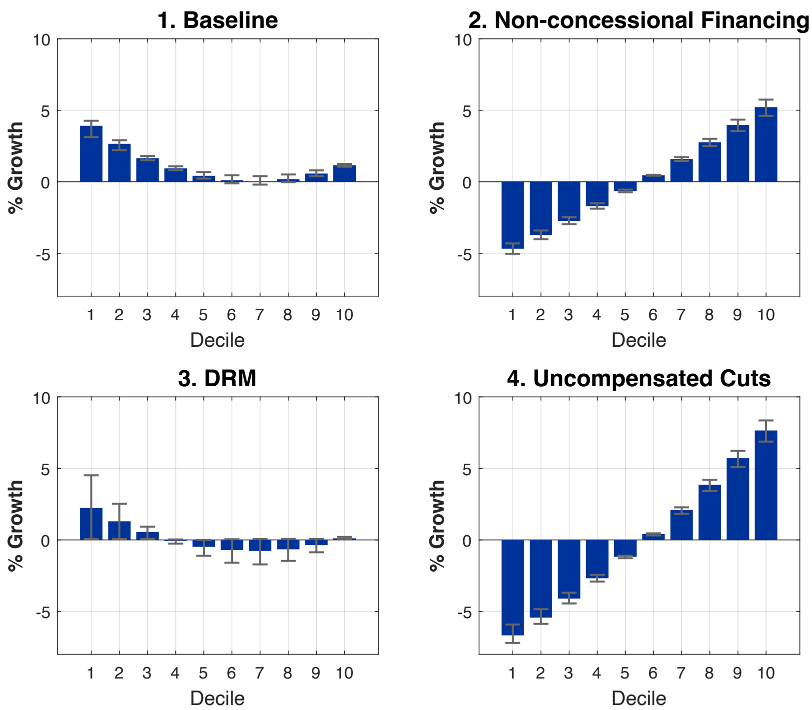
Notes: Unemployment and GST are in percent; debt variables in percent of GDP; all others as steady-state deviations.
Source: Authors' simulations.

Figure A.7: Income Growth by Decile

a *Average income growth by decile, medium term*



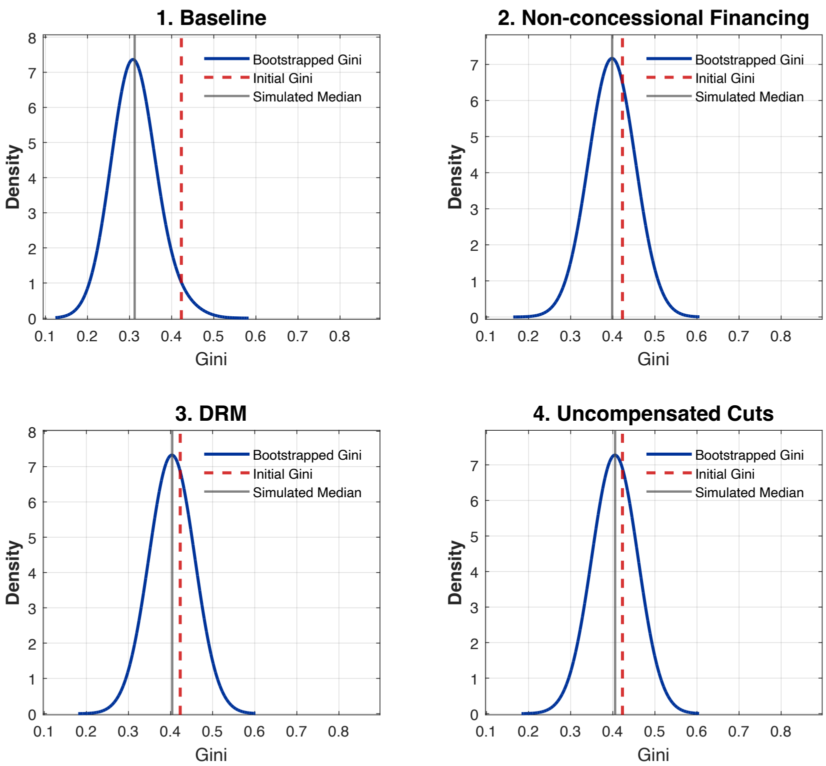
b *Average income growth by decile, across steady states*



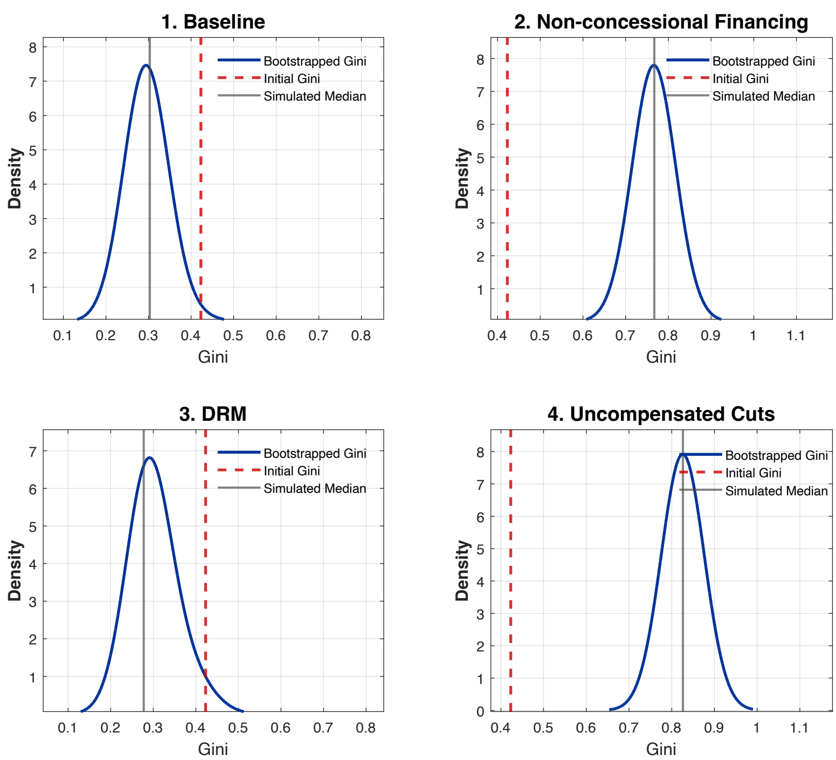
Notes: The 10-year horizon is defined as the medium term, capturing key adjustment dynamics, while the 50-year horizon represents outcomes across steady states after full convergence.
Source: Authors' simulations.

Figure A.8: Simulated Gini Coefficients

a Simulated Gini, medium term



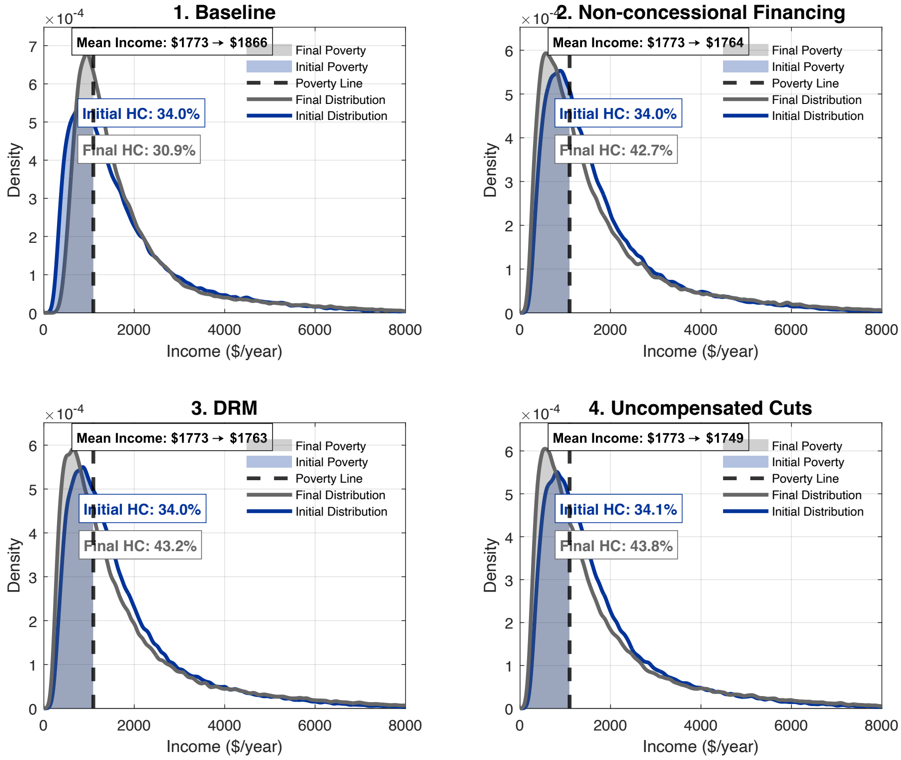
b Simulated Gini, across steady states



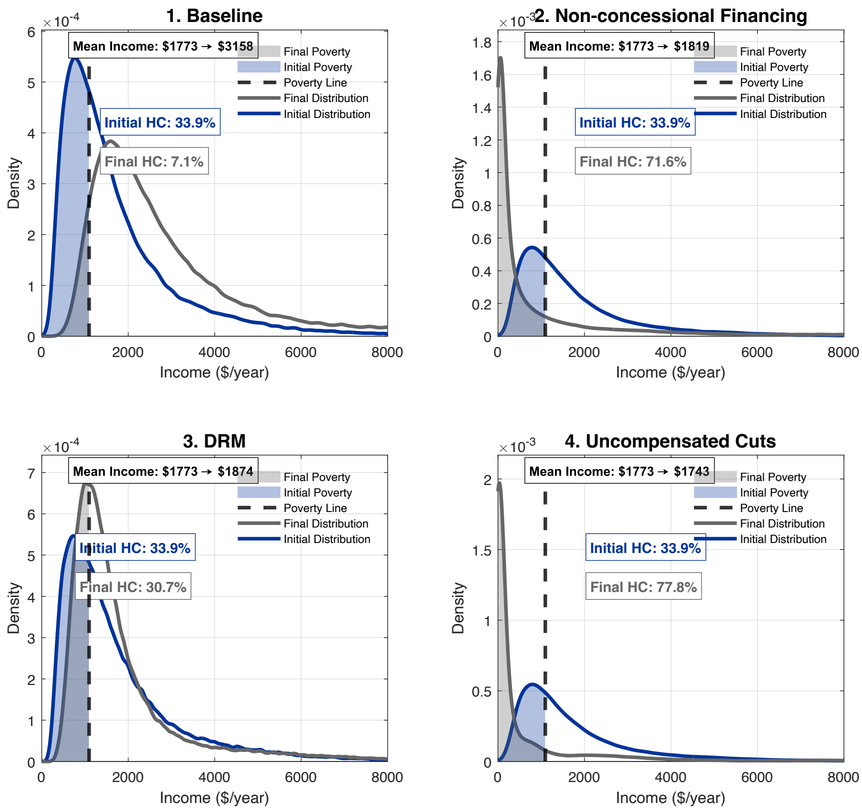
Notes: The 10-year horizon is defined as the medium term, capturing key adjustment dynamics, while the 50-year horizon represents outcomes across steady states after full convergence.
Source: Authors' simulations.

Figure A.9: Simulated Poverty Headcount

a Simulated Poverty Headcount, medium term



b Simulated Poverty Headcount, across steady states



Notes: The 10-year horizon is defined as the medium term, capturing key adjustment dynamics, while the 50-year horizon represents outcomes across steady states after full convergence.
Source: Authors' simulations.

A.2 Distributional Sensitivity Analysis

The main distributional analysis in the paper translates aggregate model output into household-level inequality measures through a growth incidence curve that allocates economy-wide growth across income deciles. While this approach is useful when baseline distributional information is patchy, it raises a natural question: how much of the distributional result is driven by the structural macro model, and how much is an artifact of the particular functional form and/or the constraining assumptions chosen for the growth incidence curve?

This question is especially pertinent for the long-run distributional analysis, where small annual growth differentials across deciles are compounded over many periods. A 2 percentage-point gap between the first and tenth decile's growth rate, applied for 50 years, produces dramatically different income distributions depending on whether one assumes a quadratic, piecewise-linear, or concave mapping from percentile rank to growth. The body of the paper addresses this concern by presenting the 10-year horizon as the primary quantitative benchmark and treating the long-run results with caution. This annex goes further and subjects the distributional exercise to a systematic sensitivity analysis to determine whether the scenario ranking is robust across a wide range of plausible approaches. We vary the functional form of the growth incidence curve, the constraining assumptions, the persistence of growth differentials, impose empirical bounds on projected inequality, and the initial income-share vector.

A.2.1 Alternative GIC specifications

We consider five specifications, each of which maps the same pair of aggregate growth moments, *total output growth* G_y and *bottom-80-percent income growth* G_{80}, into a vector of decile growth rates $g_1, \ldots, g_{10}$. The specifications are chosen to span the key dimensions of uncertainty: functional form (polynomial, piecewise-linear, log-concave, root-concave), constraining assumptions (Pareto tail, Lorenz convexity), and identification strategy (over-identified with numerical optimizer versus exactly identified in closed form). We describe each in turn.

Quadratic (baseline)

The body of the paper uses a quadratic GIC:

$$g(p) = \alpha + \beta\, p + \gamma\, p^2, \tag{1}$$

where p is the percentile rank evaluated at decile midpoints ($p_i = 0.05, 0.15, \ldots, 0.95$). With three parameters and two moment conditions, the system is over-identified. One degree of freedom remains after matching G_y and G_{80} which is used to satisfy three nonlinear inequality constraints. The first is a Pareto tail condition requiring $g_{10} \geq g_9 + \delta$, where δ is a tail premium drawn from $\{0,\ 0.5,\ 1.0\}$ percentage points; this prevents the top decile from growing more slowly than the ninth, which would violate the empirical regularity of heavy upper tails in developing-country income distributions. The second is Lorenz convexity, which ensures that cumulative income shares remain orderedthroughout the projection horizon. The third imposes Gini and top-decile-share ceilings (binding only in the long-run year exercise; see below). The quadratic form is parsimonious and smooth, but its rigidity means that the single free parameter cannot produce large departures from the constrained shape.

Piecewise-linear (three segments)

A natural concern with the quadratic form is that it imposes a smooth, symmetric curvature across the entire distribution. In practice, the bottom, middle, and top of the income distribution may respond to aggregate shocks in quite different ways.To allow for this, we estimate a piecewise-linear GIC with knots at $p = 0.50$ and $p = 0.80$:

$$g(p) = \begin{cases} a_1 + b_1\, p & \text{if } p \leq 0.50 \\ a_2 + b_2\, p & \text{if } 0.50 < p \leq 0.80 \\ a_3 + b_3\, p & \text{if } p > 0.80 \end{cases} \tag{2}$$

This yields four free parameters (a_1, b_1, b_2, b_3), giving the bottom half, the 50th–80th percentile range, and the top quintile each their own slope. The knot at $p = 0.80$ aligns with the bottom-80-percent aggregate constraint; the knot at $p = 0.50$ allows the middle of the distribution to depart from the behavior at the tails. The same Pareto, Lorenz, and cap constraints apply as in the quadratic. This specification tests whether allowing heterogeneous slopes across segments changes the scenario ranking.

Quadratic without Pareto tail

While the Pareto tail condition is an empirically motivated regularity (Kennickell, 2024), if a scenario's top decile's relative advantage is expected to erode (e.g., progressive taxation limits top-end accumulation), the constraint could be unnecessary. To test the sensitivity of the results to this assumption, we re-estimate the quadratic GIC with Lorenz convexity and empirical Gini cap constraints (the highest historically observed Gini in recent years is 0.65) but without the tail condition.

This allows us freedom to allocate growth between the ninth and tenth deciles and test whether the Pareto tail assumption is driving the distributional ranking.

Log-linear

The three specifications above share a feature: their shapes are disciplined by the Lorenz convexity and Pareto constraints, leaving limited room for the functional form to matter independently. To provide a different perspective, we introduce two specifications that are exactly identified from the aggregate moments and impose no shape constraints at all. The first is a log-linear GIC. With two parameters and two moment conditions, this specification is solved in closed form. The logarithmic shape is concave in percentile rank, steep at low percentiles and nearly flat at the top, implying that growth differentials are concentrated at the bottom of the distribution.

$$g(p) = a + b\ \ln(p). \tag{3}$$

This is also the functional form used by (Ravallion and Chen, 2003) in their analysis of growth and poverty dynamics, motivated by the observation that income distributions are approximately log-normal, so that growth rates that are linear in the log of rank provide a natural description of how aggregate growth is distributed. The log function is steep near $p = 0$: $\ln(0.05) \approx -3.0$ while $\ln(0.95) \approx -0.05$. For strongly progressive scenarios (where G_{80} substantially exceeds G_y), this steepness can produce growth differentials of 20–30 percentage points between the first and tenth decile, which massively compounds over long horizons. To prevent this, only in long horizons, we cap the spread between the highest and lowest decile growth rates at 10 percentage points. When the raw spread exceeds this bound, the profile is compressed toward its mean while preserving the log shape.

$$g_i \leftarrow \bar{g} + \frac{0.10}{\max(g) - \min(g)} \times (g_i - \bar{g}). \tag{4}$$

Square-root-linear

The second exactly-identified specification replaces the logarithm with the square root:

$$g(p) = a + b\,\sqrt{p}. \tag{5}$$

Like the log-linear, this is concave in p and weights bottom-decile growth more heavily than the quadratic. The key difference is the degree of concavity: $\sqrt{0.05} \approx 0.22$ versus $\sqrt{0.95} \approx 0.97$, giving a ratio of roughly 4:1 between the basis-function values at the extremes, compared with approximately 60:1 for the logarithm. The square-root specification therefore produces a milder bottom-heavy growth profile, making it an intermediate case between the quadratic (which is symmetric in p) and the log-linear (which is extremely steep at the bottom). The same 10-percentage-point spread cap is applied.

Taken together, the five specifications span a range from tightly constrained (*quadratic with Pareto and Lorenz*) through partially relaxed (*no Pareto*) to fully unconstrained (*log-linear and sqrt-linear*), and from symmetric (quadratic) through segmented (piecewise) to globally concave (log and sqrt). If the scenario ranking is consistent across all five, the distributional conclusions are robust to the choice of functional form and constraining assumptions.

Handling cross-decile growth, and Gini upper bounds

In the body of the paper, decile-specific growth rates are applied uniformly across all years of the projection horizon. Over long horizons, this compounds initial distributional wedges mechanically. Even a modest annual growth differential of 1–2 percentage points between the poorest and richest decile produces dramatic income-share divergence after five decades. The economic rationale for expecting such wedges to persist unchanged is weak. Household composition evolves; policy responses alter the distributional landscape over time. To control for this, we introduce an exponential decay parameter $\lambda \in (0, 1]$ that damps the cross-decile growth differential over time. Let $\bar{g}$ denote the mean decile growth rate and $\tilde{g}_i = g_i - \bar{g}$ the deviation for decile i. In year t, the effective growth rate is:

$$g_{i,t} = \bar{g} + \lambda^{t-1}\,\tilde{g}_i. \tag{6}$$

When $\lambda = 1$, there is no damping and the projection replicates the original method. As λ falls, the distributional wedge fades. A value of $\lambda = 0.95$ implies a half-life of approximately 14 years; $\lambda = 0.90$ implies roughly 7 years; and $\lambda = 0.85$ implies about 4 years. The grid $\lambda \in \{0.85,\ 0.90,\ 0.95,\ 1.00\}$ covers the range from aggressive damping (where growth differentials essentially disappear within a decade) to the undamped boundary case. Income shares are then updated year by year using arithmetic compounding, consistent with the construction of the aggregate annual growth rates from cumulative model outputs:

$$y_{i,t} = y_{i,t-1} \cdot (1 + g_{i,t}), \qquad s_{i,t} = \frac{y_{i,t}}{\sum_{j=1}^{10} y_{j,t}}. \tag{7}$$

No country in recent history has recorded an income Gini above about 0.65. Rather than allowing the distributional mapping to produce arbitrarily high inequality, we impose empirical bounds directly when solving the growth incidence curve. We constrain the projected Gini to remain below a ceiling drawn from $\{0.60, \ 0.65\}$ and the projected top-decile income share to remain below $\{0.45, \ 0.50\}$. These constraints are again only active during studying long run impacts. For the medium term distributional analysis, the caps are non-binding.

Each configuration is evaluated over 5,000 bootstrap draws for the 10-year horizon and 1,000 draws for the 50-year horizon. The bootstrap resamples the annual macro growth paths with replacement Initial income shares are perturbed independently in each draw using multiplicative log-normal noise ($\sigma = 0.06$) to reflect uncertainty in the 2016 HIES calibration; both in the medium and long term simulations. The medium-term benchmark uses the quadratic GIC with moderate damping ($\lambda = 0.90$) and non-binding caps. For the long-run exercise, all grid points are evaluated; results are reported separately by specification and by λ.

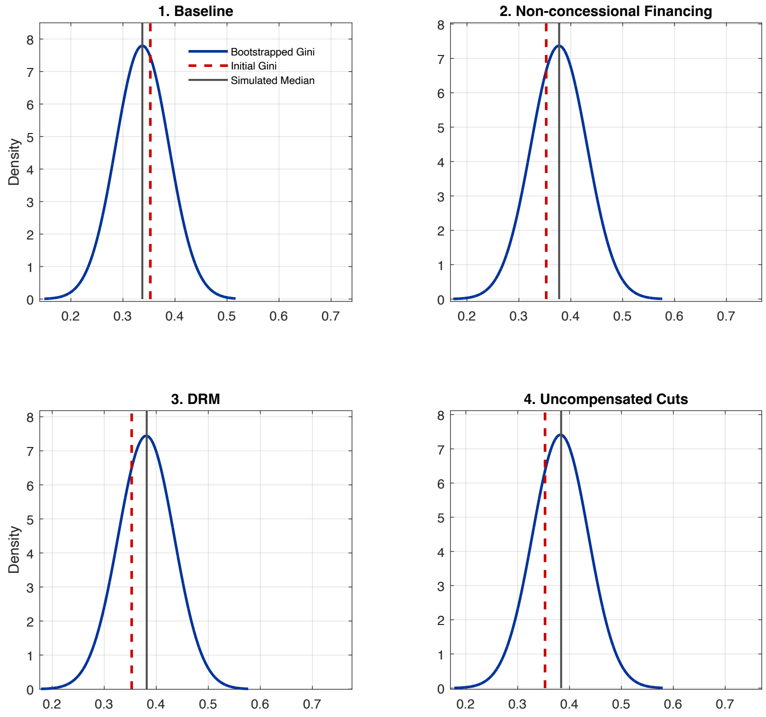
A.2.2 Results

Medium-term distributional results with adjusted Q-GIC

Figure A.10 shows the medium Gini estimates with the quadratic GIC with empirical bounding and perturbed initial income shares (*adjusted Q-GIC*). The results show that ranking remain consistent with the original results. The baseline delivers the most progressive outcome (Gini declines from 0.35 to 0.33), followed by DRM, non-concessional financing, and uncompensated cuts (Gini rises to about 0.384). These results confirm that the medium-term distributional ranking is robust to perturbation of initial shares. The baseline distribution is tightly concentrated below the initial Gini, indicating a consistently progressive outcome. The other financing scenario densities are shifted rightward and more dispersed than the baseline, confirming that in the medium term all other scenarios produce higher expected inequality and the greater uncertainty.

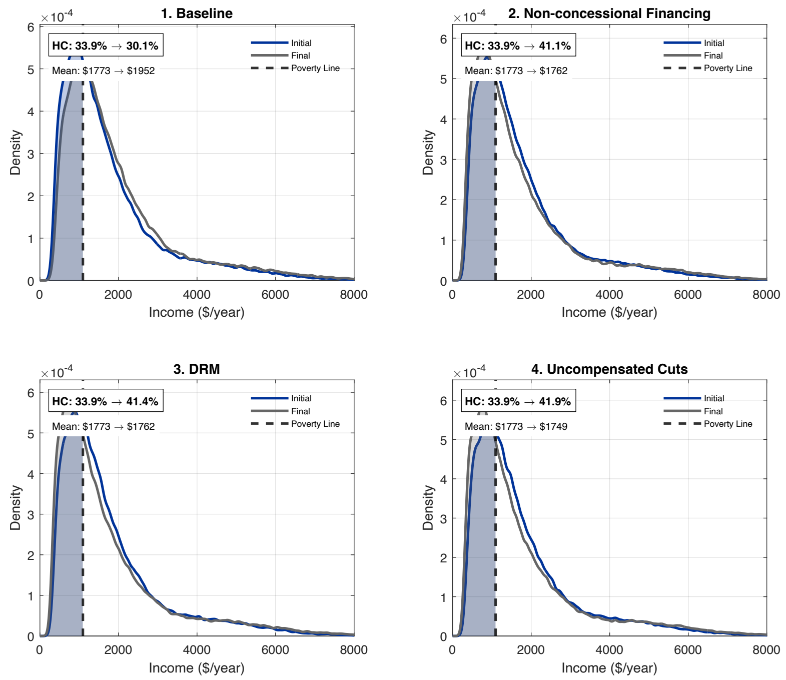
Figure A.11 documents changes in income distribution in the medium term. Again, the baseline shows a modest rightward shift of the income distribution and a decline in the poverty headcount from 33.9 to 30.1 percent. The three aid-cut scenarios all show a leftward compression at the bottom: poverty headcounts rise to 41.1 percent (non-concessional financing), 41.4 percent (DRM), and 41.9 percent (uncompensated cuts). The DRM and non-concessional financing outcomes are nearly indistinguishable at this horizon, consistent with the fact that the DRM revenue mobilization strategy is regressive in the medium term through GST broadening and user fees that fall on consumption.

Figure A.10: Bootstrap Gini density, medium term



Notes: Kernel density estimates of the bootstrapped Gini for each scenario. Vertical dashed lines show the initial.
Source: Authors' simulations.

Figure A.11: Income distribution shift and poverty headcount, 10 years



Notes: Each panel shows the initial (gray) and final (blue) income density for one scenario. The vertical dashed line marks the $3/day poverty line. Shaded areas represent populations below the poverty line.
Source: Authors' simulations.

Long run distributional results with adjusted Q-GIC

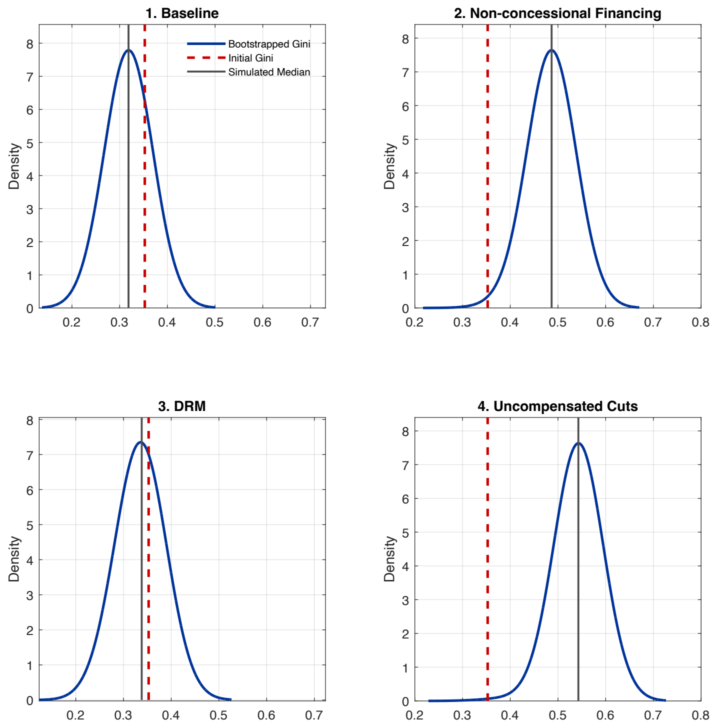
Figure A.12 presents the long-run Gini density plots for the quadratic specification at $\lambda = 0.90$, perturbed initial income shares and empirical bounding of the Gini (*adjusted Q-GIC*). The baseline density is concentrated at low Gini values, while the uncompensated-cuts density is spread across a wide range up to the empirical ceiling. DRM occupies an intermediate position, with a density that is shifted leftward relative to non-concessional financing.

In Figure A.13, the long-run income distribution shifts reveal the mechanism behind the DRM result. In the baseline, continued aid finances public investment that raises mean income from $1,773 to $3,619 per year and reduces the poverty headcount from 33.9 to 4.9 percent. Among the three aid-cut scenarios, DRM produces the most favorable long-run outcome: mean income rises to $1,822 and the poverty headcount falls to 31.1 percent. This improvement relative to the medium term, where DRM's poverty headcount was 41.4 percent, reflects the long-run returns to revenue-financed human capital investment. Continued investment in education and infrastructure improves the productivity of low-skill labor and facilitates the conversion of some low-skill workers into higher-skill employment, offsetting the initial regressive burden of the revenue mobilization strategy.

Non-concessional financing produces a mean income of equivalent to the DRM scenario but a substantially higher poverty headcount of 50.7 percent, because the distributional incidence of debt service falls disproportionately on liquidity-constrained households. Uncompensated cuts produce the worst outcome with mean income virtually unchanged in the long run and the poverty headcount rising to 57.0 percent.

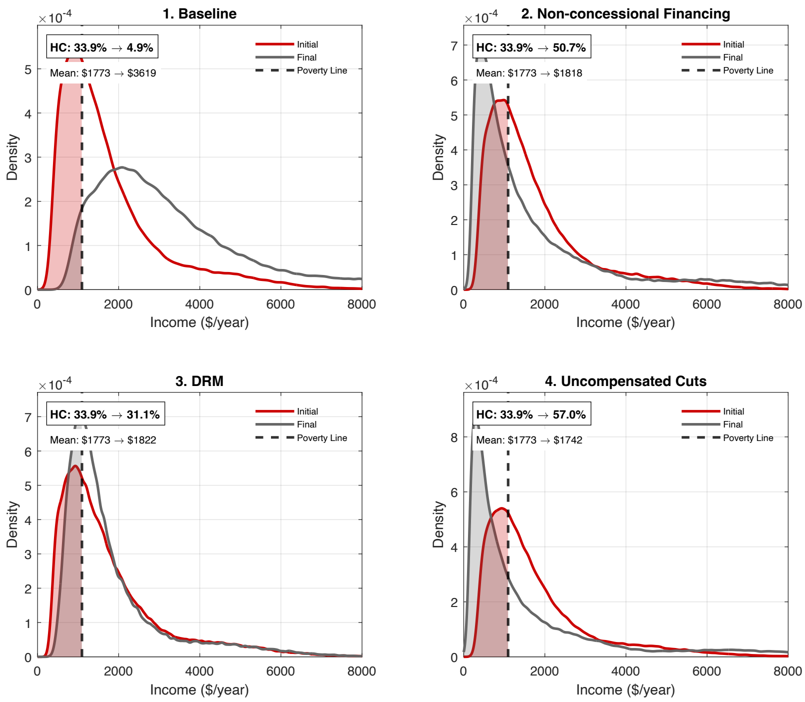
Although not shown here, in the medium term, the baseline Lorenz curve shifts inward towards equality, while the three aid-cut scenarios shift outward. In the long run, the baseline Lorenz curve shifts further inward reflecting a sustained progressive growth path. In contrast, the DRM Lorenz curve is closer to the initial distribution than the other two aid-cut scenarios, consistent with the Gini findings. The decile-level income-share changes also show that in the medium term, the share changes are modest. The baseline shows small gains for the bottom deciles and small losses for the top; the aid-cut scenarios reverse this pattern, with the top decile gaining at the expense of the bottom. In the long run, the magnitudes are larger and the pattern is starker. Under uncompensated cuts, the top decile gains over 10 percentage points of total income share, while the bottom eight deciles all lose. Under DRM, the share changes are much more moderate, with the bottom deciles experiencing near-zero changes and the top decile gaining only modestly.

Figure A.12: Bootstrap Gini density, long run ($\lambda = 0.90$, quadratic)



Notes: Kernel density estimates of the bootstrapped 50-year Gini (quadratic specification, $\lambda = 0.90$) for each scenario.
Source: Authors' simulations.

Figure A.13: Income distribution shift and poverty headcount, long run

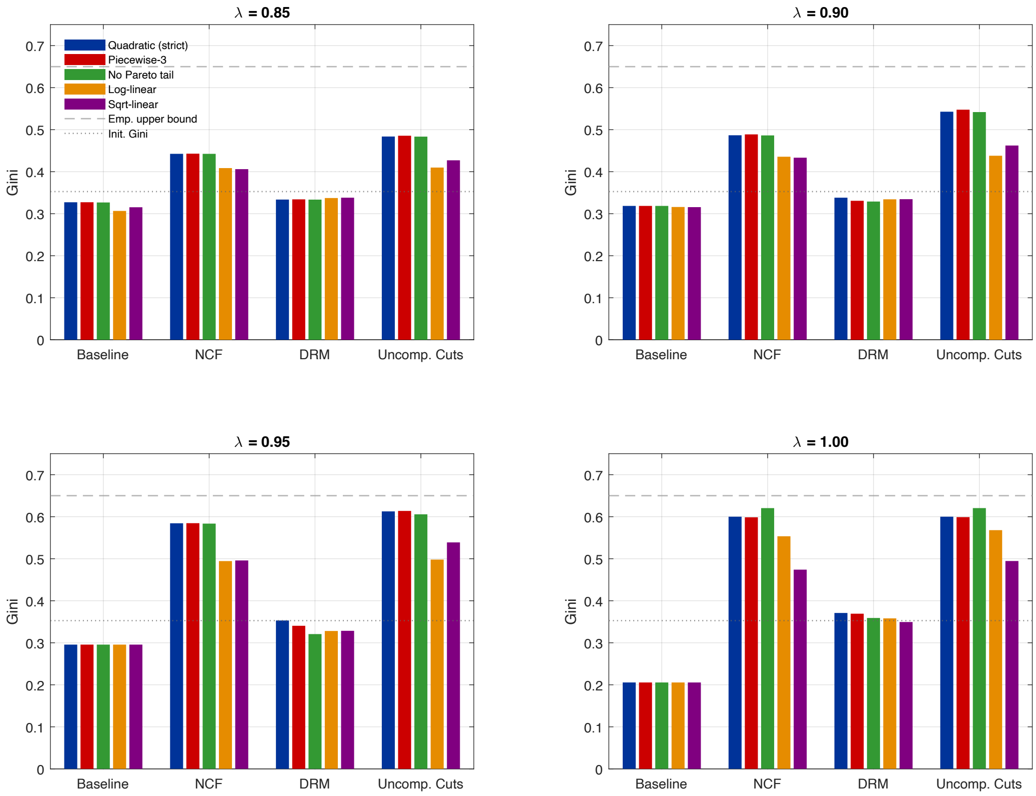


Notes: Each panel shows the initial (gray) and final (red) income density for one scenario at 50 years (quadratic specification, $\lambda = 0.90$). Shaded areas represent populations below the \$3/day poverty line.
Source: Authors' simulations.

Long-run distributional results by specification

Figure A.14 reports the long run Gini for each of the five GIC specifications at each damping assumption λ. Each of the four panels corresponds to a value of λ; within each panel, grouped bars show the five specifications side by side for each scenario. We find three notable results. First, the scenario ranking in the body of the paper holds in every panel. Across all five specifications and all four damping values λ, the Gini is lowest for the baseline, followed by DRM, non-concessional financing, and uncompensated cuts. No specification or damping assumption reverses the ordering.

Figure A.14: Long-run Gini by specification



Notes: Grouped bars show the median 50-year Gini for each GIC specification at each damping parameter λ. Gini and top-share caps are imposed. The dashed line marks the empirical ceiling (0.65); the dotted line marks the initial Gini (0.35).
Source: Authors' simulations.

Second, there is more variation across specifications in the long-run steady state results than in the medium term, particularly at higher values of λ (less damping). The log-linear and square-root-linear specifications, which are concave and weight bottom-decile growth more heavily, tend to produce somewhat different absolute Gini levels from the quadratic and piecewise specifications. This is expected since the concave forms allocate more of the growth differential to the poorest deciles, which over long horizons either compresses the distribution more (in the progressive baseline) or produces a different pattern of share accumulation (in the regressive scenarios). The fact that the ranking is preserved despite these differences confirms that it is driven by the aggregate growth moments rather than by the assumptions surrounding the growth incidence curve.

Third, the three constrained quadratic variants (strict, piecewise-3, no Pareto) produce very similar results to each other, indicating that neither the Pareto tail assumption nor the choice between polynomial and piecewise functional forms is a quantitatively important driver of the distributional results.

The sensitivity analysis confirms the paper's central finding. Across five GIC specifications, spanning polynomial, piecewise-linear, and concave functional forms, with and without Pareto tail and Lorenz convexity constraints, four growth damping assumptions, three tail-premium values, two Gini caps, two top-share caps, and perturbed initial distributions, the ranking of policy responses is the same.

First, the baseline with continued aid delivers the best distributional outcome. Second, the phased DRM strategy is the least regressive of the three aid-cut responses. Third, non-concessional financing is more regressive than DRM. Fourth, uncompensated expenditure cuts produce the worst distributional outcome. The near-invariance of this ranking across specifications indicates that the distributional results are driven by the aggregate growth moments from the structural model rather than by the assumptions imposed on the distributional mapping. The log-linear and sqrt-linear specifications, which impose no shape constraints and are solved in closed form, produce somewhat different absolute Gini levels from the constrained quadratic variants, but the ranking is preserved.

PUBLICATIONS

Closing the Gap: A LIC's Policy Options Under and Aid Shock
Working Paper No. WP/2026/151