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Abstract

How should governments deleverage public debt, and who gains or loses under alternative fiscal packages? We study this question in a heterogeneous-agent general-equilibrium model with endogenous assets, labour supply, and human-capital accumulation, calibrated to the pre-pandemic United Kingdom. The government reduces the public-debt stock by an amount equal to 10 percent of initial output over 25 years. We compare front-loaded, linear, and back-loaded schedules; labour-tax, returns-tax, and transfer closures; and four uses of the fiscal capacity created by lower debt service: Government Spending, Fiscal Discipline, Additional Transfers, and Public Investment. Four results stand out. First, we find a clear ranking among the fiscal instruments: labour taxation usually creates the largest welfare losses, followed by transfer reductions, while returns taxation generates the smallest losses. Second, among workers alive when the policy is announced, back-loaded paths generally deliver higher mean welfare, but heterogeneity can create conflicts of interest that may change this ranking. Third, endogenous human capital amplifies the cost of labour-tax consolidation. Fourth, fiscal headroom is itself distributional; Fiscal Discipline protects households exposed to the chosen closure instrument; Additional Transfers build support among low-asset households, especially under returns-tax financing; and Public Investment creates broader productivity gains and can make faster deleveraging politically attractive. Debt reduction should therefore be evaluated as a package combining the debt path, the fiscal instrument, and the allocation of fiscal headroom.

JEL codes: E21, E62, H63.

Keywords: public debt, fiscal consolidation, heterogeneous agents, inequality, human capital.

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1 Introduction

Across many advanced economies public debt levels are at historic highs, following the Global Financial Crisis and the Covid-19 pandemic. This leaves many governments with limited fiscal space and large debt-service costs (International Monetary Fund, 2024; OECD, 2025; Checherita-Westphal et al., 2024). If governments seek to rebuild fiscal space, they need to decide how to consolidate and how to manage the macroeconomic and distributional consequences of debt reduction.

This paper addresses the following question: how do the distributional consequences of public-debt deleveraging depend on the consolidation schedule, the fiscal instrument, and the use of fiscal headroom? We study this question using a heterogeneous-agent general-equilibrium model with incomplete markets, endogenous financial assets and human capital, and idiosyncratic productivity. Our modelling framework allows us to study the effects of fiscal consolidations along the distributions of wealth and human capital, tracing the medium- and long-run consequences of different fiscal instruments.

Our quantitative exercise is calibrated to the pre-pandemic United Kingdom. From the initial steady state, the government then reduces the debt stock by an amount equal to 10 percent of initial output over 25 years. We cross three debt consolidation paths–front-loaded, linear, and back-loaded–with three budget-closing instruments: a labour income tax, a tax on asset returns, and a reduction of direct transfers, as well as four uses of the fiscal headroom created by lower debt service. The baseline assigns the projected debt-service dividend to residual Government Spending. We then study three alternative uses of the same projected fiscal capacity: Fiscal Discipline, which lets the dividend relax the budget-closing instrument; Additional Transfers, which return it to households through the transfer component; and Public Investment, which accumulates productive public capital.

Our first finding is that labour-tax consolidation is especially costly when households endogenously accumulate human capital. In the linear Government Spending transition, the mean welfare loss among initial incumbents under labour taxation amounts to 1.030 percent of lifetime consumption in the benchmark model, compared with 0.727 percent in a comparable model without endogenous human capital—about 42 percent larger. Models that abstract from this margin are therefore likely to understate the transition cost of fiscal consolidation, especially when adjustment operates through labour income taxation.

Our second finding is that alternative instruments can reduce aggregate costs, but only by creating sharper distributional conflicts. Returns taxation is the least costly instrument for many households because it preserves labour-supply and human-capital-accumulation incentives. Its losses, however, are concentrated among high-wealth households. Transfers adjustment removes much of the production-side distortion, but shifts the burden toward low-asset and low-human-capital households, for whom public transfers are more important and private buffers are limited. The choice of fiscal instrument therefore determines not only the size of the welfare cost, but also which households bear it.

Our third finding is that the preferred timing of consolidation depends on whose welfare is evaluated. Among initial incumbents, gradual consolidation generally delivers higher mean welfare, but heterogeneity generates departures from this aggregate ranking. Earlier work emphasises that delayed adjustment can be welfare-improving because it smooths the transition. We show that this result depends on both the fiscal instrument and the use of headroom. Under labour taxation and transfers adjustment, most households prefer back-loading because it delays the main labour-market distortion or the withdrawal of transfers. Under returns taxation, by contrast, low-asset households can prefer earlier consolidation because they bear little of the asset-tax burden. This creates an additional conflict over timing: under returns taxation, Additional Transfers and Public Investment both shift household support toward front-loading, with 57.0 and 63.6 percent of households preferring the front-loaded path, respectively. Once future entrants are included in the social-welfare criterion, the case for back-loading weakens further: at a social discount factor of 0.96, the welfare-maximising package is front-loaded for three of the four uses of headroom.

Our fourth finding is that the use of fiscal headroom is itself a central policy margin. Fiscal Discipline uses debt-service savings to relax the budget-clearing instrument. Across instruments and timing paths, this lowers mean incumbent CEV losses by about 33–52 percent relative to the baseline, equivalent to gains of 0.11–0.66 percentage points of lifetime consumption. But headroom also creates a new distributive conflict. Additional Transfers benefit low-asset and low-income households, especially when financed by returns taxation. Public Investment changes the household support more broadly: by raising productive public capital, it generates gains that reach a wider coalition of households and can make faster deleveraging more attractive, because faster debt reduction brings forward the buildup of productive capacity.

Taken together, these results show that once wealth and human capital jointly shape household exposure to fiscal policy, consolidation is not only a question of how much adjustment is required, but also of which instrument is used, when the adjustment occurs, and who captures the fiscal space created by lower debt service.

1.1 Related Literature

Our paper contributes to a range of distinct literatures. The first antecedent is the quantitative general-equilibrium literature that examines the transition costs and financing choices associated with fiscal consolidation and lower public-debt targets. In a neoclassical general-equilibrium framework, Baxter and King (1993) show that the macroeconomic effects of fiscal policy depend on its financing method and on the associated responses of capital and labour, while Leeper et al. (2010) emphasise that the effects of public investment depend critically on implementation delays and on the anticipated fiscal adjustments required to finance debt-funded spending. In open-economy and currency-union DSGE models, Coenen et al. (2008), Almeida et al. (2013), and Erceg and Lindé (2013) analyse permanent or gradual reductions in public-debt targets under alternative expenditure- and revenue-based instruments, highlighting the trade-off between short-run adjustment costs and longer-run gains from lower debt and reduced distortions. Finally, Sakkas and Varthalitis (2021) show that consolidation can also have important distributional consequences when households differ in skills and asset holdings, with transition dynamics shaped by the interaction between debt reduction, capital accumulation, and wage inequality. Collectively, this literature establishes that the macroeconomic consequences of deleveraging depend not only on the ultimate debt target, but also on the timing of adjustment, the fiscal instrument used to implement it, and the financing mechanisms.

The second antecedent is the literature on public debt and fiscal policy in heterogeneous-agent economies. Aiyagari and McGrattan (1998), Flodén (2001), Heathcote (2005), and Bassetto (2014) show how public debt and fiscal instruments affect liquidity provision, crowding out, insurance, and redistribution when households face uninsurable risk. Work on debt reduction, including Desbonnet and Weitzenblum (2012), Röhrs and Winter (2017), and Romei (2015), shows that transition dynamics and political feasibility are central for debt policy. Recent heterogeneous-agent fiscal-policy papers, including Cahn et al. (2026) and Le Grand and Ragot (2025), continue this agenda, and Auclert et al. (2025) provide a broader survey. We add to this work by separating three components of a deleveraging package–the debt path, the fiscal instrument, and the allocation of fiscal headroom–in an economy where households differ jointly in assets and human capital.

The third set of related work is the human-capital and taxation literature. Ben-Porath (1967) and Heckman et al. (1998) establish skill accumulation as an investment margin, while Krebs (2003) and Huggett et al. (2011) show that human-capital risk and heterogeneity shape saving and inequality. Guvenen et al. (2014) and Heathcote et al. (2017) show that tax policy can change wage inequality and optimal tax design by altering labour supply and skill investment. We add a public-debt transition to this mechanism. In our model, a labour-tax consolidation not only reduces current labour supply; it also lowers future productive capacity by discouraging human-capital accumulation.

Our analysis is also related to optimal-fiscal-policy models in which financial frictions (e.g. Angeletos et al. (2023)), imperfect sovereign creditworthiness or debt-sensitive sovereign borrowing costs (e.g. Aizenman et al. (2000), Philippopoulos et al. (2017)), and labour-market frictions and associated wedges (e.g. Arseneau and Chugh (2012)), all of which can challenge the tax-smoothing prescription Barro (1979). Unlike those studies, we do not solve for an unrestricted Ramsey allocation. Instead, we welfare-rank alternative announced debt paths in a heterogeneous-agent economy. At the level of mean incumbent welfare, gradual consolidation is generally preferred. However, heterogeneity and the inclusion of future entrants both generate departures from this aggregate ranking. The case for front-loading in our framework is therefore conditional on the fiscal package and can arise either from distributional household support among incumbents or from the weight a social planner places on future cohorts, rather than representing a general rejection of tax smoothing.

The final antecedent is work on public investment, fiscal consolidation, and distribution. Leeper et al. (2010) show that government investment depends on financing and timing while Economides et al. (2014) further show that the aggregate and distributional effects of publicly financed goods depend on the mode of provision. Chatterjee et al. (2017), Chatterjee et al. (2018), and Cozzi (2023) connect public debt to infrastructure, welfare, and growth. Empirical work by Ball et al. (2013), Woo et al. (2013), Alesina et al. (2017), González García (2025), Ando et al. (2025), Adler et al. (2024), and Frangiamore et al. (2025) shows that consolidation effects vary with composition, initial conditions, and distributional exposure. In addition, Bom and Ligthart (2014) provide evidence on the output elasticity of public capital. We add a structural comparison of what happens to the fiscal dividend from debt reduction: it can be absorbed by residual spending, used to reduce fiscal pressure, returned through transfers, or invested in productive public capital.

The remainder of the paper is organised as follows. Sections 2 and 3 describe the quantitative model and the initial calibration. Section 4 studies fixed-debt-path transitions using Government Spending as the baseline use of debt-service savings. Section 5 considers Fiscal Discipline, Additional Transfers, and Public Investment as alternative uses of fiscal capacity and summarises the resulting conflict of interest tradeoffs. Section 6 concludes.

2 Stationary Model

The economy comprises a unit-mass continuum of households, indexed by $i \in [0, 1]$, each represented by a prime-age worker aged 25–55. Time is discrete and annual. The current worker supplies labour, consumes, saves, and invests in human capital. Households receive labour income net of taxes and transfers and earn returns on financial assets supplied to firms through competitive capital markets.

Human capital is a one-dimensional index of skills, experience, and other attributes that raise general labour productivity. Because the model focuses on prime-age workers, it abstracts from formal education choices and interprets human-capital accumulation mainly as on-the-job skill acquisition, training, and related investments during working life. Human capital is only partially retained from one year to the next: δ_h is the annual retention rate, and $1 - \delta_h$ is the implied depreciation rate.

Labour productivity depends on both human capital and an exogenous productivity state. The exogenous state captures job-match quality and other idiosyncratic productivity components and evolves stochastically. Human capital is therefore *risky*: two workers with the same human-capital stock can earn different labour income because they draw different exogenous productivity states. Histories of these shocks, together with household saving and investment choices, generate cross-sectional inequality in wealth, earnings, and human capital.

Workers face a constant probability of leaving the labour force at the end of each period.[1] When this event occurs, the worker derives warm-glow utility from the end-of-period assets left behind and her individual value terminates. Each exit is followed one-for-one by a new worker in the next period, keeping the population mass constant. The entrant inherits those assets but begins a separate lifetime problem. Human capital is not transferable: the entrant starts from a newborn level of human capital h_{newborn} rather than inheriting the previous worker's skills. The model therefore permits intergenerational wealth transmission without dynastic preferences, while skill accumulation restarts with each entrant.[2]

2.1 Workers' preferences and constraints

Preferences are of the Greenwood–Hercowitz–Huffman (GHH) type in consumption and labour supply:

$$u(c_t, l_t) = \frac{\left(c_t - \psi \frac{l_t^{1+\theta}}{1+\theta}\right)^{1-\sigma}}{1-\sigma}, \tag{1}$$

where $\sigma \neq 1$ is the coefficient of relative risk aversion, $\psi > 0$ governs the disutility of labour, and $\theta > 0$ determines the Frisch elasticity of labour supply. Consumption in period t is denoted by $c_t > 0$, and l_t denotes labour supply.

Each worker maximises expected discounted utility over her remaining lifetime.[3] Because the exit shock is independent of the worker's other risks, we can integrate it out

[1]To simplify computation, we do not specify a full life-cycle model and instead use a "hybrid" model of stochastic exit and replacement; see, for example, Ríos-Rull (1996).

[2]For contrasting quantitative treatments of intergenerational wealth transmission, see Hubmer et al. (2021) and De Nardi (2004).

[3]We drop worker-specific subscripts for ease of exposition.

and write the objective as

$$E_0 \left[\sum_{t=0}^{\infty} \left[\beta(1-\varpi) \right]^t \left(u(c_t, l_t) + \beta \varpi b(a_t) \right) \right], \tag{2}$$

where $\beta \in (0,1)$ is the worker's discount factor and $\varpi \in (0,1)$ is the constant probability of exiting at the end of each period. The factor $[\beta(1-\varpi)]^t$ captures both time discounting and the probability that the worker remains active through period t. If she exits, she receives warm-glow utility from her end-of-period assets, $b(a_t)$.

The bequest motive is represented by the warm-glow function

$$b(a_t) = \varphi_B \frac{a_t - a_{\min}}{\bar{a}_B + (a_t - a_{\min})}, \tag{3}$$

where a_t denotes end-of-period asset holdings, $\varphi_B > 0$ governs bequest intensity, and $\bar{a}_B > 0$ controls the bequest-satiation scale.

Households earn income from their asset holdings a_{t-1} at the risk-free interest rate r_t, as well as from supplying labour services to firms. Labour earnings depend on hours worked, the wage rate w_t, and individual labour productivity n_t, described in detail in the next subsection.

Labour income is subject to a progressive tax system combined with a flat transfer. Net labour income is defined following Heathcote et al. (2017) as an isoelastic mapping of gross earnings, augmented by a lump-sum transfer:

$$y_t = \tau_1 \left(l_t n_t w_t \right)^{1-\tau_2} + \tau_0, \tag{4}$$

where $\tau_1 > 0$ determines the average level of taxation, $\tau_2 \in (0,1)$ governs the progressivity of the tax system, and $\tau_0 \geq 0$ denotes a flat transfer received by all households. When $\tau_2 = 0$, the tax system collapses to a flat tax rate of $1 - \tau_1$, while higher values of τ_2 imply greater redistribution from high-earning to low-earning households. The flat transfer τ_0 captures redistribution through cash transfers and social benefits without directly affecting marginal tax rates.

The household's budget constraint is

$$c_t + a_t + x_t = R_t(a_{t-1}) a_{t-1} + y_t, \tag{5}$$

where the gross return on current liquid assets is

$$R_t(a) = \begin{cases} 1 + r_t(1 - \tau_{a,t}) & \text{if } a \geq 0, \\ 1 + r_t + r^{\text{pen}} & \text{if } a < 0. \end{cases} \tag{6}$$

Here $a_t \in [a_{\min}, \infty)$ denotes end-of-period asset holdings, $\tau_{a,t}$ is a proportional tax on positive asset income, and r^{pen} is the additional borrowing rate applied to debt. In the stationary baseline, the natural borrowing limit is $a_{\min} = -\tau_0/(r + r^{\text{pen}})$.[4] The variable $x_t \geq 0$ represents investment in human capital.

2.2 Human capital accumulation

Workers accumulate human capital by investing in a human-capital good x_t, whose price is normalised to one. This good captures resources devoted to skill acquisition rather than pleasurable consumption: training, certification, mentoring, networking, or other activities that raise future productivity.[5] The model has no explicit time budget, but x_t can also be interpreted as foregone earnings or employer-provided training costs that reduce current disposable resources while raising future human capital.

Human-capital accumulation is governed by the following law of motion, a modified version of the standard equation used in the literature (Ben-Porath, 1967; Heckman et al., 1998; Krebs, 2003):

$$h_t = \delta_h h_{t-1} + \chi x_t^{\gamma}, \tag{7}$$

where $1 - \delta_h$ is the implied depreciation rate of human capital. The parameters $\chi > 0$ and $\gamma \in (0, 1)$ govern the transformation of the investment good x_t into human capital. For the numerical solution, human capital is represented on a compact grid, $h_t \in [h_{\min}, h_{\max}]$, whose upper bound is chosen large enough not to bind in the calibrated equilibrium. The grid includes a small buffer below the newborn reset point h_{newborn}, as described in Appendix B; neither numerical boundary is active in the calibrated stationary distribution. The stochastic exit shock and associated reset of human capital at replacement also help keep the problem bounded; see also Kuhn (2013) for a discussion of permanent income shocks.

2.3 Labour productivity

Labour productivity depends on two factors: (i) the worker's beginning-of-period stock of human capital h_{t-1} and (ii) an exogenous component capturing how productive that human capital is in the current job (e.g. industry and occupation). These factors are summarised by the random variable e_t. Combining them, a worker's effective labour

[4] In principle, labour income can approach zero. However, because households receive the flat transfer τ_0, the relevant income floor is positive, implying a well-defined borrowing limit with $a_{\min} < 0$. The transition exercises retain the baseline numerical lower bound as policy instruments and prices vary. While assets are theoretically unbounded above, the numerical implementation uses a finite asset grid with an upper bound chosen sufficiently large that it is never binding.

[5] We abstract from expenditures that may be both pleasurable consumption and skill-improving investment.

supply is given by

$$n_t = e_t \cdot \log(1 + h_{t-1}), \tag{8}$$

where $e_t > 0$ is the exogenous productivity state. The functional form $g(h_{t-1}) = \log(1 + h_{t-1})$ provides an increasing and concave mapping from raw human capital into labour services.[6] Exogenous productivity therefore does not exclusively determine labour earnings, but instead interacts with human capital (Guvenen et al., 2014). This distinguishes the model from frameworks in which human capital is the sole driver of labour income (Krebs, 2003; Huggett et al., 2011).

Exogenous productivity follows an AR(1) process in logs:

$$\log(e_{t+1}) = \rho \log(e_t) + \varepsilon_{t+1}, \tag{9}$$

with $\varepsilon_t \sim N(0, \sigma_\epsilon^2)$ and $|\rho| < 1$. This specification is standard in heterogeneous-agent incomplete-markets models and ensures that e_t follows a stationary process with an ergodic distribution. New entrants draw exogenous productivity from its stationary active-worker distribution and start at h_{newborn} on the human-capital grid.

2.4 Government budget

The government redistributes income via the tax and transfers system defined above. Beyond this function, the government issues one-period bonds B_t, pays interest at rate r_t, undertakes productive public investment $I_{g,t}$, and finances non-productive government spending G_t. Let T_t denote net government revenues from the tax-and-transfer system, including the transfer component in (4) and any tax on asset returns. Its period budget constraint is

$$T_t + B_t = G_t + I_{g,t} + (1 + r_t)B_{t-1}. \tag{10}$$

Public capital evolves according to

$$K_{g,t} = (1 - \zeta_g)K_{g,t-1} + I_{g,t}, \tag{11}$$

where ζ_g is the depreciation rate of public capital.

2.5 Aggregate quantities and market clearing

A representative firm rents private capital and labour services in competitive factor markets. Productive public capital enters the aggregate technology as a total-factor-

[6] Most studies in labour economics consider logged earnings (or earnings residuals) as their object of interest, making this a reasonable choice; see, for example, Mincer (1974). Adding 1 is a rescaling that ensures labour earnings cannot be negative.

productivity term. Aggregate output is produced using a Cobb–Douglas technology:

$$Y_t = Z_t K_{t-1}^{\alpha} L_t^{1-\alpha}, \tag{12}$$

where $\alpha \in (0,1)$ is the capital share. Economy-wide productivity depends on inherited public capital according to

$$Z_t = \left(\frac{K_{g,t-1}}{\xi_g} \right)^{\phi_g}, \tag{13}$$

where $\phi_g > 0$ is the output elasticity with respect to public capital and $\xi_g > 0$ is a normalisation parameter. Private capital depreciates at the constant rate $\zeta_p \in (0,1)$.

We consider a small open economy in which the interest rate is determined by a markup over the world interest rate $\overline{r}$. The model variable NFA_t is liabilities-positive: it measures the part of domestic capital and public debt not financed by domestic household assets. A higher value therefore corresponds to a larger net external borrowing position and raises the spread:

$$r_t = \overline{r} + \psi_r \left(\exp\left(\frac{NFA_t}{Y_t} \right) - 1 \right). \tag{14}$$

The firm's optimality conditions imply that the capital–labour ratio satisfies

$$\frac{K_{t-1}}{L_t} = \left(\frac{\alpha Z_t}{r_t + \zeta_p} \right)^{\frac{1}{1-\alpha}}, \tag{15}$$

which in turn implies the wage rate

$$w_t = (1-\alpha) Z_t \left(\frac{K_{t-1}}{L_t} \right)^{\alpha}. \tag{16}$$

2.6 Stationary equilibrium

The economy is initially in a stationary equilibrium. Individual households continue to move across asset, human-capital, and productivity states, but the cross-sectional distribution is invariant and aggregate variables are constant. In this equilibrium $K_t = K_{ss}$, $L_t = L_{ss}$, $G_t = G_{ss}$, $K_{g,t} = K_{g,ss}$, and $B_t = B_{ss}$, while public investment satisfies $I_{g,ss} = \zeta_g K_{g,ss}$. Factor prices, value functions, and policy functions are therefore time-invariant. The stationary equilibrium is a recursive competitive equilibrium with market clearing and a balanced government budget. Appendix E describes the household solution, and Appendix F.1 derives the asset-market condition.

Specifically, the stationary equilibrium of the model economy is defined as follows:

1. The representative firm solves its profit maximization problem, and factor prices equal their respective marginal products, with $Z_{ss} = \left(\frac{K_{g,ss}}{\xi_g} \right)^{\phi_g}$,

$w_{ss} = (1-\alpha) Z_{ss} \left(\frac{K_{ss}}{L_{ss}}\right)^{\alpha}$, $r_{ss} = \overline{r} + \psi_r \left(\exp\left(\frac{NFA_{ss}}{Y_{ss}}\right) - 1\right)$.

2. Given w_{ss} and r_{ss}, households solve the stationary problem, giving rise to a stationary distribution λ_{ss}.

3. Capital and labour markets clear, $L_{ss} = \int n_i l_i d\lambda_{ss}(i), K_{ss} + B_{ss} = \int a_i d\lambda_{ss}(i) + NFA_{ss}$.

4. The government's budget clears, $T_{ss} = \int \left[w_{ss} n_i l_i - y_i + \tau_{a,ss} r_{ss} \max\{a_i, 0\}\right] d\lambda_{ss}(i) = G_{ss} + I_{g,ss} + r_{ss} B_{ss}$, with $I_{g,ss} = \zeta_g K_{g,ss}$.

We solve the household's problem using dynamic programming. For this purpose, the household's problem can be written in recursive form:

$$V\left(a_{t-1}, h_{t-1}, e_t\right) = \max_{\{c_t, a_t, x_t, l_t\}} \Big\{ u(c_t, l_t) + \beta E[(1-\varpi) V\left(a_t, h_t, e_{t+1}\right) + \varpi b(a_t) \mid e_t] \Big\} \tag{17}$$

$$\begin{aligned} \text{s.t.} \quad c_t + a_t + x_t &= R_{ss}(a_{t-1}) a_{t-1} + y_t \\ h_t &= \delta_h h_{t-1} + \chi x_t^{\gamma} \\ y_t &= \tau_1 (l_t n_t w_{ss})^{1-\tau_2} + \tau_0 \\ c_t - \psi \frac{l_t^{1+\theta}}{1+\theta} &> 0, \quad h_t \geq 0, \quad a_t \geq a_{\min}, \quad x_t \geq 0, \quad l_t \geq 0. \end{aligned}$$

Here R_{ss} is the stationary counterpart of the gross-return schedule in equation (6).

The main computational difficulty is the presence of human capital as a second endogenous state variable. Two-state household problems are now common in quantitative macroeconomics, but they often involve liquid and illiquid financial assets (Kaplan et al., 2014, 2018). Human capital is different: households can augment it but cannot sell it, so the adjustment margins are asymmetric (see also Angelopoulos et al., 2021).

We solve the household problem using a modified two-state endogenous-gridpoint algorithm based on Auclert et al. (2021). The key observation is that the human-capital technology generates a convex adjustment-cost structure, which allows us to adapt their approach; Appendix E provides the details.

The main outcomes of interest are the value function $V\left(a_{t-1}, h_{t-1}, e_t\right)$ and the policy functions for assets, consumption, labour supply, and human-capital investment, denoted by $g^a\left(a_{t-1}, h_{t-1}, e_t\right)$, $g^c\left(a_{t-1}, h_{t-1}, e_t\right)$, $g^l\left(a_{t-1}, h_{t-1}, e_t\right)$, $g^h\left(a_{t-1}, h_{t-1}, e_t\right)$, and $g^x\left(a_{t-1}, h_{t-1}, e_t\right)$, respectively. Together with the productivity transition and the exit-and-replacement probabilities, these policies define a transition operator Λ^{ss} that maps current states into next-period states. The stationary distribution associated with Λ^{ss} is denoted by λ_{ss}.

We compute the stationary distribution of endogenous and exogenous variables using a non-stochastic simulation (histogram) method (Heer and Maußner, 2009; Young, 2010; Angelopoulos et al., 2021). We begin by constructing a histogram over the joint state space, $\lambda(a, h, e) \geq 0$, with total probability mass one. We then define an approximation $\widetilde{\Lambda}^{ss}$ to the transition operator using linear interpolation to map next-period states that fall between grid points back onto the grid (for related details with two endogenous states Angelopoulos et al., 2021). Initialising λ_0 with uniform mass, we update the distribution according to

$$\lambda_{n+1} = \lambda_n \widetilde{\Lambda}^{ss}. \tag{18}$$

We continue updating λ_n until the difference between successive histograms falls below a pre-specified convergence criterion. The next section describes the calibration procedure and shows that the model reproduces key features of the UK economy prior to Covid-19.

3 Calibration

We calibrate the baseline version of the model to the United Kingdom economy around 2019. The calibration has three blocks. First, a set of preference, technology, fiscal, and demographic parameters is fixed outside the estimation loop at standard values or normalisations. This block includes the discount factor $\beta = 0.96$, the capital share $\alpha = 0.30$, utility curvature $\sigma = 1.5$, Frisch elasticity $\frac{1}{\theta} = 0.5$, the annual exit probability $\varpi = 1/30$, an initial steady-state interest rate of 3 percent, and the initial government debt ratio $B/Y = 0.8$. The values $\sigma = 1.5$ and a Frisch elasticity of 0.5 are in line with standard heterogeneous-agent macro calibrations and with the micro-to-macro labour-supply evidence surveyed by Chetty et al. (2011) and used in quantitative models such as Kaplan et al. (2018). Given α and the initial interest-rate target, private capital depreciation is pinned down internally to match $K/Y = 2.3$.

The public-capital block is mostly a normalisation in the initial steady state, but it governs the counterfactual in which fiscal capacity is invested productively. We set initial productive public investment to $I_g/Y = 0.05$, close to recent UK public-sector gross investment relative to GDP in HM Treasury fiscal data (HM Treasury, 2023), and set public-capital depreciation to $\zeta_g = 0.075$, a standard annual benchmark in quantitative public-investment models (Leeper et al., 2010; Chatterjee et al., 2018). These values imply $K_{g,ss}/Y_{ss} = 0.667$. The public-capital output elasticity is $\phi_g = 0.135$. This value follows from a recent OBR estimate that a sustained additional 1 percent of GDP in public investment raises long-run potential output by about 2.5 percent (Office for Budget

Responsibility, 2024).[7] We normalise $\xi_g = K_{g,ss}$, so $Z_{ss} = 1$ in the initial steady state. The elasticity ϕ_g therefore affects only the productivity response to changes in public capital, not the initial level of productivity.

Table 1: Baseline calibration summary

Category	Object	Value	Notes
Preferences	Discount factor β	0.960	Fixed annual value
Preferences	Utility curvature σ	1.500	Fixed preference value
Preferences	Labour-supply curvature θ	2.000	Fixed Frisch-curvature value
Technology	Capital share α	0.300	Fixed production value
Technology	Private depreciation ζ	0.100	Pinned down by the K/Y target
External sector	Initial steady-state interest rate r_0	0.030	Imposed initial steady-state rate
External sector	NFA spread elasticity ψ_r	0.007	Debt-spread estimate of Kónya and Maduko (2020), rounded from 0.0074
Human capital	Scale χ	0.699	Internally calibrated
Human capital	Curvature γ	0.461	Internally calibrated
Human capital	Retention δ_h	0.961	Disciplined by the late-career earnings profile
Human capital	Newborn reset h_{newborn}	0.433	Internally calibrated
Earnings process	Persistence ρ	0.740	Internally calibrated
Earnings process	Innovation scale σ_ϵ	0.219	Internally calibrated
Labour supply	Disutility scale ψ	1.712	Internally calibrated
Borrowing	Penalty/wedge r^{pen}	0.124	Internally calibrated
Bequests	Satiation scale $\bar{a}_B$	29.814	Internally calibrated
Bequests	Intensity φ_B	92.495	Internally calibrated
Fiscal	Labour tax level τ_1	0.739	Disciplined by the tax schedule
Fiscal	Tax progressivity τ_2	0.200	Fixed policy value
Fiscal	Transfers τ_0	0.065	Disciplined by average transfers
Fiscal	Initial debt ratio B/Y	0.800	Initial fiscal target
Public capital	Public investment share I_g/Y	0.050	Initial public-investment target
Public capital	Public capital depreciation δ_g	0.075	Fixed annual depreciation
Public capital	Output elasticity ϕ_g	0.135	OBR-implied scenario value

Notes: Values are annual where applicable.

Second, several policy and empirical objects are disciplined directly by data. The annual human-capital retention rate is estimated from Understanding Society using a

[7] With $\zeta_g = 0.075$, increasing I_g/Y from 0.05 to 0.06 raises the steady-state public-capital ratio from 0.667 to 0.800, so $(1.20)^{\phi_g} - 1 \simeq 0.025$ implies $\phi_g \simeq 0.135$.

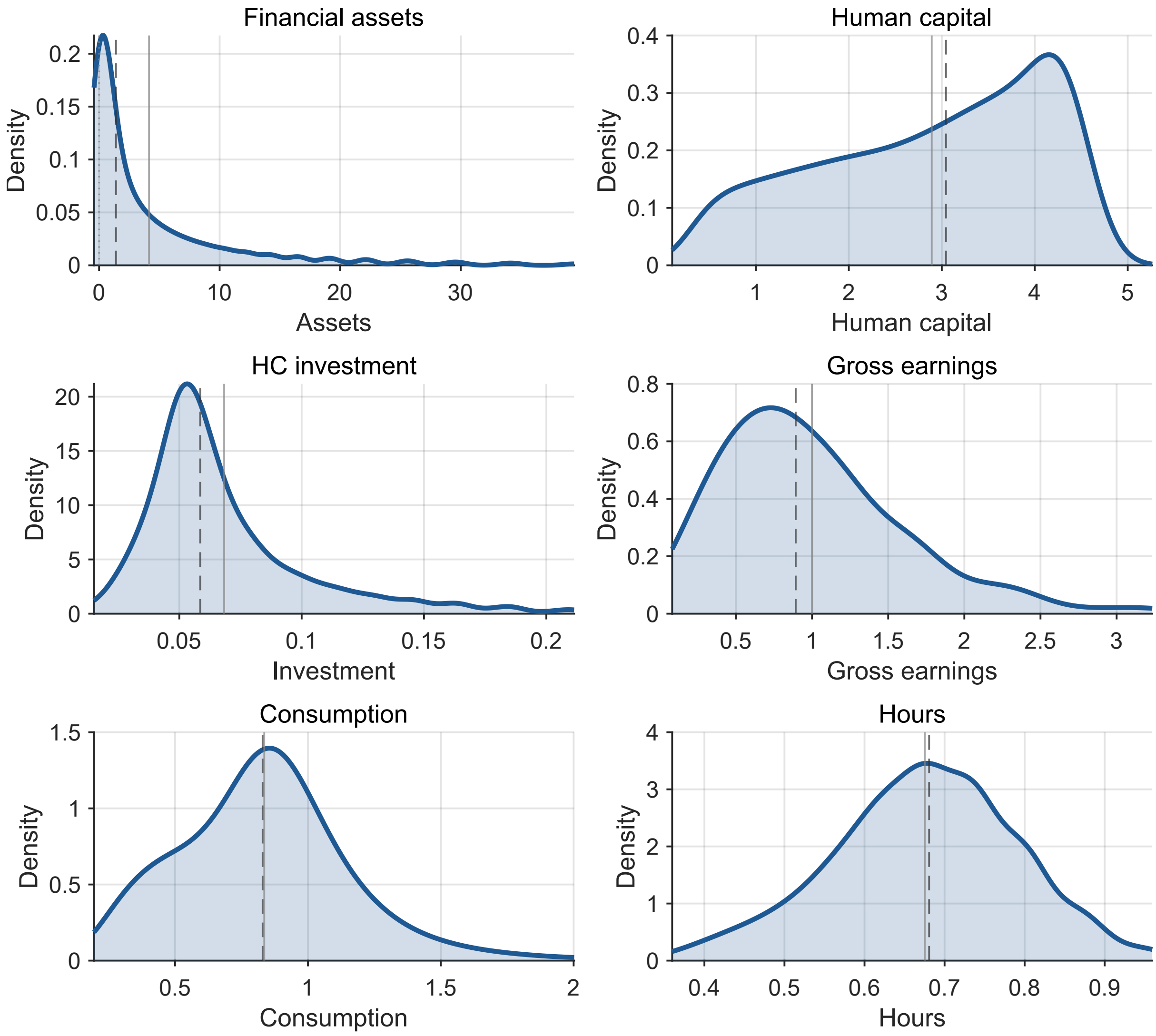
flat-spot regression on older full-time workers, which provides the estimate $\delta_h = 0.961$. The tax-and-transfer system follows the Heathcote et al. (2017) reduced-form schedule in (4). In the quantitative baseline, we set $\tau_2 = 0.2$, choose $\tau_1 = 0.739$ to match the average tax rate in the data, and set $\tau_0 = 0.065$ to match average transfers.

Third, we estimate the remaining household-side parameters to match nine stationary moments. These parameters are the human-capital accumulation parameters $(\chi, \gamma, h_{\text{newborn}})$; the earnings-process parameters (ρ, σ_ϵ); disutility of labour ψ; the borrowing wedge r^{pen}; and the bequest parameters $(\varphi_B, \bar{a}_B)$. The targets span effective labour, residualised earnings shares, hours, wealth accumulation, liquidity, and wealth concentration.

For a candidate parameter vector $\boldsymbol{\vartheta}$, we solve the stationary equilibrium, compute the model-implied moment vector $M^{\text{model}}(\boldsymbol{\vartheta})$, and choose $\widehat{\boldsymbol{\vartheta}}$ to minimise the sum of squared target-scaled moment gaps using a nonlinear optimisation routine. Table 1 reports the resulting parameter values; Appendix B reports the target fit in Table B1 and describes the empirical inputs and numerical diagnostics.

3.1 Stationary Distribution and Summary Statistics

Figure 1: Weighted stationary distributions.



Note: Distributions of key household outcomes in the calibrated steady state. Each panel reports a kernel density over the central 99 percent of weighted mass. Dashed lines denote medians and solid lines denote means.

Figure 1 and Table 2 summarise the stationary distribution implied by the calibrated model. The figure reports weighted kernel densities for asset holdings, human capital, human-capital investment, gross earnings, consumption, and hours, while the table reports a common set of average and distributional statistics for these outcomes together with net earnings. The figure makes the main cross-sectional patterns visually clear. Asset holdings are strongly right-skewed, with a long upper tail and a substantial gap between the mean and the median. Gross earnings are also right-skewed, but their density is much tighter than that of wealth. By contrast, consumption and hours are concentrated in relatively narrow ranges, with much smaller mean-median gaps, which is consistent with

Table 2: Initial steady-state distribution summary

Variable	Mean	p10	p50	p90	p99	Gini
Financial assets	4.143	-0.088	1.402	12.298	34.133	0.711
Human capital	2.892	1.029	3.046	4.407	4.609	0.238
HC investment	0.068	0.037	0.059	0.114	0.194	0.256
Gross earnings	1.000	0.328	0.893	1.725	3.044	0.330
Net earnings	0.783	0.368	0.740	1.208	1.866	0.249
Consumption	0.836	0.411	0.830	1.224	1.831	0.217
Hours	0.675	0.521	0.681	0.811	0.944	0.098

Notes: Statistics are weighted by the initial stationary. The asset Gini is computed from raw asset positions, including debt.

the insurance role of assets and the comparatively smooth labour-supply margin in the stationary equilibrium.

The figure also shows that human capital is dispersed: its density is single-peaked and much less stretched than the asset distribution. Human-capital investment has a visibly longer upper tail than the stock of human capital itself, although the two distributions are much closer by the Gini coefficient. Table 2 reports a Gini coefficient of 0.238 for human capital and 0.256 for human-capital investment, compared with 0.711 for financial assets. The longer investment tail is consistent with the model's convex investment cost and the stronger concentration of resources at the top of the asset distribution. Overall, the combination of a highly skewed wealth distribution and a more moderate distribution of earnings, human capital, consumption, and hours is the central cross-sectional feature that the calibrated stationary model is designed to reproduce.

4 Debt Deleveraging

Many advanced economies entered the post-pandemic period with debt burdens that were already elevated by the Global Financial Crisis and were then pushed higher again by the Covid-19 shock (International Monetary Fund, 2024; OECD, 2025; Checherita-Westphal et al., 2024). This has revived concerns about fiscal sustainability, but also about fiscal preparedness: governments facing higher debt-service costs have less room to respond to future recessions and less scope to accommodate new structural spending needs, including defence, demographic transitions, and other long-run public commitments. These concerns naturally shift the policy discussion from whether fiscal space matters to how it should be rebuilt. In the rest of the paper we consider the case of a large reduction in public debt aimed at increasing fiscal headroom and improving public finances. We analyse the effects of different fiscal instruments to finance the deleveraging, different consolidation trajectories and alternate uses of the gained fiscal headroom.

In short, the government chooses a path for the public-debt stock and then selects a fiscal instrument path that implements it, taking into account the effect that this has on prices and household decisions. The exercise is close in spirit to the transition analysis of Röhrs and Winter (2017), who show that the timing of debt reduction matters in an incomplete-markets economy with inequality. We depart from their implementation in two important ways. First, we compare alternative fiscal instruments rather than a single composite. Second, we allow for different uses of the additional fiscal headroom generated by the debt reduction. The results of our analysis show that the distinction matters both qualitatively and quantitatively.

4.1 Lower-Debt Steady States

For all our experiments, we assume that the government aims to reduce the public-debt stock by an amount equal to 10 percent of initial output, equivalent to a 10-percentage-point reduction in the initial debt-to-output ratio when measured at initial output. Because the model is solved in levels, all scenarios use the same terminal debt stock rather than mechanically imposing the same terminal debt-to-output ratio.[8] A lower level of public debt changes the final equilibrium in two distinct ways. First, lower government borrowing reduces the total demand for savings and the interest rate, encouraging a higher level of privately employed capital and thereby raising output and wages. Second, lower debt service gives the government additional resources that can finance general expenditure, public investment, or household transfers. We refer to these cases as *Government Spending*, *Public Investment*, and *Additional Transfers*, respectively. Appendix Table D1 reports the initial steady state and the three distinct lower-debt steady states used in the quantitative exercises.

In the remainder of this section we focus on the base case of additional government spending, meaning that the government spends all savings associated with the lower debt along the transition path, and in final equilibrium. This is the natural starting point for the fiscal-capacity analysis: the interest saving from lower debt is visible in the budget, but is spent in a way that does not distort the incentives of the households. In the following section we will then extend the analysis to cover alternative uses of fiscal headroom.

The second column of Table D1 shows the lower-debt allocation at the Government Spending baseline. Debt falls from $B = 1.143$ to $B = 1.000$, while output is essentially unchanged, moving from $Y = 1.428$ to $Y = 1.429$. The realised debt ratio is therefore $B/Y = 0.700$. The equilibrium interest rate falls only slightly, from 0.0300 to 0.0299, and the main fiscal accounting change is that residual government spending rises from 0.111

[8] We assume a fixed path for the debt level rather than the debt-to-output ratio because the strong response of output under some fiscal instruments makes certain debt-to-output paths infeasible. This distinction matters once the use of fiscal space changes output.

to 0.116 in the terminal steady state. The other two columns preview the Additional Transfers and Public Investment cases analysed in Section 5. When the same debt-level reduction is invested in productive public capital, output rises to 1.462, public capital rises from 0.952 to 1.009, and productivity rises by 0.8 percent. Because output is higher, the same terminal debt level implies a lower realised debt ratio, $B/Y = 0.684$. When the fiscal capacity is allocated to transfers, the lump-sum transfer rises from 0.065 to 0.069 and the realised debt ratio is $B/Y = 0.698$.[9]

4.2 Fixed Debt-Path Transition Experiments

At time $t = 0$, the government announces a permanent deleveraging plan aiming to reduce public debt by 10% of initial output over a 25-year horizon. Households perfectly foresee the resulting transition path. The full transition is solved over a long finite horizon with terminal conditions pinned down by the relevant lower-debt steady state. The policy object is an announced debt-level path $\{\bar{B}_t\}_{t=0}^{T}$. Let

$$\upsilon_t = \min\{t/25, 1\} \tag{19}$$

be the fraction of the policy window that has elapsed. The three timing cases are defined by progress functions $p(\upsilon_t)$ that map elapsed time into the fraction of total debt reduction completed:

$$p^F(\upsilon) = 1 - (1-\upsilon)^3, \quad p^L(\upsilon) = \upsilon, \quad p^B(\upsilon) = \upsilon^3, \tag{20}$$

where F denotes front-loading, L a linear path, and B back-loading of the debt reduction. The debt-level path is then

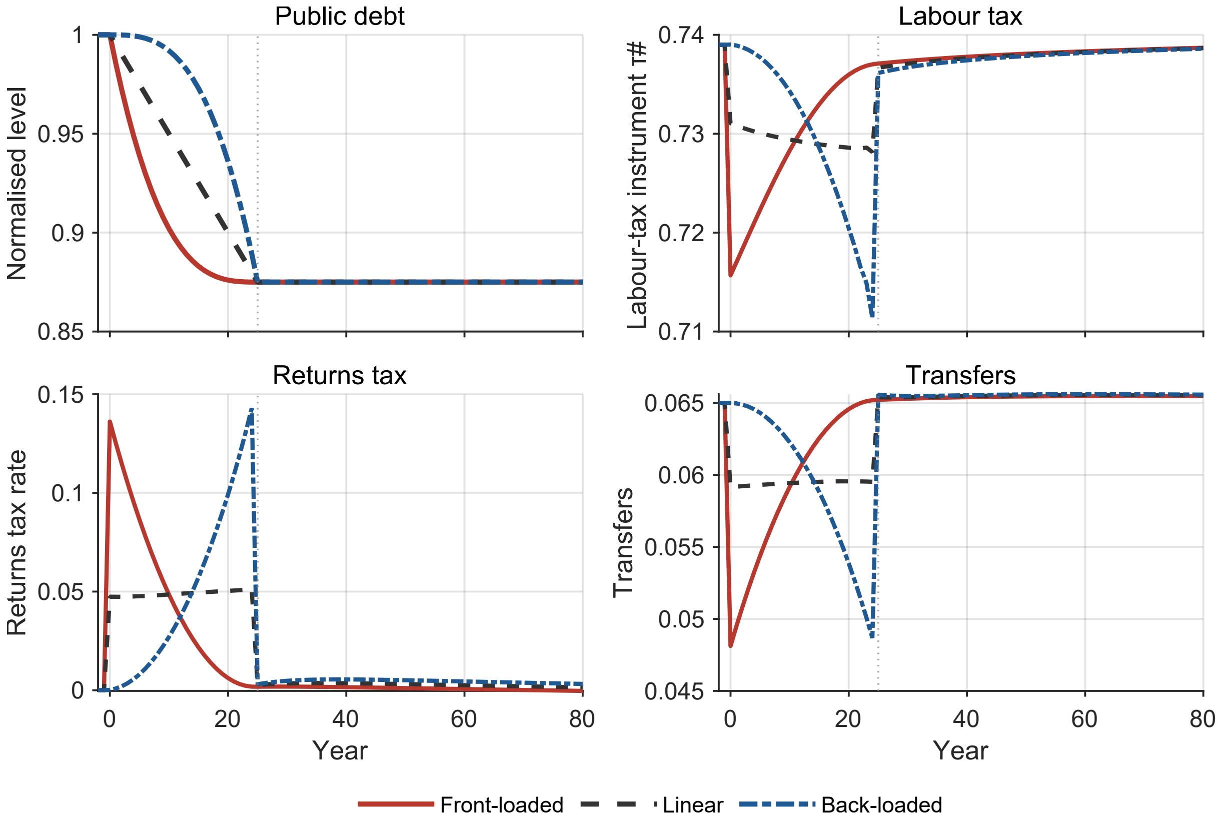
$$\bar{B}_t = B_0 - p(\upsilon_t)(B_0 - B^*). \tag{21}$$

After year 25 the public-debt level is held at B^* while the rest of the economy continues to converge.[10]

[9] These terminal differences mean that the following fiscal-capacity allocations should be read primarily as matched transition experiments, not as a single ranking over identical terminal economies.

[10] The budget-clearing instrument remains endogenous through year 150. From year 151 onwards it is fixed at its terminal steady-state value and residual government spending G_t absorbs the remaining budget adjustment.

Figure 2: Government Spending baseline: debt and instrument paths.



Note: The public-debt subplot shows the fixed public-debt paths, while the remaining subplots show the budget-clearing instrument paths under the labour income tax, returns tax, and transfers closures. The vertical dotted line marks year 25, the end of the debt-adjustment window.

At the same time, the government announces how it will allocate the projected fiscal headroom. Let H_t denote the level of projected debt-service savings available in period t, measured relative to the initial fiscal allocation. We assume that this component follows progress along the announced debt path, valued at the initial steady-state interest rate:

$$H_t = r_0 \left(B_0 - \bar{B}_t\right), \qquad t \geq 0. \tag{22}$$

This rule captures a government that commits an ex-ante projection of the interest savings rather than conditioning the allocation on the realised interest-rate path.[11]

To achieve the transition, the government selects one out of the available fiscal instruments, namely general labour taxation τ_1, transfers τ_0 or taxes on returns to assets τ_a. These three instruments span the main incidence margins of the model: labour earnings and human-capital accumulation incentives, asset-return income and wealth, and disposable resources for households reliant on transfers. For a given fiscal instrument q_t, the

[11]This may approximate a setting in which the government cannot perfectly forecast the interest-rate path, or in which budget rules limit subsequent flexibility. It also reduces the complexity of the dynamic problem.

government chooses one value of q_t in each period so that the government budget clears along the announced debt path,

$$\mathcal{R}_t(q_t, \lambda_t, \mathbf{P}_t) + \bar{B}_t = \mathcal{G}_t + (1 + r_t)\bar{B}_{t-1}, \qquad t \geq 0, \tag{23}$$

where $\bar{B}_{-1} \equiv B_0$, λ_t is the household distribution, $\mathbf{P}_t$ collects equilibrium prices and aggregate quantities, $\mathcal{G}_t$ denotes government purchases and public investment, and $\mathcal{R}_t$ denotes net fiscal revenues, including taxes and transfers. Under Government Spending, H_t raises G_t; under Additional Transfers, it raises $\tau_{0,t}$ and therefore lowers net revenues; under Public Investment, it raises $I_{g,t}$; and under Fiscal Discipline, it is left unallocated so that the budget-clearing instrument moves by less. In every case, the debt path is fixed, one fiscal instrument clears the budget, and household and firm decisions are consistent with the implemented path.

As our baseline, we assume for simplicity that the government increases G_t in line with available headroom, which captures government spending that is outside household utility and private-sector productivity. It can be interpreted as public consumption or other commitments not modelled explicitly, such as defence spending. This convention keeps the debt-service savings inside the government-spending component of the budget while the remaining budget pressure is met by one of the three fiscal instruments.

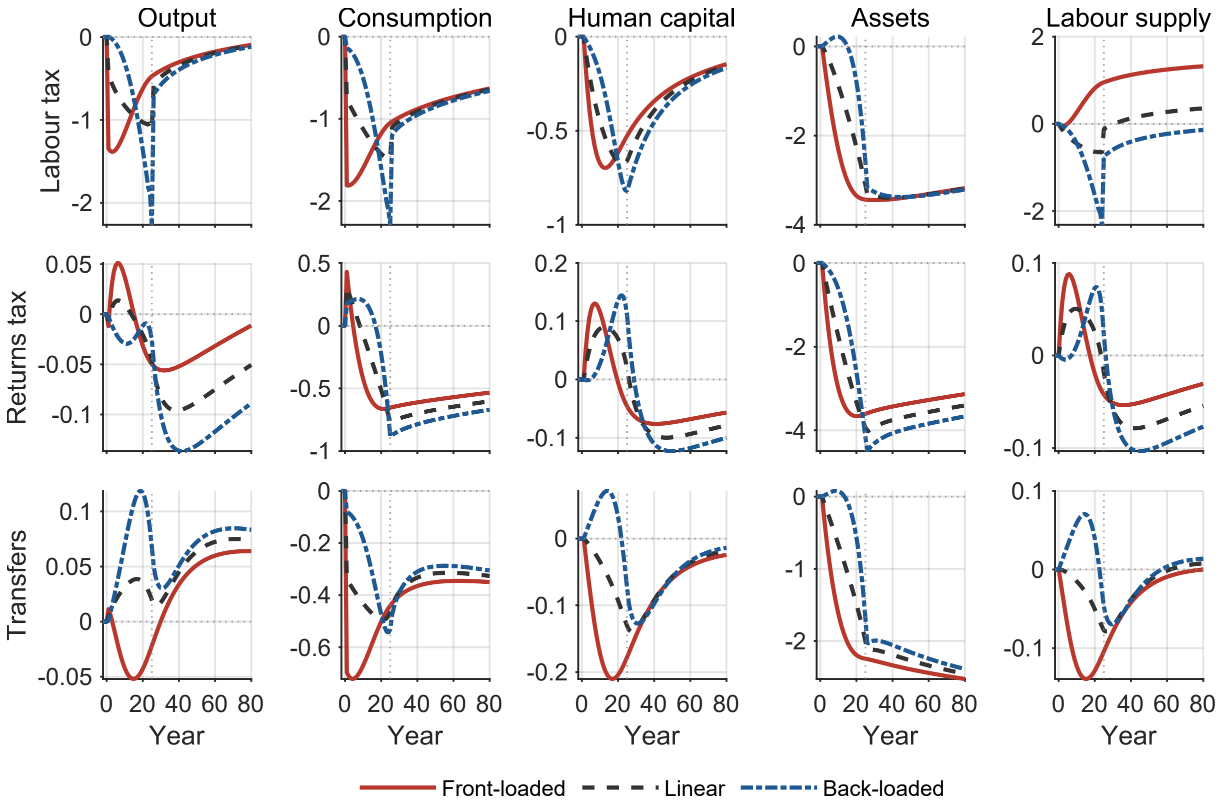
Figure 2 shows the fixed debt paths and the instrument paths in this baseline. The public debt panel confirms that all timing cases reach the same debt level by year 25. The other panels show the fiscal effort needed to implement the path of publicly held debt. Front-loaded consolidations require large early movements; back-loaded consolidations postpone the adjustment but create large instrument movements near the end of the policy window, especially under the labour-income-tax and returns-tax closures.

4.3 Aggregate Transition Dynamics

Figure 3 reports the headline macroeconomic transitions under the Government Spending baseline. The labour-income-tax row is the most contractionary for output, consumption, human capital, and labour supply. These outcomes, together with assets, fall below their initial steady-state levels around the main adjustment. Labour supply subsequently rebounds and can rise above baseline as households respond to lower resources. Front-loading produces an earlier downturn, while back-loading postpones the main recession until the end of the policy window. This distinction is important: back-loading changes the timing of the pain, but it does not remove it.

The returns-tax row looks very different. Output and labour supply remain close to their initial levels over most of the transition. The main aggregate cost is visible in assets and, to a lesser extent, consumption. This is consistent with the instrument's incidence: returns taxation shifts the burden toward asset holders without directly reducing the after-tax return to work or the resources generated by labour income. The transfers row provides a third case. Output and labour supply are comparatively stable, but consumption and assets fall because the instrument directly reduces disposable resources and households smooth the transfer reduction.

Figure 3: Government Spending baseline: aggregate transitions.



Note: Rows correspond to the three fiscal instruments and columns to output, mean consumption, mean human capital, mean assets, and labour supply. Series are reported as percentage deviations from year 0. The vertical dotted line marks year 25.

Table 3: Macroeconomic transition losses: Government Spending

Timing	Output trough	Trough year	Cumulative losses, years 0–25 Y	C	H	X	A	N
Panel A: Labour tax								
Front-loaded	-1.38	3	24.15	36.43	13.82	47.40	59.62	0.15
Linear	-1.11	25	21.42	29.83	11.77	47.08	33.82	11.25
Back-loaded	-2.26	25	18.55	23.30	9.18	46.01	10.91	21.10
Panel B: Returns tax								
Front-loaded	-0.06	32	0.33	10.78	0.16	3.97	70.69	0.21
Linear	-0.10	39	0.25	6.54	0.00	1.34	54.06	0.02
Back-loaded	-0.14	42	0.48	3.35	0.00	1.21	35.81	0.02
Panel C: Transfers								
Front-loaded	-0.05	15	0.82	15.13	3.91	12.59	40.44	2.67
Linear	0.00	0	0.00	11.00	1.38	6.17	23.25	0.72
Back-loaded	0.00	0	0.00	7.20	0.15	4.18	7.59	0.08

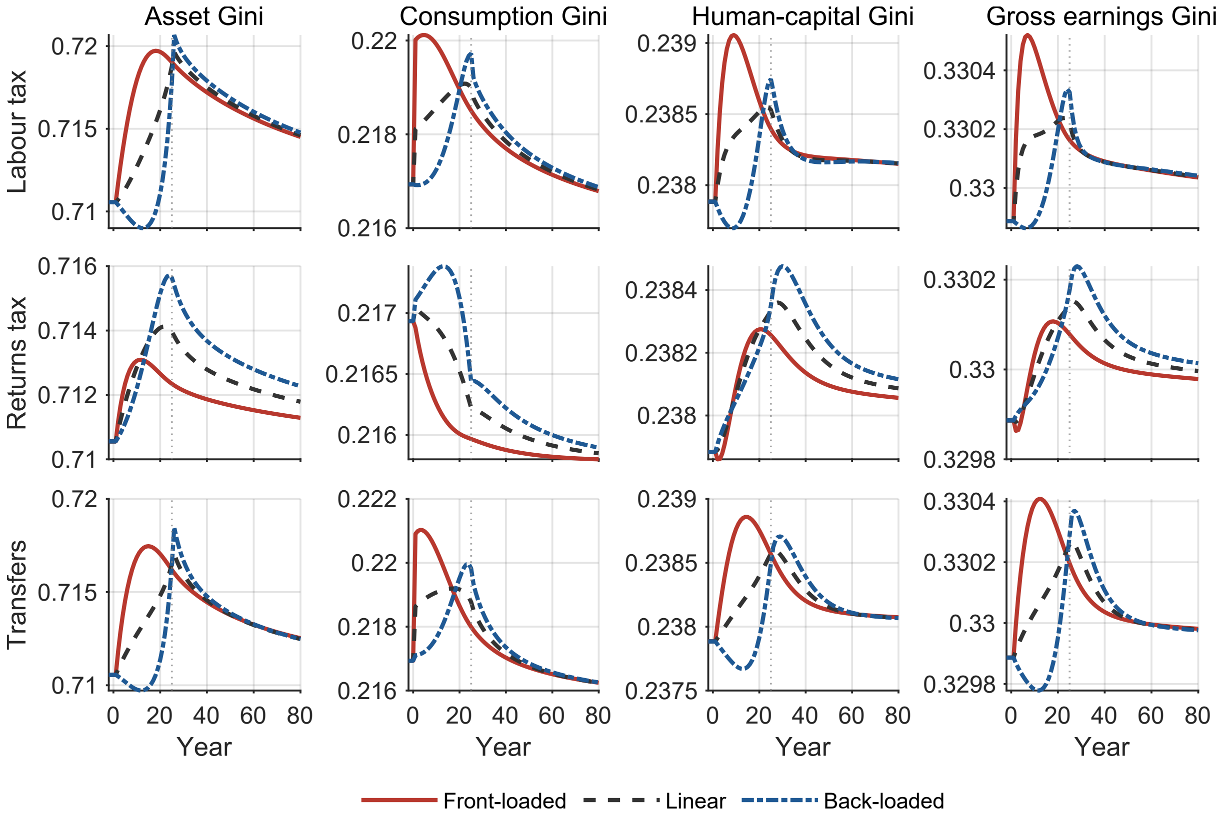
Notes: Series are percentage deviations from year 0. For each reported series p, cumulative loss is $\sum_{t=0}^{25} \max\{-\Delta p_t, 0\}$ and is measured in percentage-point-years. Y is output, C mean consumption, H mean human capital, X mean human-capital investment, A mean financial assets, and N effective labour supply.

Table 3 compresses the policy-window dynamics into trough and cumulative-loss measures. Under labour-income-tax closure, the linear path generates a cumulative output loss of 21.42 percentage-point-years over years 0–25. Back-loading lowers this measure to 18.55 percentage-point-years, but produces a deeper output trough of 2.26 percent in year 25. Under returns taxation, output losses are negligible, while they remain small under transfers closure; the relevant aggregate costs appear mainly in assets and consumption.

4.4 Distributional Dynamics

Figure 4 reports the evolution of inequality in the baseline. The asset-Gini panels show that the timing of consolidation affects the distribution of wealth, especially under labour-income-tax closure. Front-loaded labour-tax consolidation raises asset inequality earlier, while back-loading shifts the increase toward the end of the policy window. Consumption inequality follows a similar but more muted pattern. Under returns taxation, timing effects on the Gini series are more muted, even though the welfare incidence below is sharply polarised because the burden falls on asset-return income. Under transfers adjustment, both asset and consumption inequality rise during the consolidation window, with the larger absolute movement occurring in the asset Gini. The increase in consumption inequality reflects the direct withdrawal of common disposable resources.

Figure 4: Government Spending baseline: distributional dynamics.



Note: Rows correspond to the three fiscal instruments and columns to asset, consumption, human-capital, and pre-tax earnings Gini coefficients. The vertical dotted line marks year 25.

4.5 Welfare and Incidence

We evaluate welfare using a state-by-state consumption-equivalent variation (CEV) measure. Let $s = (a, h, e)$ denote an initial household state and let $V^{\mathrm{tr}}(s)$ denote the value of living through a given transition. To construct the comparison value $V^0(s; \nu)$, we scale consumption under the initial steady-state policy by $1 + \nu$ while holding the baseline policy functions and their induced state transition fixed. The state-specific CEV solves

$$V^0(s; \nu(s)) = V^{\mathrm{tr}}(s). \tag{24}$$

The mean incumbent welfare statistic is the initial-distribution-weighted mean of these state-level objects,

$$\overline{\nu} = \sum_s \omega_0(s)\nu(s), \tag{25}$$

where $\omega_0(s)$ denotes the initial stationary distribution on the state space. Thus ν is measured as a proportional change in baseline consumption: positive values indicate that the transition is preferred to remaining in the initial steady state, and negative values indicate welfare losses.

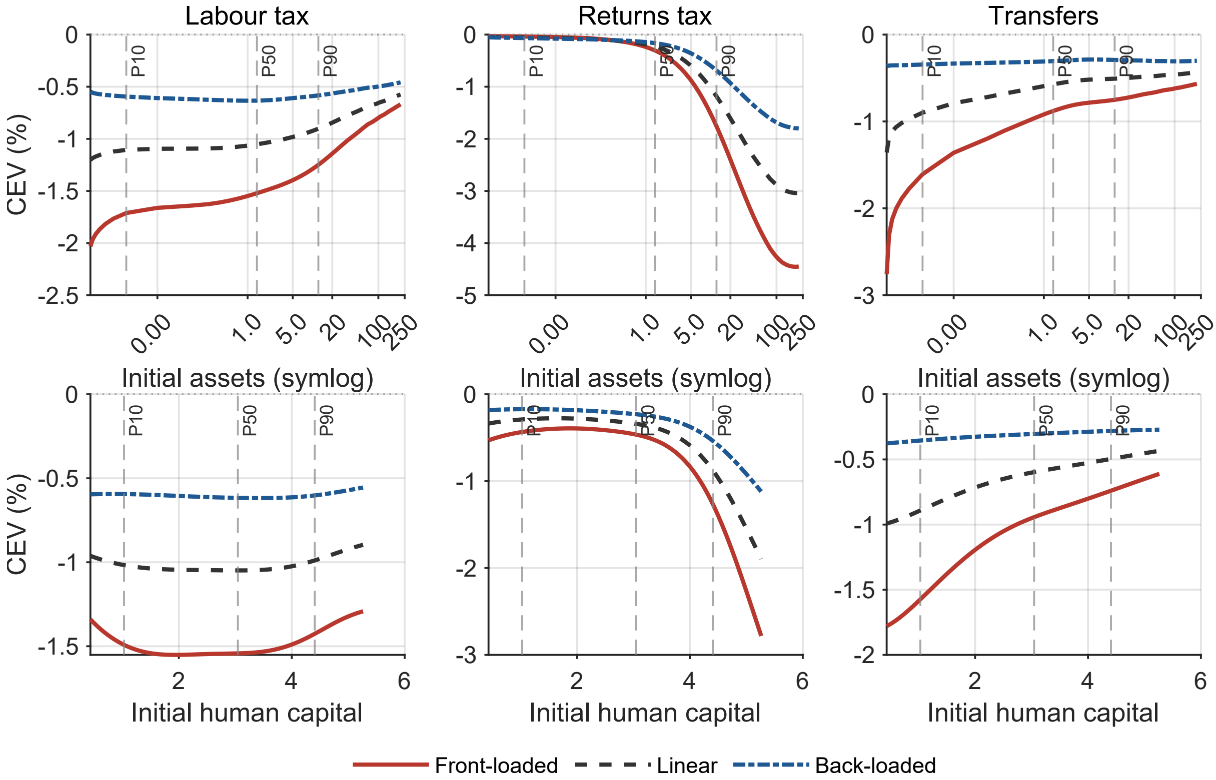
Table 4: Welfare, preferences, and incidence: Government Spending

	CEV			Preferred share		Initial assets			Initial HC		
	Mean	Rel. disp.	> 0 share	Pref. policy	Pref. timing	Bottom 10%	Top 10%	Δ	Bottom 10%	Top 10%	Δ
Panel A: Labour tax											
Front-loaded	-1.509	0.158	0.0	0.2	0.0	-1.825	-1.159	0.666	-1.420	-1.430	-0.010
Linear	-1.030	0.098	0.0	0.0	0.0	-1.140	-0.852	0.288	-0.991	-0.984	0.006
Back-loaded	-0.609	0.044	0.0	0.0	100.0	-0.576	-0.565	0.011	-0.594	-0.594	-0.001
Panel B: Returns tax											
Front-loaded	-0.617	1.201	0.0	71.2	30.8	-0.032	-2.358	-2.326	-0.477	-1.429	-0.952
Linear	-0.436	1.118	0.0	70.1	0.3	-0.048	-1.584	-1.536	-0.310	-0.989	-0.679
Back-loaded	-0.278	0.976	0.0	66.9	68.9	-0.058	-0.919	-0.861	-0.175	-0.602	-0.427
Panel C: Transfers											
Front-loaded	-1.041	0.456	0.0	28.6	0.0	-1.995	-0.721	1.273	-1.717	-0.726	0.991
Linear	-0.641	0.331	0.0	29.9	0.0	-1.058	-0.496	0.562	-0.960	-0.489	0.470
Back-loaded	-0.311	0.101	0.0	33.1	100.0	-0.353	-0.295	0.059	-0.368	-0.280	0.088

Notes: CEVs are reported as percentages of baseline consumption. Relative dispersion is the weighted standard deviation of state-level CEV divided by the absolute weighted mean CEV. CEV > 0 share, preferred policy, and preferred timing are percentages. Preferred policy is the weighted share of households for whom the fiscal instrument gives the highest CEV among the three instruments, holding the timing path fixed. Preferred timing is the weighted share of households for whom the timing path gives the highest CEV among the three timing paths, holding the fiscal instrument fixed. Bottom and top 10% columns report weighted mean CEVs for households in the corresponding deciles of the initial asset or human-capital distribution. The Δ column is the top-decile mean CEV minus the bottom-decile mean CEV and is measured in percentage points.

Table 4 summarises the welfare implications of the Government Spending baseline for initial incumbents. Under the linear debt path, mean incumbent CEV is -1.030 percent under the labour income tax, -0.436 percent under returns taxation, and -0.641 percent under transfers adjustment. The instrument ranking is therefore clear in the baseline case: returns taxation has the smallest mean incumbent welfare loss, transfers are intermediate, and the labour income tax is the most costly. Back-loading improves mean incumbent welfare within all three instruments. Moving from the linear labour-tax path to the linear returns-tax path improves mean incumbent CEV by 0.594 percentage points, while moving from front-loading to back-loading within returns taxation improves mean incumbent CEV by 0.339 percentage points. The timing gains are larger under labour taxation and transfers adjustment, but they do not overturn the instrument ranking at any given timing.

Figure 5: Government Spending baseline: CEV incidence by initial assets and human capital.



Note: The top row conditions on initial assets and the bottom row on initial human capital. Columns correspond to the three fiscal instruments. Dashed vertical lines mark selected percentiles of the initial distribution; the horizontal dotted line denotes zero CEV.

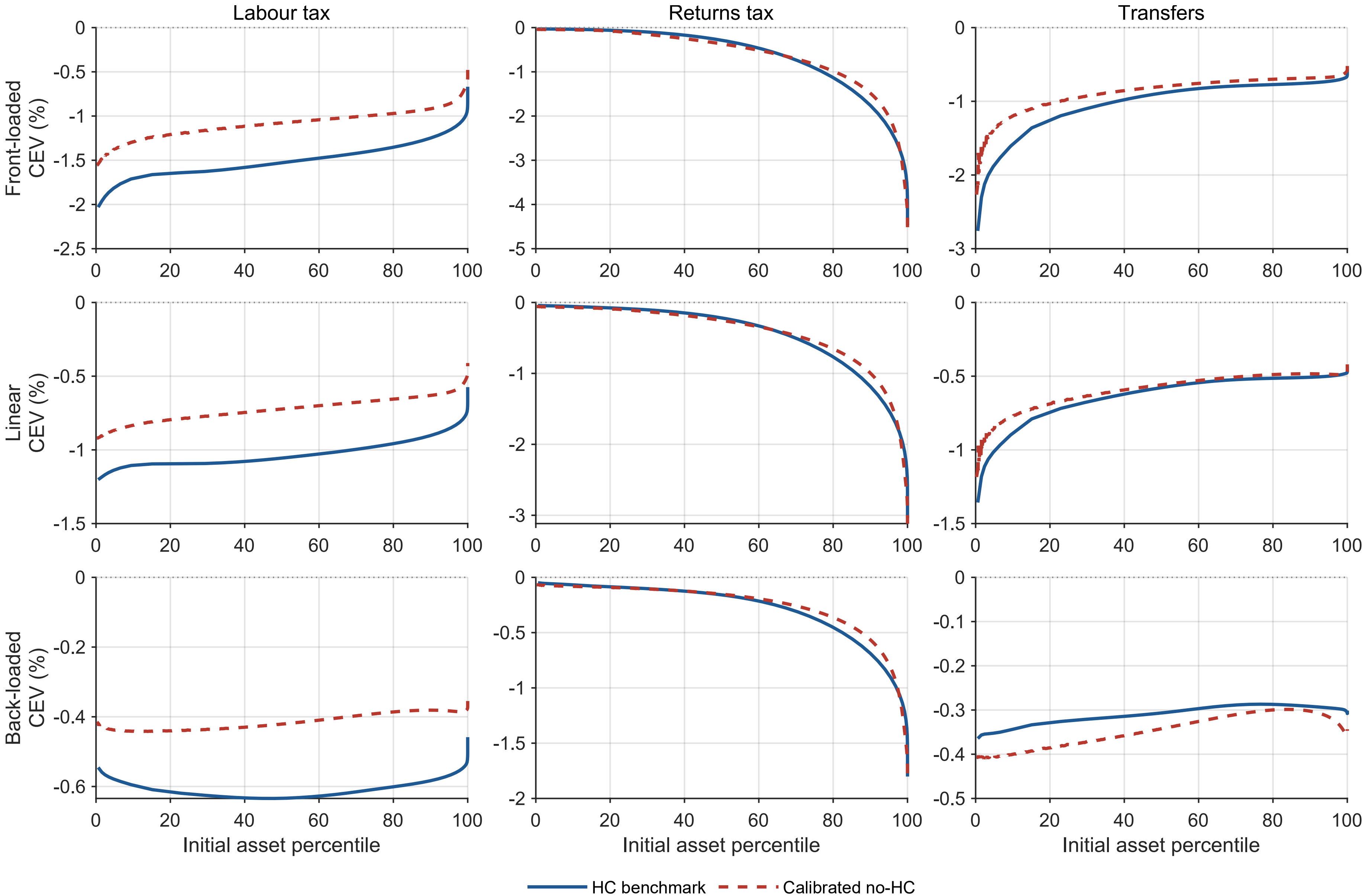
The average incumbent welfare statistics mask considerable heterogeneity in incidence across the distribution of households. The third column of Table 4 highlights that the relative dispersion of welfare losses varies considerably across policy instruments and timing choices. Dispersion is particularly high when asset returns are taxed, suggesting that losses are concentrated among a smaller number of households, whereas they are more evenly distributed when labour taxes or transfers are chosen as fiscal instruments. This pattern reflects the strong concentration of wealth in the model and is also visible in the initial-assets columns of the same table. Under the labour-tax and transfers closures, assets provide a buffer that helps households maintain consumption as taxation reduces their available resources. Welfare losses are therefore larger for the bottom asset decile than for the top decile. Under returns taxation, assets instead provide the tax base, leaving low-asset households largely insulated from the tax. Similar, though more muted, patterns appear across the initial human-capital distribution.

While the choice of fiscal instrument has the most pronounced effects on the distribution of welfare, there exist interesting patterns with respect to the choice of deleveraging timing even conditional on the choice of fiscal instrument. On average, incumbent welfare improves as debt reductions are back-loaded in time. Back-loading improves incumbent welfare for two reasons: First, workers discount future utility, so adjustments required in the far future do not harm them as much. Second, when the fiscal adjustment bites in the more distant future, workers have time to prepare by adjusting their choices in the lead-up to the tax increase. This echoes the result of Röhrs and Winter (2017), who show that in an incomplete-markets economy with assets, public-debt reductions are optimally back-loaded. However, our results uncover some nuance in this mechanism. In the case of Returns taxation, front-loading the transition is actually preferred by low-asset households. This is intuitive, as these households do not hold many assets that can be taxed but anticipate that they may become wealthy in the future. They therefore prefer to shift the burden of debt repayment towards their currently wealthier contemporaries.

This conflict of interest is summarised by the preferred share columns in the table. Holding timing of the adjustment fixed, roughly 70 percent of households prefer returns taxation and roughly 30 percent prefer transfers adjustment. Holding the fiscal instrument fixed, back-loading is unanimously preferred under labour taxation and transfers adjustment. Returns-tax timing preferences are more divided: under the Government Spending baseline, 30.8 percent of households prefer front-loading and 68.9 percent prefer back-loading. This split reflects the asset-tax mechanism. Front-loading taxes predetermined wealth earlier and can be attractive to households that bear relatively little of this burden, while back-loading softens losses for high-asset households.

Figure 5 maps the same welfare effects across the initial state space. The labour-income-tax panels show broad losses, with larger losses among low-asset households. The returns-tax panels show the opposite asset gradient: low-asset households lose little relative to the mean, while welfare falls sharply in the high-asset tail. The transfers panels provide the third pattern: losses are again larger for low-asset and low-human-capital households because transfers provide disposable resources and insurance to households with limited private buffers.

Figure 6: Human-capital and no-human-capital comparison: Government Spending CEV incidence by initial assets.



Note: Rows correspond to front-loaded, linear, and back-loaded debt paths. Columns correspond to labour-tax, returns-tax, and transfer closures. Each panel overlays the human-capital benchmark and the calibrated model without human capital. CEVs are percentages of baseline consumption and are plotted against the midpoint of each initial-asset mass bin.

4.6 Human-Capital Mechanism

To isolate the role of endogenous skill accumulation, Appendix C repeats the deleveraging exercises in an economy without human capital, which we denote no-HC. The calibrated no-HC model re-estimates household-side parameters to match the main stationary moments of the benchmark economy, as shown in Table C1.

The comparison confirms the broad incidence regimes, but shows that the human-capital margin is central for the size and persistence of labour-tax losses. Table C3 shows that labour-tax consolidation is still contractionary without human capital, but the benchmark economy also loses human capital during the transition. Under the linear Government Spending path, the cumulative output loss over years 0–25 is 21.42 percentage-point-years in the benchmark economy, compared with 10.78 in the calibrated no-HC model. Labour taxation therefore damages the economy through two channels: it reduces current labour supply and it discourages investment in future earnings capacity, which leaves a longer-lived effect on output and the tax base. The welfare evidence in Table C4 makes the same point. Under the same path, mean incumbent CEV under labour taxation is -1.030% in the benchmark economy, compared with -0.727% in the calibrated no-HC model. Figure 6 reports the baseline incidence profiles.

5 Alternative Uses of Fiscal Capacity

The baseline analysis assigns the fiscal dividend from lower debt-service costs to residual Government Spending, G_t. This provides a clean benchmark in which the additional fiscal capacity is absorbed without changing household tax or transfer schedules, but it raises a natural question: does the welfare ranking of deleveraging packages depend on how this spare fiscal capacity is used?[12] This section therefore examines how incumbent welfare and its distribution vary when the same projected headroom is assigned to alternative uses.

We consider three alternatives to the Government Spending benchmark. Under *Fiscal Discipline*, the debt-service savings relax the budget-clearing instrument during the transition. Under *Additional Transfers*, they are returned directly to households through the lump-sum transfer. Under *Public Investment*, they finance productive public capital. Each experiment imposes the same fixed debt-level path and uses the same projected fiscal headroom. Government Spending and Fiscal Discipline share a terminal steady state, whereas Additional Transfers and Public Investment imply different final allocations. The

[12]For example, Röhrs and Winter (2017) vary the speed and tax instrument while holding other budget components fixed. Coenen et al. (2008) and Almeida et al. (2013) compare several long-run uses of lower interest payments, including tax relief, transfers, and public spending. Sakkas and Varthalitis (2021) consider a broader allocation across government consumption, public investment, education, transfers, and tax reductions.

latter comparisons should therefore be interpreted primarily as matched transition experiments rather than as welfare rankings across identical terminal economies. Appendix D reports the terminal allocations and the complete set of macroeconomic, welfare, and incidence results.

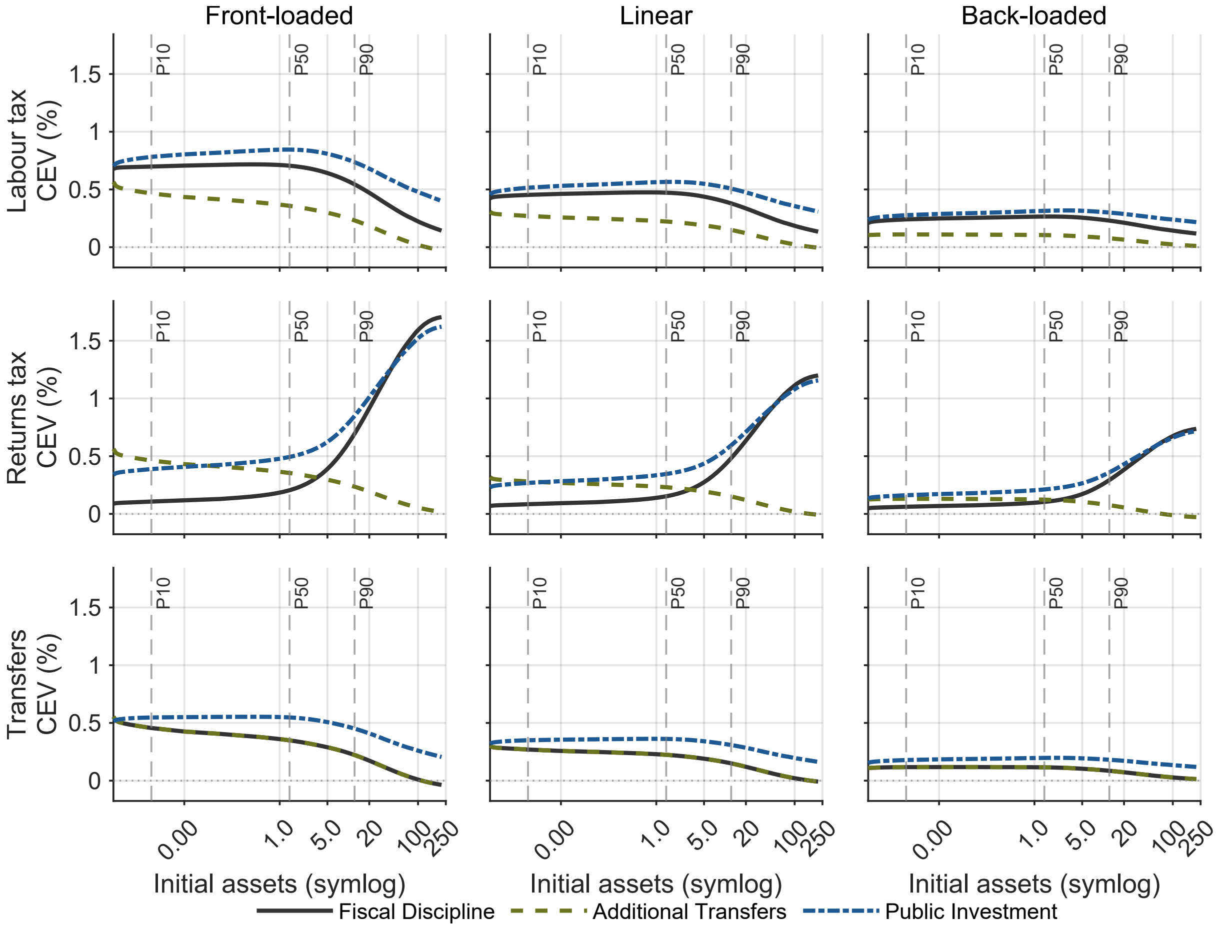
The qualitative incidence of the financing instruments is robust to how fiscal headroom is used. Low-asset households favour returns taxation because they hold little of the associated tax base. High-asset households are more likely to favour transfers adjustment because their private resources cushion the withdrawal of public transfers. Labour taxation remains unattractive throughout the distribution because it lowers current labour income and discourages investment in future earnings capacity. These patterns survive across all four uses of fiscal capacity and all three debt paths.

What changes, sometimes substantially, is the quantitative incumbent welfare cost and its distribution across households. For the linear debt path, reallocating headroom reduces mean incumbent CEV losses under every financing instrument. Relative to Government Spending, the mean loss under labour taxation falls from 1.030% to as little as 0.494% under Public Investment. The corresponding loss under returns taxation falls from 0.436% to 0.045%, while that under transfers adjustment falls from 0.641% to 0.298%. The mechanisms differ across allocations. Fiscal Discipline limits the movement in the budget-clearing instrument; Additional Transfers cushion disposable household resources; and Public Investment supports productivity, wages, human-capital accumulation, and the tax base. The use of headroom therefore changes the magnitude of the welfare consequences even though it leaves the broad instrument ranking intact.

The distributional changes are particularly pronounced under returns taxation. In the linear Government Spending case, the positive-CEV share is 0.0%, and the bottom and top asset deciles experience losses of 0.048% and 1.584%, respectively. Fiscal Discipline raises the positive-CEV share to 34.1%. Additional Transfers raise it to 50.9%, with the bottom asset decile gaining 0.248% while the top decile loses 1.463%. Public Investment broadens the gaining coalition further: 63.1% of households obtain a positive CEV, although the top asset decile still loses 0.879%. Alternative uses of headroom can thus turn small losses among low-asset households into gains without eliminating the losses borne by households with substantial exposure to the returns-tax base.

Figures 7 and 8 show these welfare changes relative to the matched Government Spending experiment. Fiscal Discipline primarily benefits households exposed to the budget-closing instrument. Its gains are broad under labour taxation, while under returns taxation they increase with initial assets because high-asset households benefit most from the smaller tax adjustment. Additional Transfers instead create a distinctly low-asset coalition. Public Investment produces gains across a broader range of initial assets and human capital through its effects on productivity and wages, although high-asset households can

Figure 7: Fiscal-capacity allocation relative to Government Spending: CEV by initial assets.



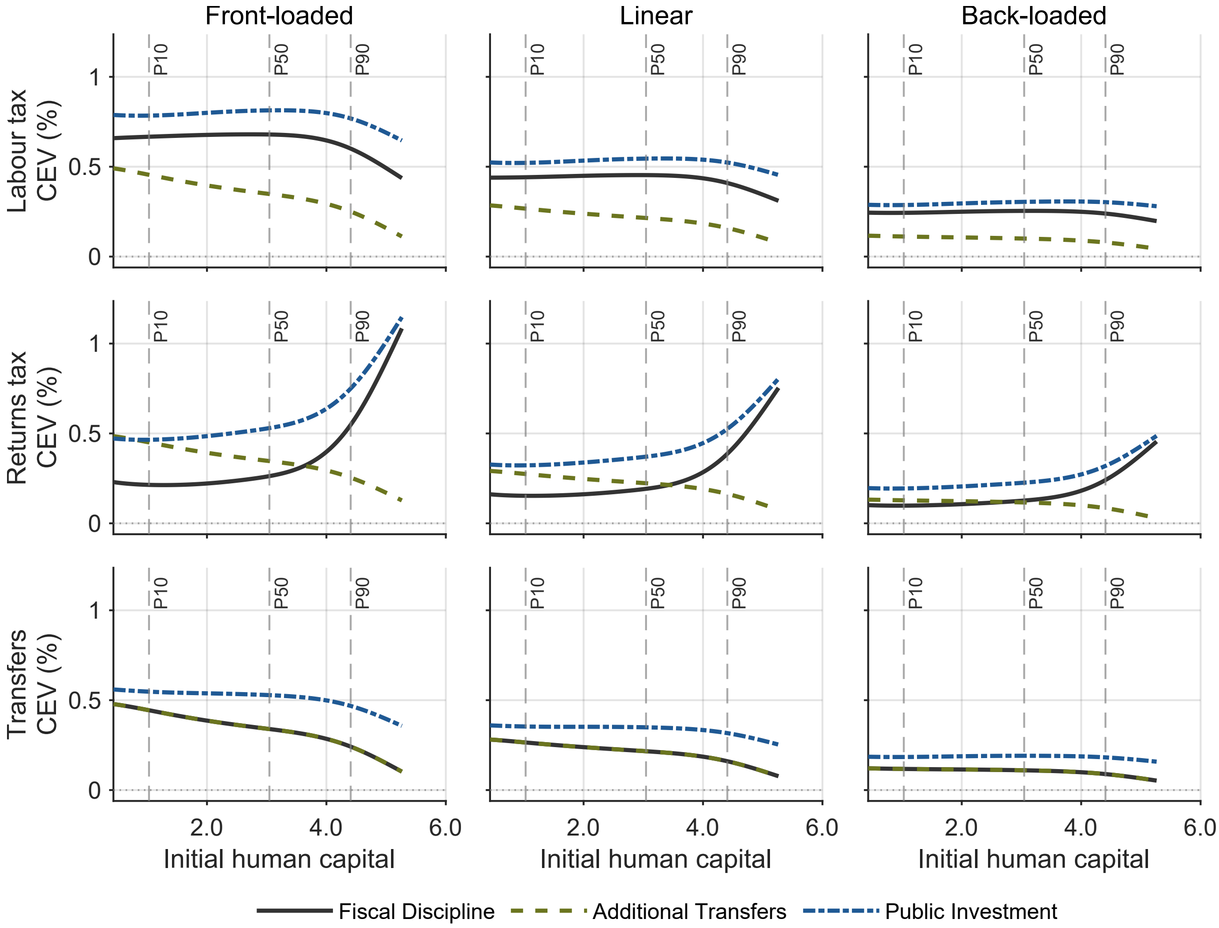
Note: The figure plots CEV percentage-point differences relative to the matched Government Spending baseline. Rows correspond to fiscal instruments and columns to timing paths. Lines compare Fiscal Discipline, Additional Transfers, and Public Investment as alternative uses of debt-service savings.

continue to lose in absolute terms when the transition is financed through returns taxation.

This quantitative heterogeneity has direct household support implications. Panel B of Table 5 confirms that the preferred financing instrument is remarkably stable. Holding the debt path fixed, approximately 67–75% of households prefer returns taxation and approximately 21–33% prefer transfers adjustment, while labour taxation receives at most 5.1% support. Headroom allocation therefore does little to change the coalition supporting each financing instrument: low-asset households continue to favour taxation of returns, while high-asset households disproportionately favour adjustment through transfers.

The timing coalition is more sensitive. Under labour taxation and transfers adjustment, back-loading remains almost unanimously preferred regardless of how the headroom is used. Under returns taxation, however, the Government Spending benchmark gives a clear back-loaded majority: 68.9% prefer back-loading and 30.8% prefer front-loading. Fiscal Discipline narrows this gap by raising support for front-loading to 45.0%. Addi-

Figure 8: Fiscal-capacity allocation relative to Government Spending: CEV by initial human capital.



Note: The figure plots CEV percentage-point differences relative to the matched Government Spending baseline. Rows correspond to fiscal instruments and columns to timing paths. Lines compare Fiscal Discipline, Additional Transfers, and Public Investment as alternative uses of debt-service savings.

tional Transfers and Public Investment overturn the ranking, with 57.0% and 63.6% of households, respectively, preferring front-loading. Earlier consolidation then brings forward either the direct transfer or the accumulation of productive public capital, allowing these benefits to offset the cost of imposing the returns tax sooner.

Comparing Table D5 with Appendix Table D6 shows that lowering the public-capital elasticity from 0.135 to 0.109 reduces incumbent welfare but preserves the returns-tax timing result: 58.8% of households still prefer front-loading. Appendix Table D7 shows that all-cohort CEV remains positive under all three returns-tax paths at the benchmark social discount factor.

Panel C compares the three alternative uses of headroom directly, excluding Government Spending. Public Investment is preferred by between 78.6% and 100.0% of households across all nine instrument-by-timing combinations. This broad support is consistent with the reach of its productivity and wage effects.

Table 5: Conditional household preference shares across fiscal-design margins

Panel A: Timing choice, holding fiscal-capacity use and instrument fixed

Fiscal-capacity use	Instrument	Front	Linear	Back		Winner	Margin
Fiscal Discipline	Labour tax	1.2	0.0	98.8	–	Back	97.6
Fiscal Discipline	Returns tax	45.0	1.2	53.7	–	Back	8.7
Fiscal Discipline	Transfers	0.0	0.0	100.0	–	Back	100.0
Government Spending	Labour tax	0.0	0.0	100.0	–	Back	100.0
Government Spending	Returns tax	30.8	0.3	68.9	–	Back	38.1
Government Spending	Transfers	0.0	0.0	100.0	–	Back	100.0
Additional Transfers	Labour tax	0.2	0.0	99.8	–	Back	99.7
Additional Transfers	Returns tax	57.0	0.6	42.4	–	Front	14.5
Additional Transfers	Transfers	0.0	0.0	100.0	–	Back	100.0
Public Investment	Labour tax	4.9	0.0	95.1	–	Back	90.2
Public Investment	Returns tax	63.6	1.2	35.2	–	Front	28.4
Public Investment	Transfers	0.0	0.0	100.0	–	Back	100.0

Panel B: Instrument choice, holding fiscal-capacity use and timing fixed

Fiscal-capacity use	Timing	Labour	Returns	Transfers		Winner	Margin
Fiscal Discipline	Front	5.1	74.0	21.0	–	Returns tax	53.0
Fiscal Discipline	Linear	0.9	74.4	24.7	–	Returns tax	49.7
Fiscal Discipline	Back	0.0	72.8	27.2	–	Returns tax	45.5
Government Spending	Front	0.2	71.2	28.6	–	Returns tax	42.5
Government Spending	Linear	0.0	70.1	29.9	–	Returns tax	40.2
Government Spending	Back	0.0	66.9	33.1	–	Returns tax	33.8
Additional Transfers	Front	0.4	71.5	28.1	–	Returns tax	43.5
Additional Transfers	Linear	0.0	70.4	29.6	–	Returns tax	40.7
Additional Transfers	Back	0.0	67.2	32.8	–	Returns tax	34.4
Public Investment	Front	4.4	74.5	21.1	–	Returns tax	53.4
Public Investment	Linear	0.7	74.6	24.7	–	Returns tax	49.9
Public Investment	Back	0.0	73.2	26.8	–	Returns tax	46.3

Panel C: Fiscal-capacity choice, holding instrument and timing fixed

Instrument	Timing	Fiscal Discipline	Additional Transfers	Public Investment		Winner	Margin
Labour tax	Front	0.0	0.3	99.7	–	Public Investment	99.4
Labour tax	Linear	0.0	0.0	100.0	–	Public Investment	99.9
Labour tax	Back	0.0	0.0	100.0	–	Public Investment	100.0
Returns tax	Front	0.3	21.1	78.6	–	Public Investment	57.5
Returns tax	Linear	0.1	14.3	85.6	–	Public Investment	71.3
Returns tax	Back	0.0	1.1	98.9	–	Public Investment	97.8
Transfers	Front	0.0	3.1	96.9	–	Public Investment	93.9
Transfers	Linear	0.0	0.8	99.2	–	Public Investment	98.3
Transfers	Back	0.0	0.0	100.0	–	Public Investment	100.0

Notes: Entries are weighted shares of initial households, in percent, for whom the option in the column gives the highest state-level CEV, conditional on the two fiscal-design dimensions shown in the first two columns. The margin column is the winner share minus the runner-up share. Panel C compares the three alternative uses of fiscal capacity and excludes the Government Spending baseline.

The qualitative conflict over financing remains unchanged: low-asset households favour returns taxation, high-asset households are more inclined to favour transfers adjustment, and labour taxation attracts virtually no support. The mean incumbent welfare cost, the distribution of CEV, and the coalition supporting faster consolidation can nevertheless change substantially. Headroom allocation is therefore quantitatively and politically important even when it does not alter the baseline ranking of financing instruments.

5.1 Welfare Across Generations

The preceding welfare analysis evaluates households alive when consolidation is announced, which is the natural object for studying support at the announcement date. To assess how the policy affects workers entering during and after the transition, we additionally construct a social-welfare criterion that combines initial incumbents with successive entrant cohorts.

Let $V_t^p(s)$ denote lifetime utility in state s under policy package p. We define the distribution-weighted lifetime utilities of initial incumbents and entrants in year t as

$$\overline{V}_0^{I,p} \equiv \sum_s \omega_0^I(s) V_0^p(s), \qquad \overline{V}_t^{E,p} \equiv \sum_s \omega_t^E(s) V_t^p(s), \tag{26}$$

where the corresponding state distributions are normalised to sum to one. We then define welfare across current and future cohorts as

$$\mathcal{W}^p(\Delta) = \overline{V}_0^{I,p} + \varpi \left[\sum_{t=1}^{T-1} \Delta^t \overline{V}_t^{E,p} + \frac{\Delta^T}{1-\Delta} \overline{V}_T^{E,p} \right]. \tag{27}$$

Here, $\Delta \in (0,1)$ is the social planner's relative weight on successive entry cohorts. Because the population has unit mass and the exit probability is constant, the share entering in each period is ϖ. The transition is computed explicitly through year $T-1$, while $\overline{V}_T^{E,p}$ denotes the lifetime utility of entrants in the final steady state.

To express this welfare measure as a consumption-equivalent variation, let

$$\mathcal{W}^0(\nu;\Delta) = \overline{V}_0^{I,0}(\nu) + \varpi \frac{\Delta}{1-\Delta} \overline{V}^{E,0}(\nu) \tag{28}$$

denote welfare in the initial steady state when baseline consumption is scaled by $1+\nu$ for both initial incumbents and all future entrants, using the same fixed-policy convention as the incumbent CEV. The all-cohort CEV, $\nu^p(\Delta)$, is defined by

$$\mathcal{W}^0(\nu^p(\Delta);\Delta) = \mathcal{W}^p(\Delta). \tag{29}$$

Table 6 compares incumbent and all-cohort welfare across policy configurations for

$\Delta \in \{0.94, 0.96, 0.98\}$. We use $\Delta = 0.96$, equal to the household discount factor, as the benchmark.[13]

[13]For comparability, we recompute the incumbent-only CEV by first aggregating incumbent lifetime utility and then solving for a common consumption adjustment. Because the CEV transformation is nonlinear, this measure differs slightly from the distribution-weighted mean of the state-specific incumbent CEVs reported above.

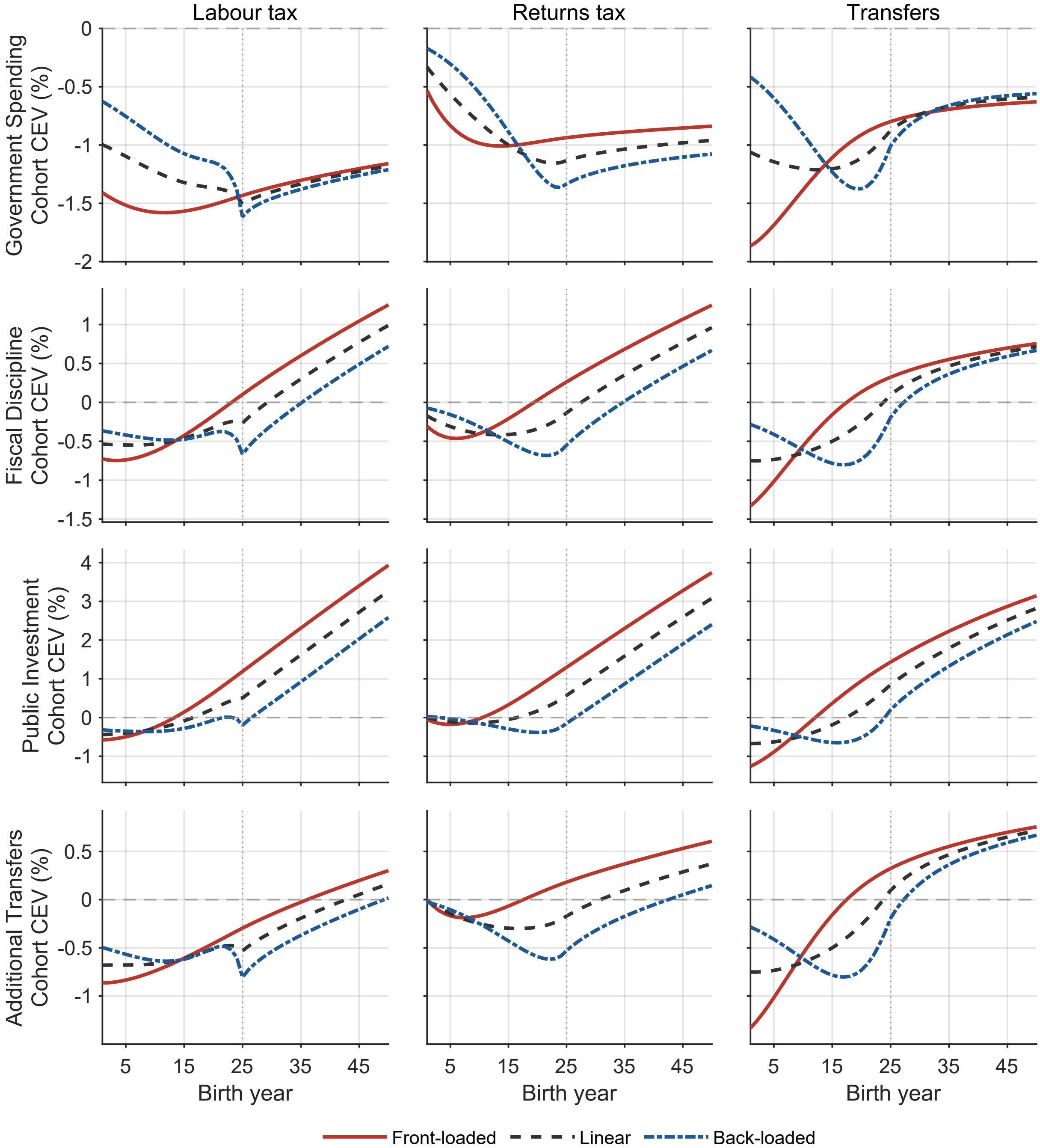
Table 6: Intergenerational welfare under alternative social discount factors

Instrument	Debt path	Incumbents	All cohorts		
			$\Delta = 0.94$	$\Delta = 0.96$	$\Delta = 0.98$
Panel A: Government Spending					
Labour tax	Front-loaded	-1.543	-1.512	-1.476	-1.351
Labour tax	Linear	-1.045	-1.109	-1.128	-1.111
Labour tax	Back-loaded	-0.610	-0.755	-0.822	-0.902
Returns tax	Front-loaded	-0.493	-0.635	-0.675	-0.720
Returns tax	Linear	-0.353	-0.523	-0.595	-0.695
Returns tax	Back-loaded	**-0.231**	**-0.413**	**-0.513**	-0.667
Transfers	Front-loaded	-1.121	-1.174	-1.119	-0.986
Transfers	Linear	-0.677	-0.812	-0.812	-0.774
Transfers	Back-loaded	-0.315	-0.504	-0.551	**-0.595**
Panel B: Fiscal Discipline					
Labour tax	Front-loaded	-0.870	-0.643	-0.426	0.154
Labour tax	Linear	-0.597	-0.474	-0.314	0.169
Labour tax	Back-loaded	-0.360	-0.333	-0.226	0.167
Returns tax	Front-loaded	-0.227	-0.157	**-0.005**	**0.445**
Returns tax	Linear	-0.160	-0.149	-0.039	0.346
Returns tax	Back-loaded	**-0.105**	**-0.140**	-0.070	0.252
Transfers	Front-loaded	-0.759	-0.612	-0.452	-0.124
Transfers	Linear	-0.452	-0.414	-0.304	-0.045
Transfers	Back-loaded	-0.205	-0.252	-0.186	0.010
Panel C: Public Investment					
Labour tax	Front-loaded	-0.741	-0.280	0.197	1.580
Labour tax	Linear	-0.509	-0.205	0.183	1.415
Labour tax	Back-loaded	-0.311	-0.155	0.148	1.235
Returns tax	Front-loaded	**0.033**	**0.284**	**0.661**	**1.811**
Returns tax	Linear	0.014	0.171	0.481	1.528
Returns tax	Back-loaded	-0.009	0.069	0.312	1.254
Transfers	Front-loaded	-0.594	-0.260	0.117	1.045
Transfers	Linear	-0.330	-0.148	0.154	0.984
Transfers	Back-loaded	-0.128	-0.068	0.163	0.902
Panel D: Additional Transfers					
Labour tax	Front-loaded	-1.172	-0.937	-0.785	-0.388
Labour tax	Linear	-0.820	-0.707	-0.607	-0.300
Labour tax	Back-loaded	-0.509	-0.507	-0.455	-0.231
Returns tax	Front-loaded	-0.125	**-0.067**	**0.009**	**0.239**
Returns tax	Linear	-0.121	-0.117	-0.071	0.119
Returns tax	Back-loaded	**-0.115**	-0.154	-0.136	0.013
Transfers	Front-loaded	-0.759	-0.612	-0.450	-0.085
Transfers	Linear	-0.452	-0.414	-0.302	-0.007
Transfers	Back-loaded	-0.205	-0.252	-0.185	0.049

Notes: Entries are consumption-equivalent variations in per cent. The first column aggregates date-0 incumbent lifetime utility; the remaining columns also include future entrants discounted by Δ. Household lifetime utility uses $\beta = 0.96$. Bold entries identify the welfare-maximising policy within each panel and column.

Figure 9 traces the welfare of the first 50 annual entrant cohorts. It therefore shows how the incidence of each policy package evolves across workers born at different points along the transition, rather than aggregating them using a particular social discount factor.

Figure 9: Ex-ante welfare of entrant cohorts by birth year.



Note: Rows correspond to the use of fiscal headroom and columns to the fiscal instrument. Lines distinguish front-loaded, linear, and back-loaded debt paths. Welfare is the cohort-aggregate CEV of newborn entrants relative to a newborn in the initial steady state. Y-axis limits are shared within each row. The horizontal dashed line denotes zero CEV and the vertical dashed line marks birth year 25.

The cohort profiles make the timing mechanism visible. Under Government Spending, entrant welfare remains below the initial-steady-state benchmark throughout the first 50 years, with the largest average cohort losses under labour taxation. Public Investment produces the clearest reversal: later cohorts gain, especially under front-loading, because earlier consolidation brings forward the accumulation of productive public capital. The figure therefore shows why aggregating cohorts can favour front-loading even when initial incumbents prefer to delay adjustment: the policy shifts costs towards early cohorts but allows later entrants to benefit sooner from the improved fiscal allocation.

Two results stand out. First, accounting for future entrants weakens the case for back-loading. At $\Delta = 0.96$, the welfare-maximising package is front-loaded for three of the four uses of headroom. For Fiscal Discipline and Additional Transfers, the ranking changes from back-loaded returns taxation among initial incumbents to front-loaded returns taxation across all cohorts. Government Spending is the exception: back-loaded returns taxation produces the highest all-cohort welfare, with a CEV of -0.513 percent, compared with -0.551 percent under back-loaded transfers.

Second, the broad ranking of financing instruments is especially strong in the all-cohort comparison. At $\Delta = 0.96$, returns taxation produces the highest all-cohort welfare in all twelve headroom-use-by-debt-path comparisons. The largest gain arises when Public Investment is financed by a front-loaded returns tax. Its all-cohort CEV is 0.661 percent, compared with 0.033 percent for initial incumbents, showing that much of the gain from bringing forward productive public capital accrues to workers who enter during or after the transition.

6 Conclusion

This paper studies public-debt consolidation in a heterogeneous-agent economy in which households differ in assets and human capital and invest endogenously in future earnings. The analysis separates three fiscal-design margins that are often bundled together: the instrument used to implement consolidation, the timing path of debt reduction, and the use of the fiscal headroom created by lower debt service. Comparing labour-income taxes, returns taxes, and transfers across front-loaded, linear, and back-loaded paths, and then reallocating headroom across Government Spending, Fiscal Discipline, Additional Transfers, and Public Investment, shows that the transition incidence of consolidation depends jointly on wealth, skills, and fiscal design.

The first finding is that labour-tax consolidation is especially costly because it depresses human-capital accumulation. In the linear Government Spending transition, mean incumbent CEV under labour taxation is -1.030 percent in the benchmark model, compared with -0.727 percent in a comparable heterogeneous agent model without human capital. The benchmark loss is therefore 0.303 percentage points larger, or about 42 percent larger, than in the no-human-capital economy. Models that abstract from endogenous human-capital investment are therefore likely to understate the transition cost of consolidation, especially when the adjustment works through labour income.

The second finding is that alternative instruments reduce mean incumbent costs but create sharper distributional conflicts. Returns taxation is the least costly instrument for a large share of households because it preserves labour-supply and human-capital incentives, but its losses are concentrated among high-asset households. Transfers adjustment removes much of the production-side distortion, but the burden falls disproportionately on low-asset and low-human-capital households because it withdraws resources from households with limited private buffers.

The third finding is that timing matters, but the standard case for back-loading is incomplete. Earlier work emphasises that delayed adjustment can be welfare-improving because it smooths the transition. Among initial incumbents, this result depends on the fiscal instrument and on the use of headroom. Under labour taxes and transfers, most households prefer back-loading because it delays the main labour-market distortion or the withdrawal of transfers. Under returns taxation, by contrast, low-asset households can prefer earlier consolidation because they bear little of the asset-tax burden. This creates an additional conflict over timing: under returns taxation, Additional Transfers and Public Investment both shift household support toward front-loading, with 57.0 and 63.6 percent of households preferring the front-loaded path, respectively. Accounting for future entrants weakens the case for back-loading further. At the benchmark value $\Delta = 0.96$, the all-cohort welfare-maximising package is front-loaded for three of the four uses of headroom.

The fourth finding is that headroom use is itself a policy margin. Fiscal Discipline reduces the harmful effects of distortionary adjustment by using debt-service savings to relax the required closure instrument; across instruments and timing paths, it lowers mean incumbent CEV losses by about 33–52 percent relative to the Government Spending baseline, equivalent to gains of 0.11–0.66 percentage points of lifetime consumption. But headroom use also creates a new distributive conflict. Governments may be tempted to return debt-service savings through transfers because this benefits low-asset and low-income households, especially when financed by returns taxes. Public Investment changes the household support more broadly: when headroom raises productive public capital, it creates gains that reach a wider coalition of households and makes faster deleveraging more attractive because faster debt reduction brings forward the buildup of productive capacity. Once wealth and skills jointly shape exposure to consolidation, the costs of deleveraging cannot be assessed without modelling both distributional conflict and human-capital accumulation.

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A Understanding Society Sample

A.1 Data

Understanding Society (UnSoc) is a large longitudinal household survey for the United Kingdom, covering roughly 40,000 households and a broad set of economic and social outcomes (Platt et al., 2020). Fieldwork for each wave is spread over a 24-month period, but respondents are interviewed at approximately the same time each year, so the data can be organised naturally as annual household-year observations (Knies, 2018). In this paper we use waves 1–13 and retain interviews observed up to 2019 so that the empirical inputs line up with the pre-pandemic baseline year used in the quantitative model. The analysis uses the standard End User Licence release of the main survey data and combines individual and household information to construct household-level income and hours measures.

A.2 Sample selection

The main estimation sample is designed to match the model's focus on prime-age working households. We therefore construct household-year observations from the household reference person and, where relevant, their spouse or partner, annualise labour-income flows, and aggregate earnings and hours across the retained adults. The baseline working sample is then restricted to employee, non-self-employed households aged 25–55, so that observed labour income is as close as possible to the earnings concept in the model. For the earnings-distribution and tax-transfer moments, we trim the top and bottom 1 percent of gross labour income within each survey year to limit the influence of extreme reported values. For the human-capital-retention exercise, we use a separate older-worker sample aged 55–65 with positive earnings and full-time hours, since late-career earnings profiles provide a flat-spot estimate of retention.

A.3 Definitions of income

For pre-policy labour income we use annual household gross labour income. For post-policy income we distinguish annual household net labour income and social transfers so that the reduced-form tax-and-transfer block can separately match the net-of-tax income schedule and average transfers. All income variables are converted into real terms using the UK CPI. Labour supply is measured by usual weekly household hours summed across the retained adults and normalised relative to a two-adult full-time benchmark. These definitions ensure that the empirical moments correspond closely to the household income and labour-supply concepts used in the quantitative model.

A.4 Residualised earnings-rank moments

To construct the earnings-distribution targets, we first residualise the logarithm of gross household labour income on a standard set of observable controls:

$$\log y_{i,t}^{\text{gross}} = \beta_0 + \beta_1 \,\text{female}_{i,t} + p_3(\text{age}_{i,t}) + \eta_r + \eta_t + \varepsilon_{i,t}, \tag{30}$$

where $p_3(\text{age}_{i,t})$ denotes a third-order polynomial in household age, η_r are region fixed effects, and η_t are survey-year fixed effects. We exponentiate the residual, $y_{i,t}^{\text{res}} = \exp(\varepsilon_{i,t})$, and use this residualised earnings index to rank households and construct earnings-share targets: the shares of the index received by the bottom 25, bottom 50, bottom 75, and top 10 percent of the working-age sample. The calibration combines these distributional earnings shares with hours, tax-transfer, and wealth moments.

B Calibration Details

This appendix documents the steady-state calibration in more detail. Appendix A describes the survey source, sample construction, income definitions, and residualised earnings-rank moments used to build the empirical inputs. Here we take those objects as given and explain how they are mapped into calibration targets. The quantitative exercise is organised in three layers: a set of parameters fixed outside the estimation loop at standard values or normalisations, a set of objects disciplined directly by data, and a final group of structural parameters chosen to match a set of empirical moments.

Numerical grids. The benchmark human-capital computations use 50 asset nodes, 50 human-capital nodes, and 9 economic productivity states. The asset grid runs from the baseline borrowing limit, $a_{\min} = -\tau_0/(r + r^{\text{pen}}) = -0.421$, to $a_{\max} = 250$. Grid points are exponentially spaced after adding the pivot $|a_{\min}| + 0.25$, which concentrates nodes near the borrowing limit while retaining a wide upper tail. The human-capital grid runs from $h_{\min} = 0.100$ to $h_{\max} = 6.000$. It is constructed in two exponentially spaced segments so that the calibrated newborn point $h_{\text{newborn}} = 0.433$ lies exactly on the grid, with three numerical buffer nodes below it and the remaining nodes above it. The calibrated stationary distribution puts essentially no mass below the newborn point, so this lower buffer is not a binding support restriction. The exogenous productivity grid is built with Rouwenhorst's method for the log AR(1) process, using the calibrated persistence and innovation scale, and then exponentiated; the grid spans $e \in [0.398, 2.514]$.

B.1 Parameters Fixed Outside the Estimation Loop

The values fixed outside the estimation loop are reported in Table 1 in the main text. This subsection focuses on the reduced-form empirical objects that are pinned down outside the estimation loop and then fed into the model.

Human-capital retention from Understanding Society. Using the older-worker sample defined in Appendix A, we discipline annual human-capital retention using the late-career earnings profile. Because earnings growth is typically limited late in working life, the within-person age slope in this sample provides a reduced-form flat-spot estimate. Specifically, we run a fixed-effects regression of log gross household income on age, year dummies, and region dummies:

$$\log y_{it}^{\text{gross}} = \alpha_i + \beta_{\text{age}}\, \text{age}_{it} + \eta_t + \eta_r + \varepsilon_{it}. \tag{31}$$

The estimated age slope is $\beta_{\text{age}} = -0.040$. We map this slope into the annual retention rate according to

$$\delta_h = \exp(\beta_{\text{age}}) = 0.961. \tag{32}$$

This is the value used in the quantitative exercise. The mapping treats the late-career earnings slope as a reduced-form measure of skill retention, conditional on the regression controls. It is an identifying approximation rather than an algebraic implication of the nonlinear productivity function $e \log(1 + h)$.

Tax and transfer system. Using the working-age sample described in Appendix A, we represent the tax and transfer system with the Heathcote et al. (2017) reduced-form schedule

$$y^{\text{disp}} = \tau_1 \left(y^{\text{gross}}\right)^{1-\tau_2} + \tau_0, \tag{33}$$

and discipline its parameters from the empirical relationship between gross income, net income, and transfers. In the quantitative baseline, we first set

$$\tau_2 = 0.2 \tag{34}$$

manually. We then normalise gross income by its sample mean,

$$\tilde{y}^{\,\text{gross}} = \frac{y^{\text{gross}}}{\mathbb{E}[y^{\text{gross}}]}, \tag{35}$$

and define the empirical mean net-to-gross ratio

$$m = \mathbb{E}\left[\frac{y^{\text{net}}}{y^{\text{gross}}}\right], \tag{36}$$

where y^{net} denotes net labour income excluding transfers. Given the imposed value of τ_2, the tax-level parameter is chosen to satisfy

$$m = \tau_1 \, \mathbb{E}\big[(\tilde{y}^{\,\text{gross}})^{-\tau_2}\big], \tag{37}$$

so that

$$\tau_1 = \frac{m}{\mathbb{E}\big[(\tilde{y}^{\,\text{gross}})^{-\tau_2}\big]} = 0.739. \tag{38}$$

Finally, the transfer term is set to

$$\tau_0 = \frac{\mathbb{E}[\text{transfers}]}{\mathbb{E}[y^{\text{gross}}]} = 0.065 \tag{39}$$

from average transfers, expressed relative to mean gross income. The appendix and the quantitative results use this baseline specification.

B.2 Internally Calibrated Parameters

The parameters estimated inside the model correspond to the vector

$$\boldsymbol{\vartheta} = (\chi, \rho, \sigma_\epsilon, \psi, r^{\text{pen}}, \gamma, \bar{a}_B, \varphi_B, h_{\text{newborn}}), \tag{40}$$

where χ and γ govern human-capital accumulation, (ρ, σ_ϵ) govern the exogenous productivity process, ψ governs labour disutility, r^{pen} is the borrowing wedge, $(\varphi_B, \bar{a}_B)$ govern the bequest motive, and h_{newborn} determines the human-capital state of replacement workers after exit.

B.3 Construction of the Micro Moments

The micro moments are constructed directly from the household-level objects described in Appendix A. The income and labour block contains six targets: the normalisation of aggregate effective labour, the shares of the exponentiated residual earnings index received by the bottom 25, bottom 50, bottom 75, and top 10 percent of households, and mean normalised hours among employed households. These moments discipline the exogenous earnings process, labour disutility, the curvature and scale of human-capital accumulation, and the newborn reset point. The remaining three moments target the household balance-sheet side of the model: the assets-to-output ratio, the hand-to-mouth share, and the top

Table B1: Targeted calibration moments and model fit

Moment	Target	Model	Gap	Residual
Effective labour L	1.000	1.000	+0.000	+0.000
Residual earnings share, bottom 25%	0.089	0.089	+0.000	+0.003
Residual earnings share, bottom 50%	0.267	0.270	+0.002	-0.009
Residual earnings share, bottom 75%	0.539	0.540	+0.001	-0.001
Mean hours, employed	0.675	0.675	+0.000	+0.000
Assets-to-output ratio A/Y	2.900	2.900	+0.000	+0.000
Hand-to-mouth share	0.190	0.190	+0.000	+0.000
Top 10% wealth share	0.500	0.500	+0.000	+0.000
Residual earnings share, top 10%	0.230	0.231	+0.001	-0.006

Notes: The objective residual is $(M_j^{\text{data}} - M_j^{\text{model}})/|M_j^{\text{data}}|$. For the reported calibration, $\sum_j e_j^2 = 0.0001$ and $\|e\|_\infty = 0.0092$.

10 percent wealth share. Taken together, the target set is designed to discipline both the earnings distribution and the degree of self-insurance and concentration in the stationary equilibrium.

B.4 Numerical Estimation Procedure

For a candidate $\boldsymbol{\vartheta}$, the stationary equilibrium is computed and the model-implied moment vector $M^{\text{model}}(\boldsymbol{\vartheta})$ is evaluated. The calibration constructs target-scaled residuals

$$e_j(\boldsymbol{\vartheta}) = \frac{M_j^{\text{data}} - M_j^{\text{model}}(\boldsymbol{\vartheta})}{|M_j^{\text{data}}|}, \qquad j = 1, \ldots, 9. \tag{41}$$

We then minimise the sum of squared entries in this residual vector using a least-squares optimisation routine.

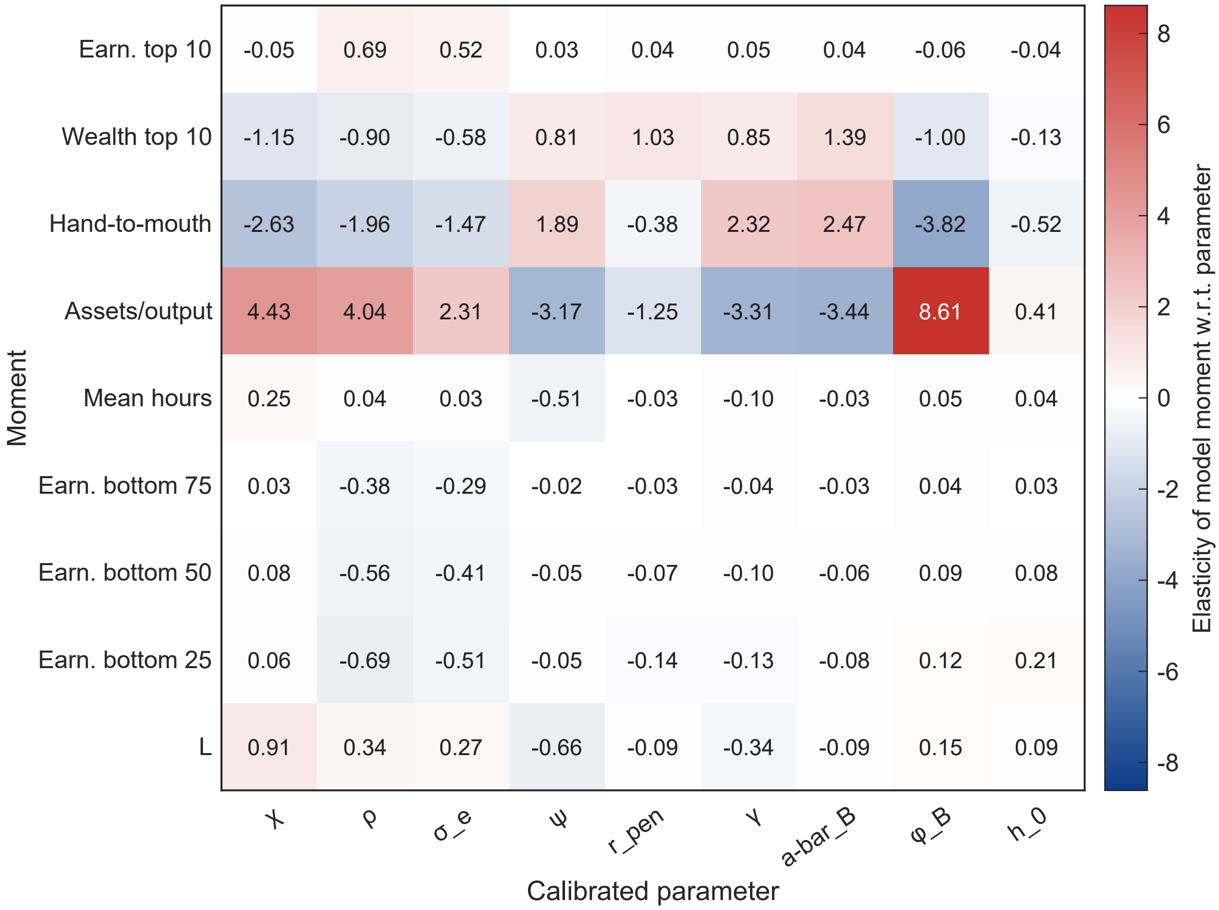
B.5 Target Moments and Fit

The calibration targets labour supply, the earnings distribution, wealth accumulation, liquidity, and wealth concentration. Table B1 reports the target values, model-implied moments, unscaled gaps, and target-scaled residuals for the reported calibration. The main text reports the estimated parameter vector, while the elasticity diagnostics below summarise local identification around the calibrated stationary equilibrium.

B.6 Elasticity Diagnostics

Figure B1 reports local elasticities of the targeted model moments with respect to the calibrated parameters, computed around the calibrated stationary equilibrium. This diagnostic shows which parameters discipline each targeted margin and helps assess local

Figure B1: Parameter-to-moment elasticity diagnostics.



Note: Each cell reports the elasticity of a targeted model moment with respect to a one-parameter perturbation around the calibrated stationary equilibrium. Rows are targeted moments and columns are calibrated parameters.

identification around the calibration.

C No-Human-Capital Benchmark

This appendix repeats the fiscal-capacity exercises in an economy without endogenous human-capital accumulation, which we refer to as the no-HC model. The household no longer chooses skill investment and there is no human-capital law of motion. The remaining problem is a one-asset incomplete-markets economy with endogenous labour supply, the same fiscal block, mortality and bequest structure, inheritable assets, and the same public-capital channel in production. The exercise is diagnostic rather than a replacement for the benchmark model: it asks which results follow from the one-asset fiscal-insurance environment alone and which require the endogenous skill margin.

C.1 Calibration Strategy

The calibrated no-HC model re-estimates the no-HC household-side parameters to match the main stationary targets of the benchmark economy. Matching these initial moments keeps the comparison focused on the endogenous human-capital margin rather than on differences in the stationary wealth distribution.

The exogenous productivity process in the no-HC model is constructed from the benchmark steady state. Using a fixed seed, we simulate the benchmark transition matrix, retain 100,000 observations after a 10,000-period burn-in, and use the resulting path to form the earnings-relevant efficiency term generated jointly by exogenous productivity and human capital. We estimate an auxiliary AR(1) for the log of this term by OLS and discretise the estimated process in the no-HC economy using Rouwenhorst's method. This deliberately assigns to exogenous risk variation that is partly endogenous in the benchmark model. The misspecification is useful here because it shows what the deleveraging experiment looks like when persistent earnings heterogeneity is treated as exogenous rather than partly chosen through skill investment.

C.2 Baseline Comparison

Table C1 compares the initial steady states. The calibrated no-HC model is close to the human-capital benchmark on the targeted stationary moments. Output is 1.429, assets/output is 2.904, the hand-to-mouth share is 18.3%, the top 10 percent wealth share is 50.2%, and external borrowing/output is 0.196. The corresponding benchmark values are 1.428, 2.900, 19.0%, 50.0%, and 0.200.

C.3 Lower-Debt Steady States

Table C2 reports the initial and lower-debt steady states for the calibrated no-HC model. As in the benchmark model, the debt experiment fixes the terminal debt level rather than mechanically imposing an identical terminal debt-to-output ratio. The Government Spending and Additional Transfers endpoints leave output almost unchanged, while the Public Investment endpoint raises output from 1.429 to 1.452. The Public Investment gain is present but smaller than in the human-capital benchmark, where the corresponding terminal output is 1.462. Because the terminal debt level is common, the calibrated no-HC Public Investment endpoint reaches $B/Y = 0.689$, compared with 0.684 in the benchmark. The NFA ratio also falls less sharply, to 0.168 rather than 0.146.

Table C1: Baseline steady states: HC and no-HC benchmarks

Variable	HC benchmark	Calibrated no-HC
Output Y	1.428	1.429
Effective labour L	1.000	1.000
Mean hours	0.675	0.675
Wage w	1.000	1.000
Interest rate r	0.0300	0.0300
Debt ratio B/Y	0.800	0.800
Assets/output	2.900	2.904
Mean assets	4.143	4.149
Hand-to-mouth share	19.0	18.3
Top 10% wealth share	50.0	50.2
External borrowing/output	0.200	0.196
Labour tax τ_1	0.739	0.739
Transfers τ_0	0.065	0.065
Public investment/Y	0.050	0.050
General government spending/Y	0.078	0.082

Notes: The HC benchmark is the initial steady state used in the main fiscal-capacity transition exercises. The calibrated no-HC model re-estimates the no-HC household-side parameters to match key stationary moments.

Table C2: No-human-capital initial and lower-debt steady states

Variable	Initial	Government Spending		Public Investment		Additional Transfers	
		Level	Change	Level	Change	Level	Change
Calibrated no-HC							
Debt ratio B/Y	0.800	0.700	-10.01 pp	0.689	-11.14 pp	0.700	-10.04 pp
Debt level B	1.143	1.000	-12.50%	1.000	-12.50%	1.000	-12.50%
Output Y	1.429	1.429	+0.02%	1.452	+1.65%	1.429	+0.06%
Effective labour L	1.000	1.000	+0.00%	1.004	+0.44%	1.000	+0.02%
Private capital K	3.286	3.287	+0.04%	3.346	+1.84%	3.291	+0.16%
Interest rate r	0.0300	0.0300	-0.4 bp	0.0298	-2.3 bp	0.0299	-1.3 bp
Mean assets	4.149	4.013	-3.27%	4.101	-1.13%	4.033	-2.78%
External borrowing/output	0.196	0.192	-0.42 pp	0.168	-2.76 pp	0.180	-1.56 pp
Public investment/Y	0.050	0.050	-0.00 pp	0.052	+0.21 pp	0.050	-0.00 pp
Transfers/Y	0.046	0.045	-0.00 pp	0.045	-0.07 pp	0.048	+0.30 pp
Residual spending/Y	0.082	0.085	+0.31 pp	0.086	+0.37 pp	0.082	+0.02 pp
Public capital K_g	0.952	0.952	+0.00%	1.010	+6.00%	0.952	+0.00%
Public-capital TFP A_g	1.000	1.000	+0.00%	1.008	+0.79%	1.000	+0.00%

Notes: Levels are steady-state values. Changes are relative to the corresponding no-HC initial steady state. Ratio changes are reported in percentage points, interest-rate changes in basis points, and other changes in percent. The lower-debt steady states hold the debt level fixed at a reduction equal to 10 percent of initial output and allocate the fiscal capacity according to the column heading.

C.4 Fixed Debt-Path Transition Diagnostics

For a fixed debt path, public-investment path, residual-spending path, and productivity transition matrix, equilibrium requires mutually consistent paths for output, the external borrowing position, and the fiscal closure instrument. The interest rate follows the NFA-elastic schedule, while firms determine capital intensity and wages from the interest rate and public-capital productivity. We solve household decisions backwards and simulate the distribution forwards, choosing the aggregate paths so that the goods market, asset market, and government budget clear in every period.

Table C3 reports the corresponding no-HC macroeconomic transition losses for output, private capital, household assets, and labour supply.

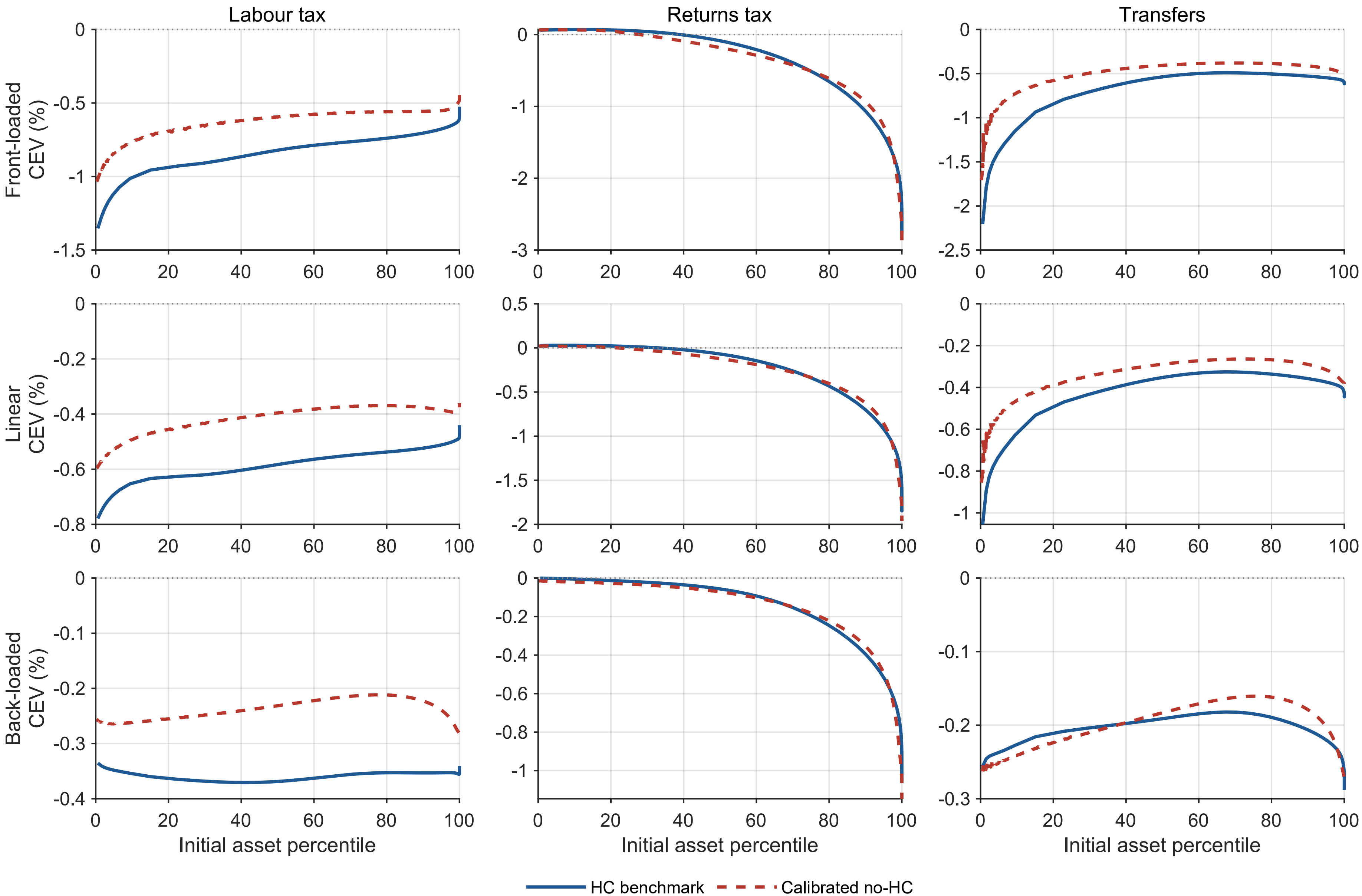
Figure 6 in Section 4.6 and Figures C1–C3 provide compact comparisons of the human-capital benchmark and the calibrated no-HC model by fiscal-capacity use. Each figure plots CEV incidence by initial asset percentile, the state variable common to both economies. Rows correspond to front-loaded, linear, and back-loaded debt paths. Columns correspond to the fiscal closure instrument. Within each panel, the two models are plotted together.

Table C3: No-human-capital macroeconomic transition losses: Calibrated no-HC

		Output	Trough	Cumulative losses, years 0–25			
Instrument	Timing	trough	year	Y	K	A	N
Panel A: Government Spending							
Labour tax	Front-loaded	-1.39	1	11.66	10.18	62.39	12.33
Labour tax	Linear	-0.47	25	10.78	8.32	37.14	11.83
Labour tax	Back-loaded	-1.51	25	10.45	7.61	14.58	11.69
Returns tax	Front-loaded	-0.05	11	0.97	2.63	77.00	0.26
Returns tax	Linear	-0.08	20	1.47	3.97	61.06	0.39
Returns tax	Back-loaded	-0.12	23	1.76	4.77	42.90	0.47
Transfers	Front-loaded	0.00	0	0.00	0.00	44.80	0.00
Transfers	Linear	0.00	0	0.00	0.00	25.29	0.00
Transfers	Back-loaded	0.00	0	0.00	0.00	8.95	0.00
Panel B: Fiscal Discipline							
Labour tax	Front-loaded	-1.36	1	8.05	7.24	56.62	8.41
Labour tax	Linear	-0.46	1	6.28	4.54	36.67	7.12
Labour tax	Back-loaded	-1.16	25	8.63	6.61	17.31	9.50
Returns tax	Front-loaded	-0.01	3	0.05	0.13	44.63	0.01
Returns tax	Linear	-0.02	7	0.15	0.41	39.73	0.04
Returns tax	Back-loaded	-0.05	17	0.79	2.13	31.92	0.21
Transfers	Front-loaded	0.00	0	0.00	0.00	44.94	0.00
Transfers	Linear	0.00	0	0.00	0.00	28.10	0.00
Transfers	Back-loaded	0.00	0	0.00	0.00	12.22	0.00
Panel C: Additional Transfers							
Labour tax	Front-loaded	-1.40	1	11.80	10.51	62.63	12.40
Labour tax	Linear	-0.47	25	11.18	9.16	40.10	12.05
Labour tax	Back-loaded	-1.54	25	11.12	8.95	18.44	12.06
Returns tax	Front-loaded	-0.06	9	0.97	2.62	76.90	0.26
Returns tax	Linear	-0.10	18	1.76	4.76	64.23	0.47
Returns tax	Back-loaded	-0.16	22	2.27	6.16	48.49	0.61
Transfers	Front-loaded	0.00	0	0.00	0.00	44.94	0.00
Transfers	Linear	0.00	0	0.00	0.00	28.10	0.00
Transfers	Back-loaded	0.00	0	0.00	0.00	12.22	0.00
Panel D: Public Investment							
Labour tax	Front-loaded	-1.40	1	7.69	7.27	62.59	9.52
Labour tax	Linear	-0.47	1	4.41	3.86	40.74	7.35
Labour tax	Back-loaded	-0.94	25	7.71	6.14	19.24	10.47
Returns tax	Front-loaded	-0.01	1	0.01	0.12	53.76	0.00
Returns tax	Linear	-0.01	2	0.02	0.26	48.29	0.01
Returns tax	Back-loaded	-0.04	11	0.35	2.04	39.04	0.09
Transfers	Front-loaded	0.00	0	0.00	0.00	47.87	0.00
Transfers	Linear	0.00	0	0.00	0.00	30.28	0.00
Transfers	Back-loaded	0.00	0	0.00	0.00	13.38	0.00

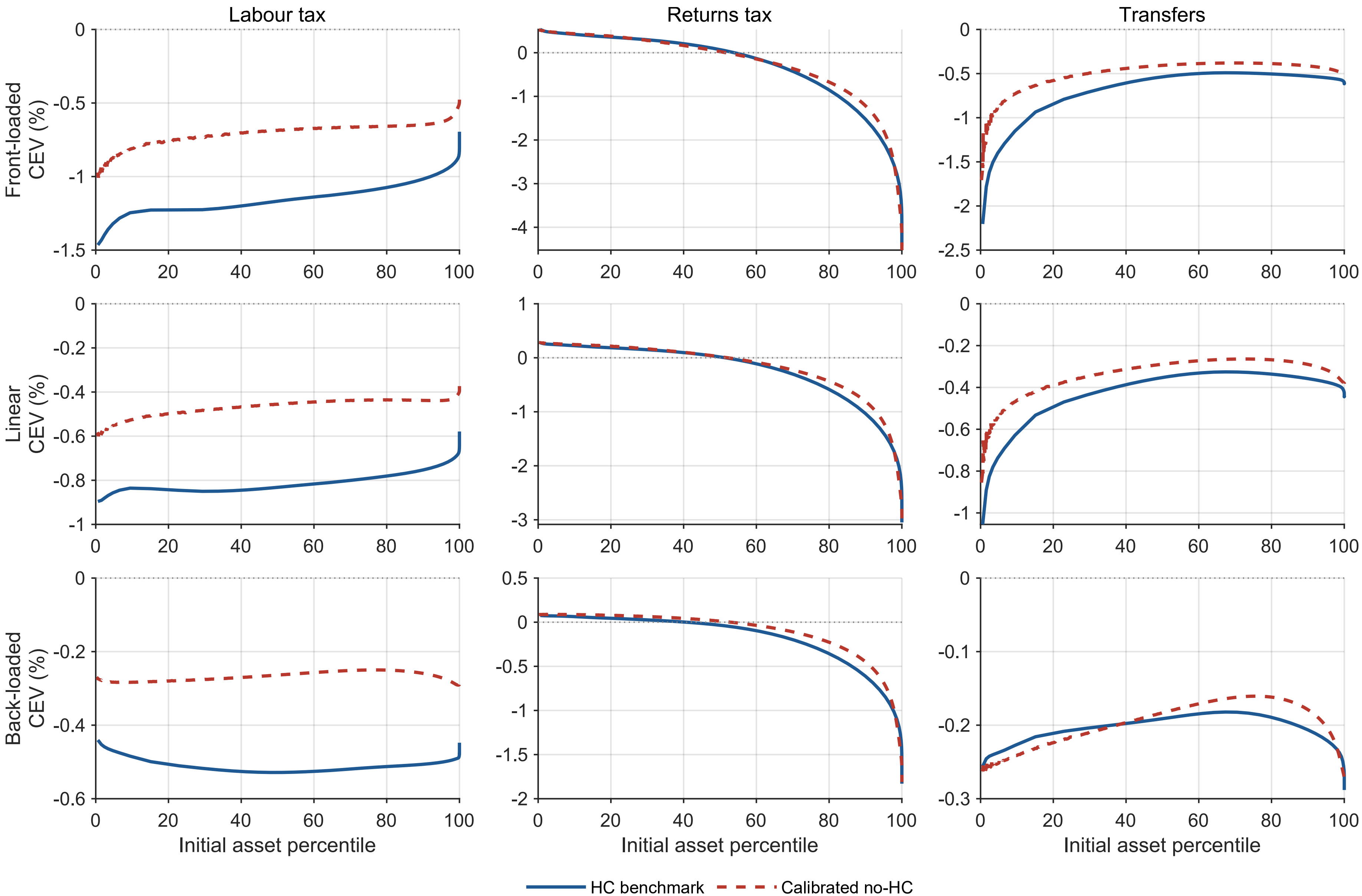
Notes: Panels correspond to alternative uses of debt-service savings. Series are percentage deviations from period 0. The output trough is searched over years 0–80. For each reported series p, cumulative loss is $\sum_{t=0}^{25} \max\{-\Delta p_t, 0\}$ and is measured in percentage-point-years. Y is output, K private capital, A household assets, and N effective labour supply.

Figure C1: CEV incidence by initial assets: Fiscal Discipline



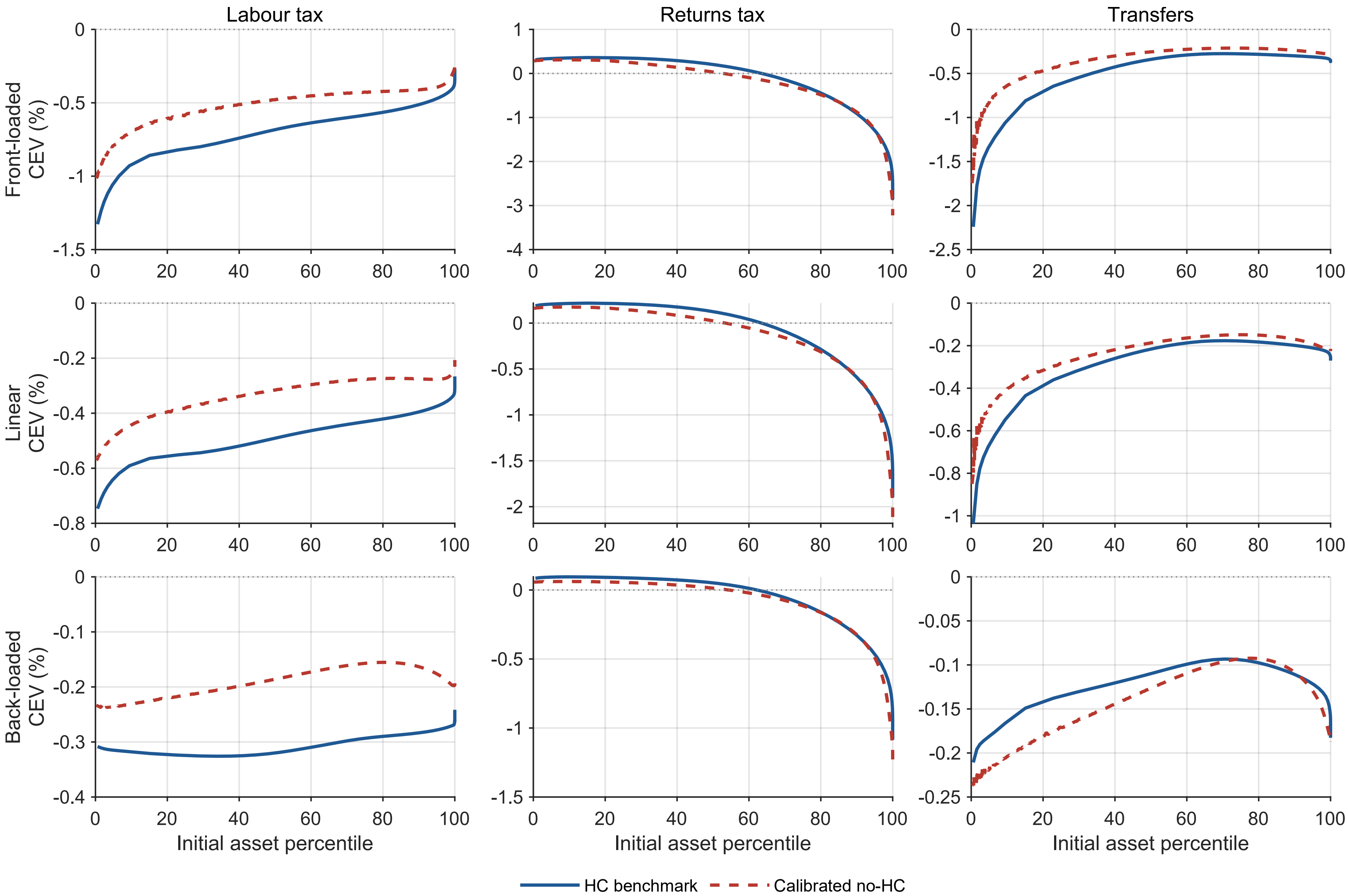
Note: Rows correspond to front-loaded, linear, and back-loaded debt paths. Columns correspond to labour-tax, returns-tax, and transfer closures. Each panel overlays the human-capital benchmark and the calibrated no-HC model. CEVs are percentages of baseline consumption and are plotted against the midpoint of each initial-asset mass bin.

Figure C2: CEV incidence by initial assets: Additional Transfers



Note: Rows correspond to front-loaded, linear, and back-loaded debt paths. Columns correspond to labour-tax, returns-tax, and transfer closures. Each panel overlays the human-capital benchmark and the calibrated no-HC model. CEVs are percentages of baseline consumption and are plotted against the midpoint of each initial-asset mass bin.

Figure C3: CEV incidence by initial assets: Public Investment



Note: Rows correspond to front-loaded, linear, and back-loaded debt paths. Columns correspond to labour-tax, returns-tax, and transfer closures. Each panel overlays the human-capital benchmark and the calibrated no-HC model. CEVs are percentages of baseline consumption and are plotted against the midpoint of each initial-asset mass bin.

Three patterns stand out. First, the broad incidence regimes are robust. Labour-tax consolidation produces broad losses; returns-tax consolidation shifts the burden toward high-asset households; and transfer consolidation is concentrated on households with weak balance sheets. The no-HC exercises therefore support the interpretation that these regimes are not artefacts of the human-capital state space.

Second, endogenous human capital amplifies the incumbent welfare cost of labour-tax consolidation. Under the linear Government Spending path, mean incumbent CEV is -1.030% in the human-capital benchmark, compared with -0.727% in the calibrated no-HC model. The same ordering holds for front-loaded and back-loaded debt paths. The asset profile is also slightly steeper in the benchmark: the linear-path top-minus-bottom asset-decile gap is 0.288 percentage points, compared with 0.274 in the no-HC model. Initial assets therefore buffer labour-tax consolidation in both models, while the additional skill-investment channel modestly steepens the asset gradient.

Third, the no-HC comparison clarifies the role of transfers and asset taxation. Returns-tax incidence remains strongly tilted against high-asset households, with negative top-minus-bottom asset gaps in both models. Transfer consolidation remains bottom-heavy, with positive asset gaps and universal preference for back-loading. Under the linear path, the transfer asset gap is 0.562 in the human-capital benchmark and 0.399 in the calibrated no-HC model. These patterns match the economic interpretation of transfers as an insurance and liquidity margin for households close to the asset floor.

The full no-HC welfare results are reported in Table C4. They cover Fiscal Discipline, Government Spending, Additional Transfers, and Public Investment as alternative uses of debt-service savings. Across those panels, the transfer-closure and Fiscal Discipline cases are the closest comparisons with the human-capital benchmark, while labour-tax-financed paths show the largest role for endogenous human capital.

Table C4: No-human-capital welfare, preferences, and incidence: Calibrated no-HC

		CEV			Preferred share		Initial assets			Initial productivity		
Instrument	Timing path	Mean	Rel. disp.	> 0 share	Pref. policy	Pref. timing	Bottom 10%	Top 10%	Δ	Low third	High third	Δ
Panel A: Government Spending												
Labour tax	Front-loaded	-1.091	0.209	0.0	3.2	0.0	-1.394	-0.836	0.558	-0.948	-1.221	-0.273
Labour tax	Linear	-0.727	0.133	0.0	0.5	0.0	-0.872	-0.597	0.274	-0.687	-0.763	-0.076
Labour tax	Back-loaded	-0.415	0.061	0.0	0.0	100.0	-0.435	-0.383	0.052	-0.432	-0.400	0.032
Returns tax	Front-loaded	-0.604	1.139	0.0	70.1	23.1	-0.045	-2.233	-2.188	-0.469	-0.727	-0.258
Returns tax	Linear	-0.419	1.089	0.0	71.5	0.1	-0.065	-1.512	-1.447	-0.319	-0.511	-0.192
Returns tax	Back-loaded	-0.254	1.001	0.0	74.0	76.8	-0.076	-0.873	-0.797	-0.192	-0.310	-0.118
Transfers	Front-loaded	-0.885	0.325	0.0	26.6	0.0	-1.471	-0.665	0.806	-1.131	-0.748	0.384
Transfers	Linear	-0.599	0.241	0.0	28.0	0.0	-0.885	-0.486	0.399	-0.727	-0.522	0.206
Transfers	Back-loaded	-0.347	0.122	0.0	26.0	100.0	-0.405	-0.320	0.085	-0.384	-0.319	0.065
Panel B: Fiscal Discipline												
Labour tax	Front-loaded	-0.632	0.314	0.0	8.1	0.5	-0.863	-0.544	0.319	-0.472	-0.778	-0.306
Labour tax	Linear	-0.417	0.194	0.0	3.3	0.0	-0.534	-0.385	0.149	-0.366	-0.465	-0.099
Labour tax	Back-loaded	-0.237	0.084	0.0	0.0	99.5	-0.263	-0.243	0.019	-0.249	-0.227	0.022
Returns tax	Front-loaded	-0.331	1.402	27.9	65.8	32.9	0.067	-1.411	-1.478	-0.247	-0.407	-0.160
Returns tax	Linear	-0.230	1.331	22.9	68.0	1.0	0.019	-0.950	-0.970	-0.163	-0.290	-0.127
Returns tax	Back-loaded	-0.140	1.207	0.0	70.8	66.1	-0.018	-0.546	-0.528	-0.096	-0.180	-0.083
Transfers	Front-loaded	-0.502	0.442	0.0	26.1	0.0	-0.962	-0.445	0.516	-0.686	-0.410	0.276
Transfers	Linear	-0.340	0.326	0.0	28.6	0.0	-0.568	-0.322	0.246	-0.436	-0.287	0.149
Transfers	Back-loaded	-0.197	0.175	0.0	29.2	100.0	-0.251	-0.209	0.042	-0.227	-0.178	0.049
Panel C: Additional Transfers												
Labour tax	Front-loaded	-0.709	0.298	0.0	3.3	0.4	-0.885	-0.616	0.269	-0.501	-0.886	-0.384
Labour tax	Linear	-0.469	0.175	0.0	0.5	0.0	-0.555	-0.434	0.121	-0.396	-0.531	-0.135
Labour tax	Back-loaded	-0.267	0.050	0.0	0.0	99.6	-0.281	-0.273	0.009	-0.275	-0.261	0.014
Returns tax	Front-loaded	-0.221	3.491	51.1	70.1	50.3	0.469	-2.018	-2.487	-0.022	-0.390	-0.368
Returns tax	Linear	-0.159	3.197	51.5	71.4	1.0	0.260	-1.359	-1.619	-0.024	-0.277	-0.253
Returns tax	Back-loaded	-0.102	2.721	52.4	74.0	48.8	0.087	-0.777	-0.865	-0.030	-0.169	-0.139
Transfers	Front-loaded	-0.502	0.442	0.0	26.6	0.0	-0.962	-0.445	0.516	-0.686	-0.410	0.276
Transfers	Linear	-0.340	0.326	0.0	28.0	0.0	-0.568	-0.322	0.246	-0.436	-0.287	0.149
Transfers	Back-loaded	-0.197	0.175	0.0	26.0	100.0	-0.251	-0.209	0.042	-0.227	-0.178	0.049
Panel D: Public Investment												
Labour tax	Front-loaded	-0.520	0.432	0.1	6.3	3.6	-0.815	-0.379	0.436	-0.359	-0.669	-0.310
Labour tax	Linear	-0.339	0.286	0.0	2.1	0.0	-0.494	-0.272	0.222	-0.292	-0.385	-0.093
Labour tax	Back-loaded	-0.191	0.151	0.0	0.0	96.4	-0.235	-0.178	0.057	-0.209	-0.178	0.031
Returns tax	Front-loaded	-0.153	3.610	52.5	66.6	51.4	0.304	-1.445	-1.749	-0.047	-0.251	-0.204
Returns tax	Linear	-0.109	3.320	53.1	68.5	1.4	0.172	-0.969	-1.140	-0.029	-0.184	-0.155
Returns tax	Back-loaded	-0.071	2.800	53.8	71.4	47.2	0.060	-0.554	-0.615	-0.021	-0.118	-0.097
Transfers	Front-loaded	-0.364	0.730	0.0	27.1	0.0	-0.920	-0.258	0.663	-0.583	-0.252	0.331
Transfers	Linear	-0.244	0.557	0.0	29.4	0.0	-0.528	-0.194	0.334	-0.360	-0.180	0.180
Transfers	Back-loaded	-0.142	0.322	0.0	28.6	100.0	-0.219	-0.135	0.084	-0.179	-0.117	0.063

Notes: Mean and incidence CEVs are reported as percentages of baseline consumption. Relative dispersion is the weighted standard deviation of state-level CEV divided by the absolute weighted mean CEV. CEV > 0 share, preferred policy, and preferred timing are percentages. Preferred policy is the weighted share of households for whom the fiscal instrument gives the highest CEV among the three instruments, holding the fiscal-capacity use and timing path fixed. Preferred timing is the corresponding share for which a timing path gives the highest CEV, holding the fiscal-capacity use and instrument fixed. Asset columns report weighted mean CEVs for bottom and top initial-asset deciles. Productivity columns report weighted mean CEVs for the bottom and top thirds of the initial productivity distribution. Δ is the high-group mean minus the low-group mean.

D Fiscal Headroom: Detailed Results

This appendix reports the complete transition, welfare, and incidence evidence underlying Section 5. The exhibits are organised by use of fiscal capacity and retain the common Government Spending benchmark used in the main text.

D.1 Steady States and Aggregate Comparisons

Table D1 reports the initial steady state and the lower-debt steady states implied by the different uses of fiscal capacity.

Table D2 collects the cumulative-loss statistics for the four fiscal-capacity uses, with Government Spending as the baseline panel.

Table D1: Initial and lower-debt steady states in the HC model

		Government Spending / Fiscal Discipline		Public Investment		Additional Transfers	
Variable	Initial	Level	Change	Level	Change	Level	Change
Debt ratio B/Y	0.800	0.700	-10.01 pp	0.684	-11.61 pp	0.698	-10.16 pp
Debt level B	1.143	1.000	-12.50%	1.000	-12.50%	1.000	-12.50%
Output Y	1.428	1.429	+0.02%	1.462	+2.35%	1.432	+0.23%
Capital employed K	3.285	3.289	+0.10%	3.374	+2.70%	3.300	+0.45%
Wage w	1.000	1.001	+0.03%	1.013	+1.28%	1.001	+0.09%
Interest rate r	0.0300	0.0299	-1.06 bp	0.0296	-4.48 bp	0.0297	-2.87 bp
Effective labour L	1.000	0.999	-0.01%	1.010	+1.05%	1.001	+0.13%
External borrowing position	0.285	0.267	-6.22%	0.213	-25.27%	0.237	-16.93%
External borrowing/output	0.200	0.187	-1.25 pp	0.146	-5.38 pp	0.165	-3.42 pp
Public investment I_g	0.071	0.071	+0.00%	0.076	+6.00%	0.071	+0.00%
General government spending G	0.111	0.116	+4.03%	0.122	+9.39%	0.113	+1.11%
Total government spending	0.183	0.187	+2.46%	0.198	+8.06%	0.184	+0.68%
Transfers	0.065	0.065	+0.00%	0.065	+0.00%	0.069	+6.59%
Public capital K_g	0.952	0.952	+0.00%	1.009	+6.00%	0.952	+0.00%
Productivity Z	1.000	1.000	+0.00%	1.008	+0.79%	1.000	+0.00%
Mean assets	4.143	4.021	-2.94%	4.161	+0.43%	4.063	-1.93%
Mean consumption	0.836	0.832	-0.47%	0.846	+1.30%	0.838	+0.23%
Mean human capital	2.892	2.891	-0.03%	2.915	+0.81%	2.896	+0.13%
Mean HC investment	0.068	0.068	-0.08%	0.070	+1.91%	0.069	+0.28%
Asset Gini	0.711	0.711	+0.04 pp	0.702	-0.89 pp	0.706	-0.46 pp
Consumption Gini	0.217	0.216	-0.11 pp	0.213	-0.34 pp	0.213	-0.36 pp

Notes: The lower-debt steady states use the same debt-level reduction, equal to 10 percent of initial output. Fiscal Discipline shares the same terminal steady state as Government Spending; the table therefore reports three distinct lower-debt steady states. Asset Ginis use raw asset positions, including debt.

Table D2: Macroeconomic transition losses across alternative uses of fiscal capacity

Instrument	Timing	Output trough	Trough year	Cumulative losses, years 0–25: Y	C	H	X	A	N
Panel A: Government Spending									
Labour tax	Front-loaded	-1.38	3	24.15	36.43	13.82	47.40	59.62	0.15
Labour tax	Linear	-1.11	25	21.42	29.83	11.77	47.08	33.82	11.25
Labour tax	Back-loaded	-2.26	25	18.55	23.30	9.18	46.01	10.91	21.10
Returns tax	Front-loaded	-0.06	32	0.33	10.78	0.16	3.97	70.69	0.21
Returns tax	Linear	-0.10	39	0.25	6.54	0.00	1.34	54.06	0.02
Returns tax	Back-loaded	-0.14	42	0.48	3.35	0.00	1.21	35.81	0.02
Transfers	Front-loaded	-0.05	15	0.82	15.13	3.91	12.59	40.44	2.67
Transfers	Linear	0.00	0	0.00	11.00	1.38	6.17	23.25	0.72
Transfers	Back-loaded	0.00	0	0.00	7.20	0.15	4.18	7.59	0.08
Panel B: Fiscal Discipline									
Labour tax	Front-loaded	-1.31	1	12.33	16.69	6.08	20.85	54.06	0.00
Labour tax	Linear	-0.60	9	12.59	16.47	6.89	23.37	33.47	2.47
Labour tax	Back-loaded	-1.66	25	14.86	16.61	7.00	32.29	13.45	16.27
Returns tax	Front-loaded	-0.01	1	0.01	8.49	0.02	2.42	41.30	0.00
Returns tax	Linear	-0.00	1	0.00	5.73	0.00	0.87	34.82	0.00
Returns tax	Back-loaded	-0.01	5	0.04	3.48	0.00	1.19	26.00	0.00
Transfers	Front-loaded	-0.06	11	0.80	6.95	4.21	12.97	37.64	2.78
Transfers	Linear	0.00	0	0.00	5.67	2.13	8.73	23.23	1.28
Transfers	Back-loaded	0.00	0	0.00	4.54	0.52	5.98	9.30	0.31
Panel C: Additional Transfers									
Labour tax	Front-loaded	-1.40	3	23.94	28.01	13.96	46.58	57.19	0.24
Labour tax	Linear	-1.11	25	22.29	24.75	12.67	49.95	34.12	12.16
Labour tax	Back-loaded	-2.36	25	20.22	21.21	10.63	51.97	12.65	22.77
Returns tax	Front-loaded	-0.01	1	0.01	3.84	0.04	2.52	67.00	0.01
Returns tax	Linear	-0.04	28	0.56	2.54	0.00	1.09	54.10	0.03
Returns tax	Back-loaded	-0.11	31	1.42	1.86	0.09	1.72	38.76	0.22
Transfers	Front-loaded	-0.06	11	0.80	6.95	4.21	12.97	37.64	2.78
Transfers	Linear	0.00	0	0.00	5.67	2.13	8.73	23.23	1.28
Transfers	Back-loaded	0.00	0	0.00	4.54	0.52	5.98	9.30	0.31
Panel D: Public Investment									
Labour tax	Front-loaded	-1.36	2	11.34	17.23	6.42	23.61	60.34	0.03
Labour tax	Linear	-0.62	7	8.99	16.07	7.25	24.53	37.49	3.38
Labour tax	Back-loaded	-1.50	25	14.68	17.84	7.75	35.97	15.04	18.11
Returns tax	Front-loaded	-0.01	1	0.01	3.89	0.00	0.00	46.70	0.00
Returns tax	Linear	-0.01	1	0.01	2.70	0.00	0.00	40.30	0.00
Returns tax	Back-loaded	-0.01	5	0.04	2.51	0.00	0.22	30.77	0.00
Transfers	Front-loaded	0.00	0	0.00	5.14	2.45	7.26	40.21	0.27
Transfers	Linear	0.00	0	0.00	3.56	0.94	2.33	25.38	0.01
Transfers	Back-loaded	0.00	0	0.00	3.69	0.18	3.33	10.62	0.00

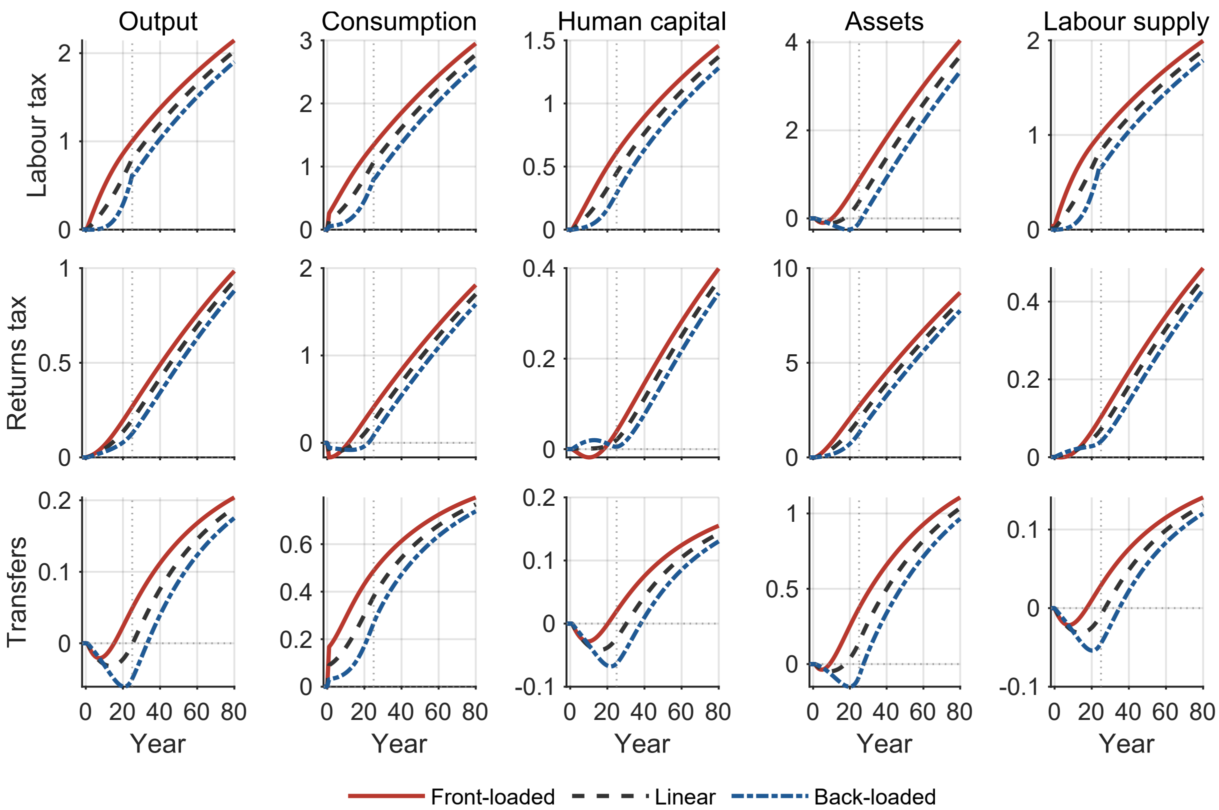
Notes: Panels correspond to alternative uses of debt-service savings, including the Government Spending baseline. Series are percentage deviations from year 0. The output trough is searched over years 0–80. For each reported series p, cumulative loss is $\sum_{t=0}^{25} \max\{-\Delta p_t, 0\}$ and is measured in percentage-point-years. Y is output, C mean consumption, H mean human capital, X mean human-capital investment, A mean financial assets, and N effective labour supply.

D.2 Fiscal Discipline

Fiscal Discipline uses the fiscal room created by lower debt service to reduce pressure on the budget-clearing instrument during the policy window. This allows the government to choose a less aggressive path for the selected fiscal instrument, meaning that the relative beneficiaries of fiscal restraint are those households most exposed to the chosen fiscal instrument. Under labour-tax closure, discipline protects labour supply and human-capital investment from larger tax movements. Under transfers closure, it protects households that rely on the transfer component. Under returns-tax closure, it protects asset holders from a larger tax on asset income.

Figure D1 plots aggregate transition paths under Fiscal Discipline as percentage differences from the matched Government Spending baseline with the same fiscal instrument and debt-path timing. The main result is that Fiscal Discipline raises output relative to that baseline over most of the transition, especially under labour-tax closure. By year 25, GDP is roughly 0.62–1.00 percent higher across the three timing paths. The mechanism is the smaller required tax movement, which supports labour supply and human-capital accumulation. Returns-tax closures show similar, but weaker, aggregate improvements, while the output response under transfers closure is smaller and can change sign over the transition.

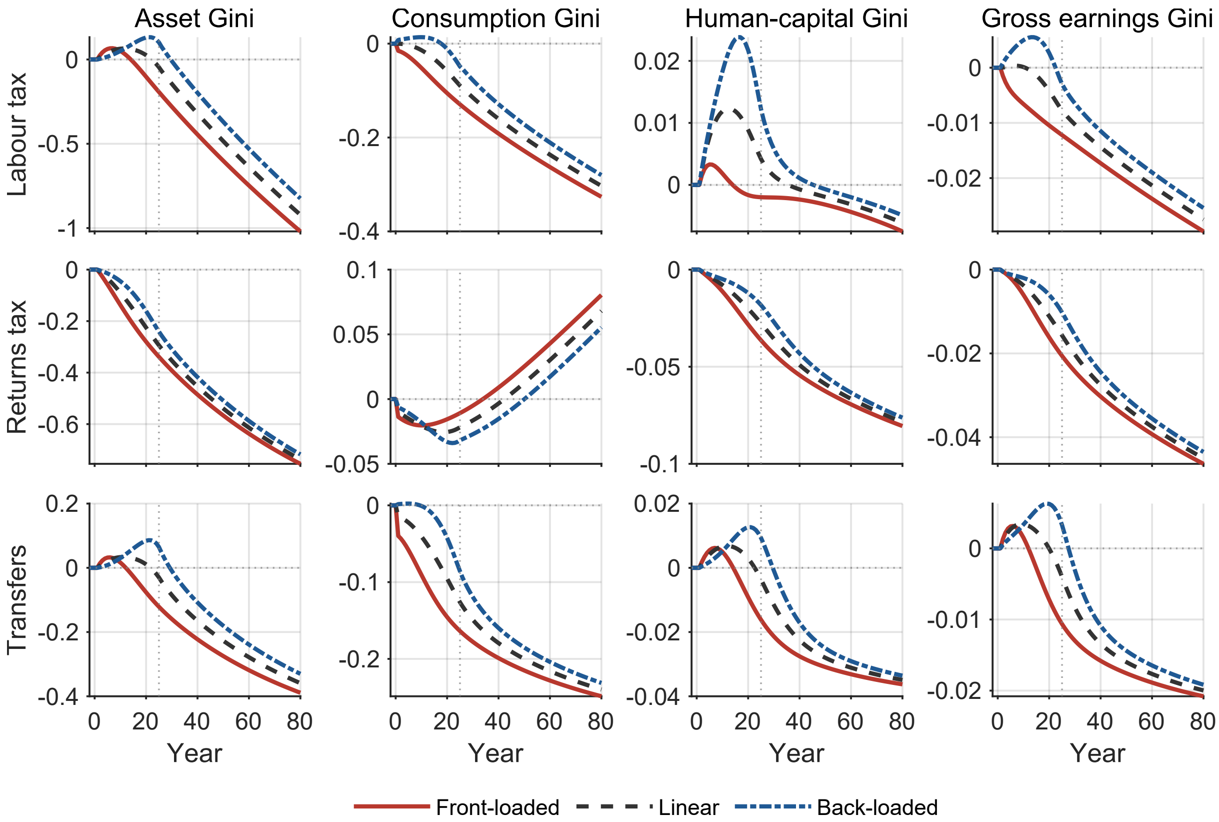
Figure D1: Fiscal Discipline relative to Government Spending: aggregate transitions.



Note: Rows correspond to the three fiscal instruments and columns to output, mean consumption, mean human capital, mean assets, and labour supply. Series are percentage differences from the matched Government Spending transition with the same instrument and timing. The vertical dotted line marks year 25.

Table D2 reports the cumulative-loss evidence together with the other fiscal-capacity cases. Under the linear labour-tax path, cumulative output losses fall from 21.42 percentage-point-years in the Government Spending baseline to 12.59 under Fiscal Discipline. Cumulative consumption losses also fall, from 29.83 to 16.47 percentage-point-years. The output changes under returns taxation and transfers closure are small because those closures generate little output loss in either case. Fiscal Discipline reduces cumulative consumption and asset losses in most cases, although some back-loaded paths exhibit higher losses. Under transfers closure, some production-side loss measures also increase modestly.

Figure D2: Fiscal Discipline relative to Government Spending: distributional dynamics.



Note: Rows correspond to the three fiscal instruments and columns to asset, consumption, human-capital, and pre-tax earnings Gini coefficients. Series are percentage-point differences from the matched Government Spending transition with the same instrument and timing. The vertical dotted line marks year 25.

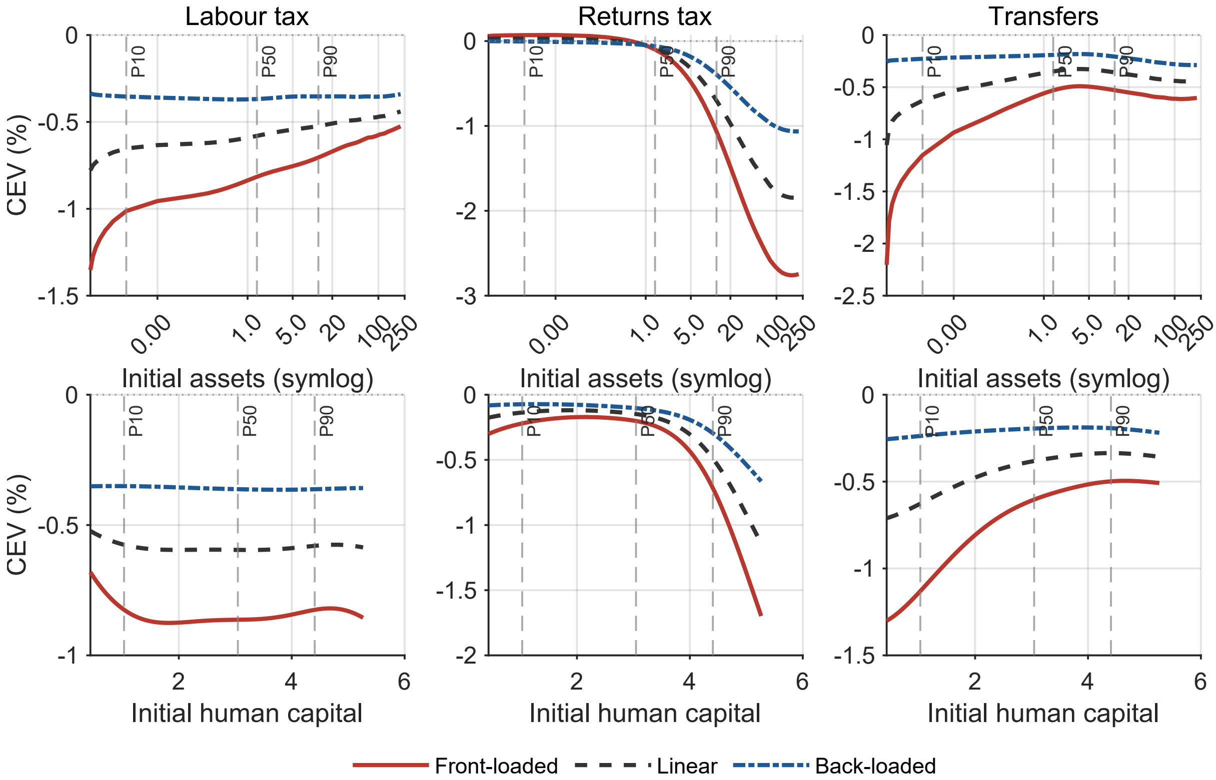
Table D3 shows the same pattern in incumbent welfare. Under the linear path, mean incumbent CEV improves relative to the Government Spending baseline from -1.030% to -0.588% under labour taxation, from -0.436% to -0.213% under returns taxation, and from -0.641% to -0.426% under transfers adjustment. The incidence comparison is also relative to the same Government Spending baseline. In the linear returns-tax case, the bottom initial-asset decile moves from a small loss of -0.048% under Government Spending to a gain of 0.029% under Fiscal Discipline, while the top initial-asset decile's loss narrows from -1.584% to -0.956%. By contrast, under the linear labour-tax and transfers paths, both bottom and top asset deciles still lose on average, although the losses are smaller than in the Government Spending baseline and remain larger at the bottom of the asset distribution.

Table D3: Welfare, preferences, and incidence: Fiscal Discipline

	CEV			Preferred share		Initial assets			Initial HC		
Timing path	Mean	Rel. disp.	> 0 share	Pref. policy	Pref. timing	Bottom 10%	Top 10%	Δ	Bottom 10%	Top 10%	Δ
Panel A: Labour tax											
Front-loaded	-0.848	0.236	0.0	5.1	1.2	-1.134	-0.685	0.449	-0.757	-0.849	-0.092
Linear	-0.588	0.137	0.0	0.9	0.0	-0.698	-0.515	0.183	-0.551	-0.588	-0.037
Back-loaded	-0.360	0.030	0.0	0.0	98.8	-0.347	-0.353	-0.006	-0.351	-0.361	-0.010
Panel B: Returns tax											
Front-loaded	-0.308	1.591	38.9	74.0	45.0	0.066	-1.455	-1.521	-0.258	-0.821	-0.563
Linear	-0.213	1.479	34.1	74.4	1.2	0.029	-0.956	-0.985	-0.154	-0.561	-0.407
Back-loaded	-0.134	1.271	7.9	72.8	53.7	-0.002	-0.540	-0.537	-0.076	-0.337	-0.261
Panel C: Transfers											
Front-loaded	-0.698	0.564	0.0	21.0	0.0	-1.501	-0.547	0.954	-1.250	-0.501	0.750
Linear	-0.426	0.409	0.0	24.7	0.0	-0.776	-0.376	0.400	-0.684	-0.339	0.346
Back-loaded	-0.203	0.128	0.0	27.2	100.0	-0.239	-0.222	0.017	-0.249	-0.195	0.053

Notes: CEVs are reported as percentages of baseline consumption. Relative dispersion is the weighted standard deviation of state-level CEV divided by the absolute weighted mean CEV. CEV > 0 share, preferred policy, and preferred timing are percentages. Preferred policy is the weighted share of households for whom the fiscal instrument gives the highest CEV among the three instruments, holding the timing path fixed. Preferred timing is the weighted share of households for whom the timing path gives the highest CEV among the three timing paths, holding the fiscal instrument fixed. Bottom and top 10% columns report weighted mean CEVs for households in the corresponding deciles of the initial asset or human-capital distribution. The Δ column is the top-decile mean CEV minus the bottom-decile mean CEV and is measured in percentage points.

Figure D3: Fiscal Discipline: CEV incidence by initial assets and human capital.



Note: The top row conditions on initial assets and the bottom row on initial human capital. Columns correspond to the three fiscal instruments. Dashed vertical lines mark selected percentiles of the initial distribution; the horizontal dotted line denotes zero CEV.

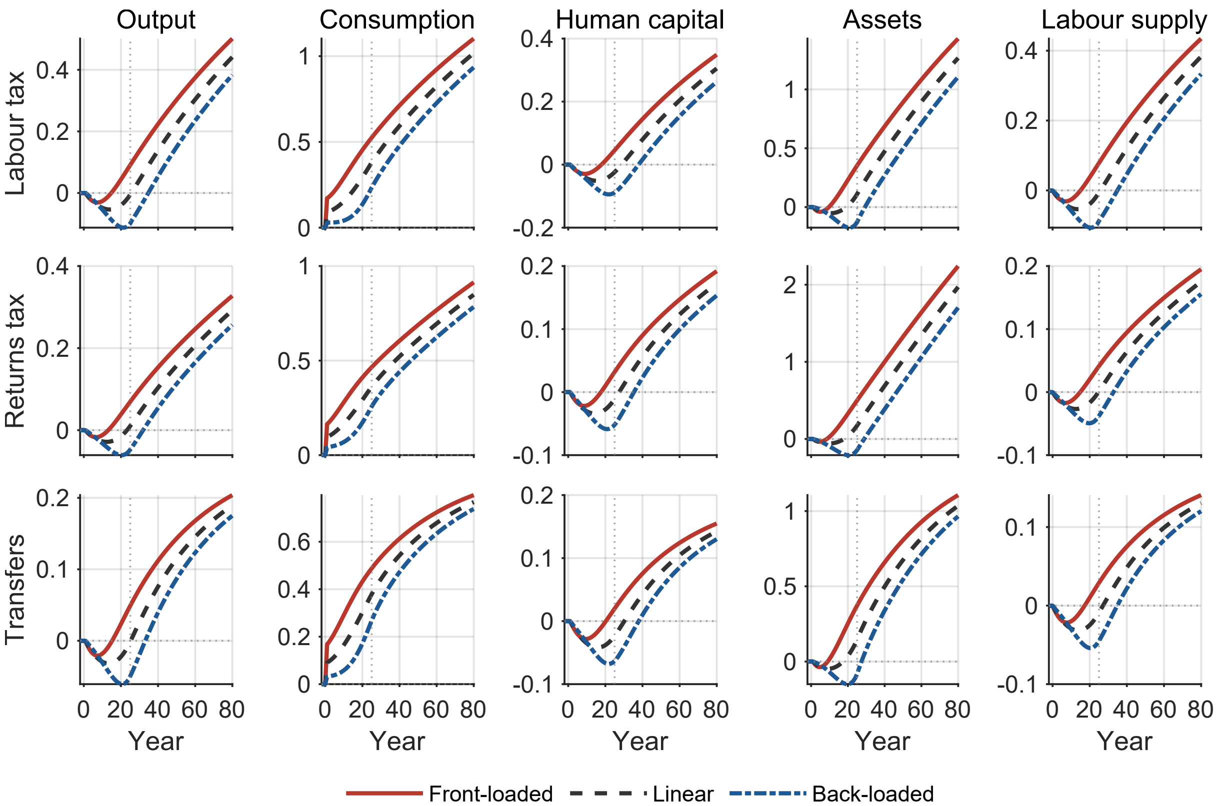
The household support implications are close to the Government Spending baseline along the instrument dimension. Returns taxation remains the broadly preferred closure, with support of about 73–74% across timing paths, while labour taxation attracts at most 5.1% support. Fiscal Discipline changes timing preferences more than instrument preferences. Within returns-tax closures, the front-loaded path becomes more attractive: the share preferring front-loading rises from 30.8% in the Government Spending baseline to 45.0% under Fiscal Discipline, because faster deleveraging is paired with a smaller required tax movement. A sizeable minority of households also experience welfare gains from the transition itself. Under returns-tax closure, the positive-CEV share rises to 38.9% in the front-loaded case and 34.1% in the linear case. These gains are concentrated among low-asset households, who pay little of the asset-income tax but benefit from the stronger wage and aggregate-output path during the transition.

D.3 Additional Transfers

The Additional Transfers scenario assigns the projected fiscal room from lower debt to the lump-sum transfer component of the government budget. In the terminal steady state, transfers rise from 0.065 to 0.069, while output remains close to the Government Spending lower-debt steady state.

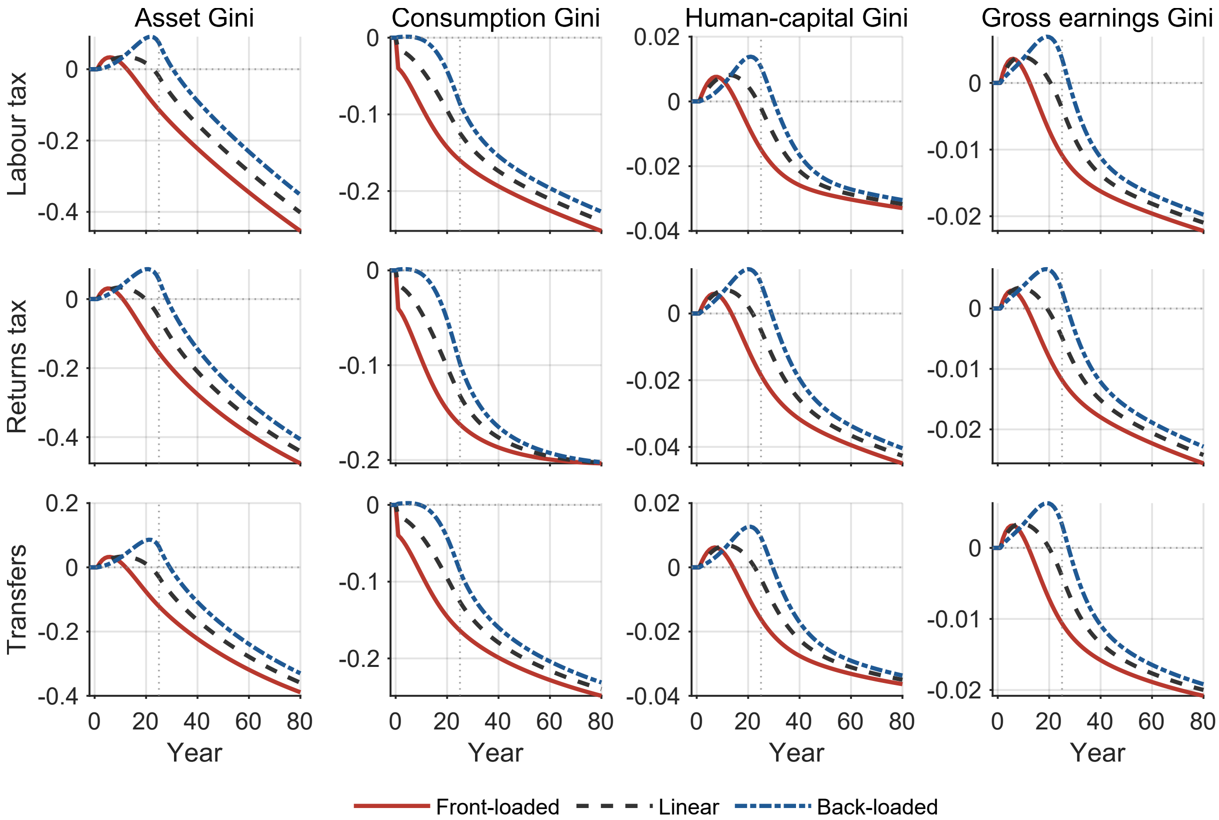
Figure D4 and Table D2 show that the aggregate transition remains close to the Government Spending baseline. Under the linear debt path with labour-tax closure, the cumulative output loss is 22.29 percentage-point-years, compared with 21.42 in the Government Spending baseline. The transfer channel mainly cushions household-side outcomes: cumulative consumption losses fall from 29.83 to 24.75 percentage-point-years under labour taxation, from 6.54 to 2.54 under returns taxation, and from 11.00 to 5.67 under transfers adjustment. Human-capital losses remain of a similar order, although they are modestly higher than the baseline under labour taxation and transfers adjustment, and remain essentially zero under returns taxation.

Figure D4: Additional Transfers relative to Government Spending: aggregate transitions.



Note: Rows correspond to the three fiscal instruments and columns to output, mean consumption, mean human capital, mean assets, and labour supply. Series are percentage differences from the matched Government Spending transition with the same instrument and timing. The vertical dotted line marks year 25.

Figure D5: Additional Transfers relative to Government Spending: distributional dynamics.



Note: Rows correspond to the three fiscal instruments and columns to asset, consumption, human-capital, and pre-tax earnings Gini coefficients. Series are percentage-point differences from the matched Government Spending transition with the same instrument and timing. The vertical dotted line marks year 25.

The welfare results in Table D4, together with the CEV incidence in Figure D6, show how this household transfer changes household preferences over the transition. Mean incumbent welfare improves relative to the Government Spending baseline in all linear cases, because the fiscal room is returned to households, but a large gap opens between fiscal instruments. Labour taxation remains the worst option: the linear mean incumbent CEV improves from -1.030 percent in the Government Spending baseline to -0.815 percent, but remains below the -0.588 percent outcome under Fiscal Discipline because transfers alleviate some pressure without reducing the distortionary labour-tax wedge. Returns taxation is clearly preferred. The linear returns-tax CEV rises to -0.213 percent, matching Fiscal Discipline and improving on Government Spending, but with a much wider incidence spread: the bottom initial-asset decile gains 0.248 percent while the top decile loses 1.463 percent as the higher transfer is financed by more punitive returns taxes. In the front-loaded and linear returns-tax paths, 53.6 and 50.9 percent of households have positive CEV, respectively, creating a strong coalition for financing higher transfers through returns taxation; within that instrument, front-loaded debt reduction becomes

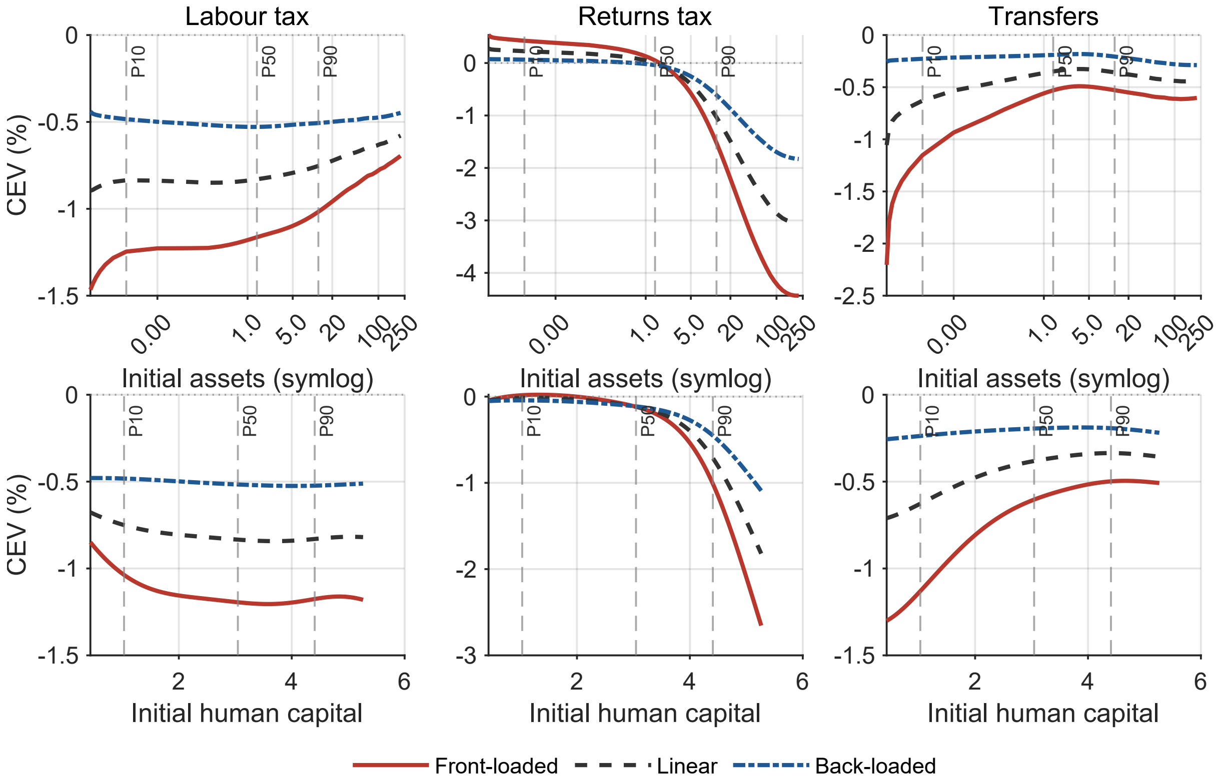
Table D4: Welfare, preferences, and incidence: Additional Transfers

	CEV			Preferred share		Initial assets			Initial HC		
Timing path	Mean	Rel. disp.	> 0 share	Pref. policy	Pref. timing	Bottom 10%	Top 10%	Δ	Bottom 10%	Top 10%	Δ
Panel A: Labour tax											
Front-loaded	-1.157	0.177	0.0	0.4	0.2	-1.322	-0.975	0.347	-0.941	-1.196	-0.254
Linear	-0.815	0.102	0.0	0.0	0.0	-0.856	-0.731	0.125	-0.712	-0.835	-0.123
Back-loaded	-0.510	0.045	0.0	0.0	99.8	-0.467	-0.500	-0.033	-0.479	-0.520	-0.040
Panel B: Returns tax											
Front-loaded	-0.267	3.081	53.6	71.5	57.0	0.468	-2.164	-2.632	-0.004	-1.190	-1.186
Linear	-0.213	2.515	50.9	70.4	0.6	0.248	-1.463	-1.711	-0.024	-0.835	-0.811
Back-loaded	-0.165	1.789	41.8	67.2	42.4	0.071	-0.863	-0.934	-0.044	-0.524	-0.480
Panel C: Transfers											
Front-loaded	-0.698	0.564	0.0	28.1	0.0	-1.501	-0.547	0.954	-1.250	-0.501	0.750
Linear	-0.426	0.409	0.0	29.6	0.0	-0.776	-0.376	0.400	-0.684	-0.339	0.346
Back-loaded	-0.203	0.128	0.0	32.8	100.0	-0.239	-0.222	0.017	-0.249	-0.195	0.053

Notes: CEVs are reported as percentages of baseline consumption. Relative dispersion is the weighted standard deviation of state-level CEV divided by the absolute weighted mean CEV. CEV > 0 share, preferred policy, and preferred timing are percentages. Preferred policy is the weighted share of households for whom the fiscal instrument gives the highest CEV among the three instruments, holding the timing path fixed. Preferred timing is the weighted share of households for whom the timing path gives the highest CEV among the three timing paths, holding the fiscal instrument fixed. Bottom and top 10% columns report weighted mean CEVs for households in the corresponding deciles of the initial asset or human-capital distribution. The Δ column is the top-decile mean CEV minus the bottom-decile mean CEV and is measured in percentage points.

the preferred timing path for 57.0 percent of households.

Figure D6: Additional Transfers: CEV incidence by initial assets and human capital.

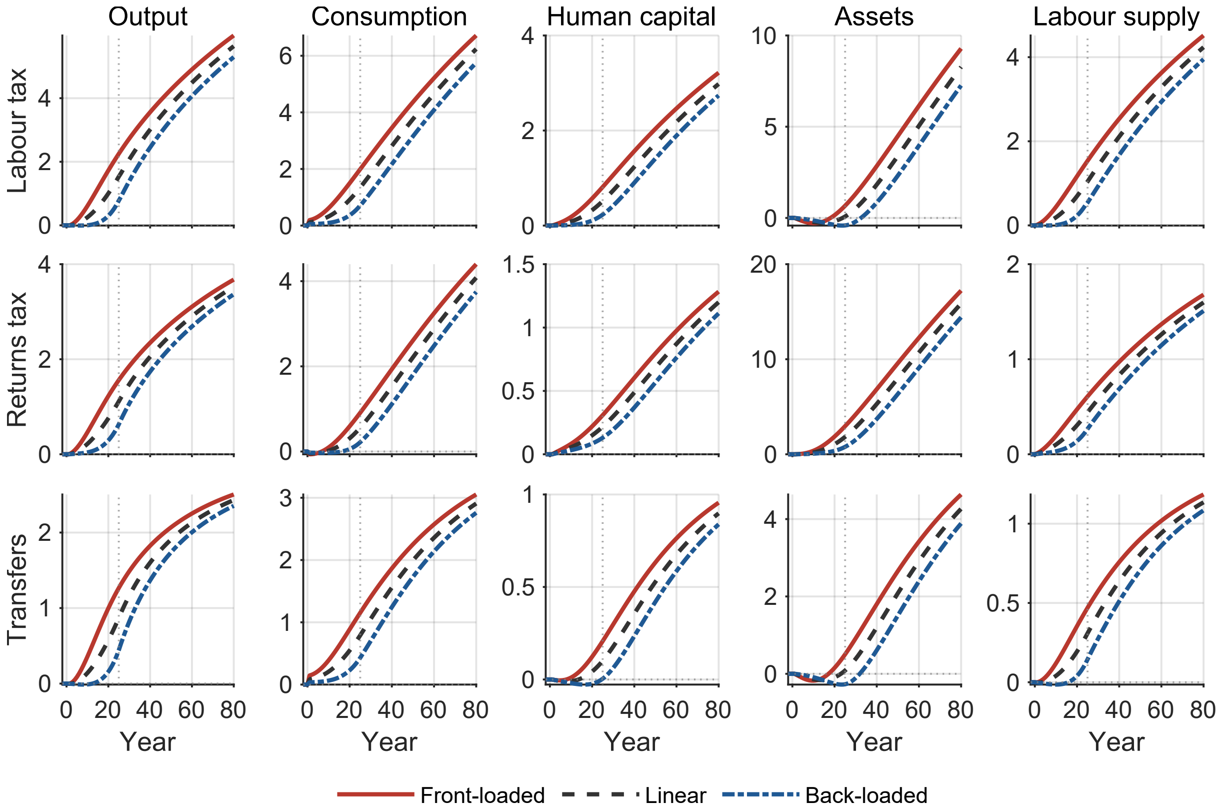


Note: The top row conditions on initial assets and the bottom row on initial human capital. Columns correspond to the three fiscal instruments. Dashed vertical lines mark selected percentiles of the initial distribution; the horizontal dotted line denotes zero CEV.

D.4 Public Investment

The Public Investment scenario uses the same projected headroom to increase productive public capital. Unlike Additional Transfers, the channel is not a direct increase in household disposable resources. It works by raising productivity, wages, and the tax base during the debt transition.

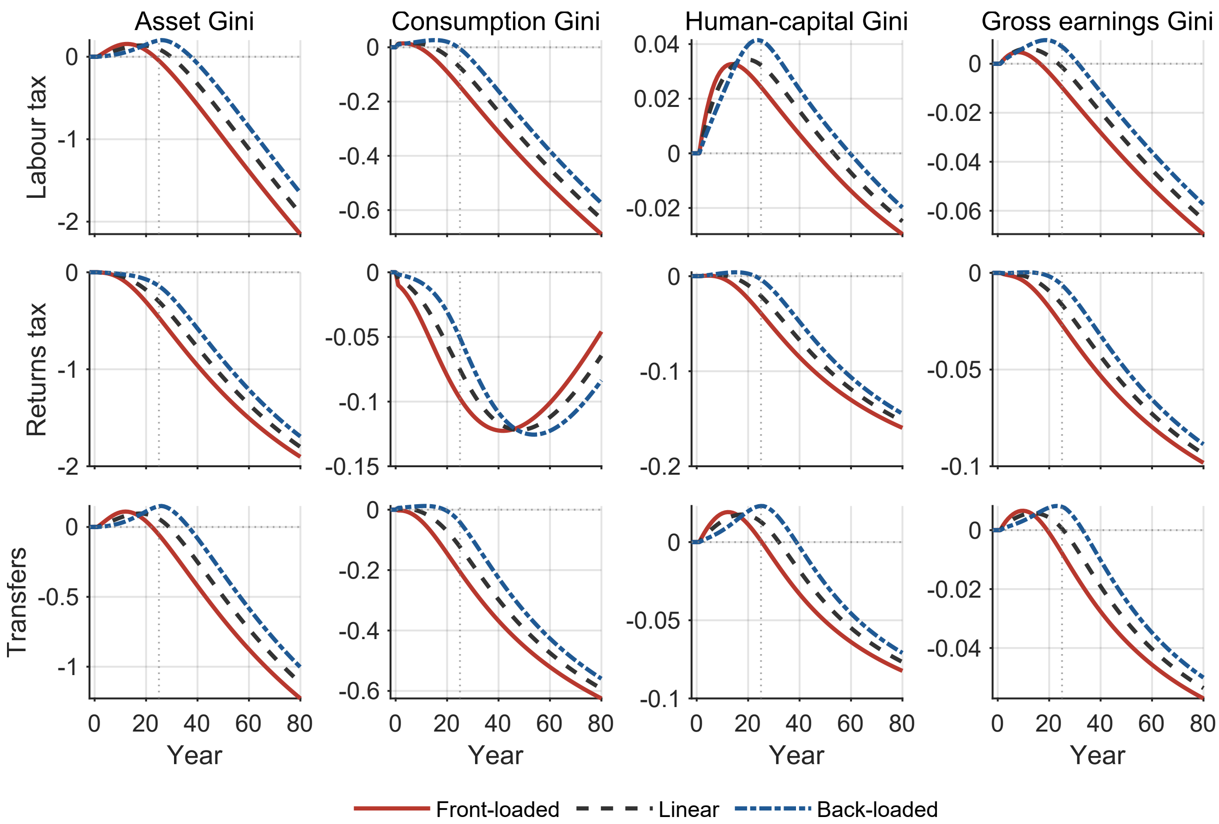
Figure D7: Public Investment relative to Government Spending: aggregate transitions.



Note: Rows correspond to the three fiscal instruments and columns to output, mean consumption, mean human capital, mean assets, and labour supply. Series are percentage differences from the matched Government Spending transition with the same instrument and timing. The vertical dotted line marks year 25.

Figure D7 and Table D2 show that this productivity channel generates broader aggregate gains overall than either Fiscal Discipline or Additional Transfers. Under the linear debt path with labour-tax closure, cumulative output losses fall to 8.99 percentage-point-years, compared with 21.42 in the Government Spending baseline, 12.59 under Fiscal Discipline, and 22.29 under Additional Transfers. Consumption losses are also lower: under the linear path they fall to 16.07 percentage-point-years with labour-tax closure, 2.70 with returns-tax closure, and 3.56 with transfers closure. The corresponding Government Spending losses are 29.83, 6.54, and 11.00 percentage-point-years. The point is therefore not only that public capital raises the terminal level of output; it also cushions the transition by supporting labour income, human-capital accumulation, and the tax base while the debt path is being implemented.

Figure D8: Public Investment relative to Government Spending: distributional dynamics.



Note: Rows correspond to the three fiscal instruments and columns to asset, consumption, human-capital, and pre-tax earnings Gini coefficients. Series are percentage-point differences from the matched Government Spending transition with the same instrument and timing. The vertical dotted line marks year 25.

The welfare results in Table D5, together with the CEV incidence in Figure D9, show the same broadening in household terms. Under the linear path, mean incumbent CEV is -0.494 percent under labour taxation, -0.045 percent under returns taxation, and -0.298 percent under transfers adjustment. These outcomes are better than the matched Government Spending baseline and also better than the corresponding Fiscal Discipline and Additional Transfers cases. Labour taxation remains the weakest closure instrument, but the productivity gain offsets more of the transition cost than in the previous two counterfactuals. Returns taxation remains clearly preferred: it combines the smallest mean incumbent welfare loss with the strongest positive-CEV coalition.

The incidence is still redistributive. In the linear returns-tax case, the bottom initial-asset decile gains 0.205 percent while the top decile loses 0.879 percent. The top decile therefore continues to bear the cost of the returns tax. Public Investment nevertheless reduces its loss relative to Fiscal Discipline at every timing: from 1.455 to 1.355 percent under front-loading, from 0.956 to 0.879 percent under the linear path, and from 0.540 to 0.492 percent under back-loading. The productivity dividend therefore cushions even high-asset households, although their CEV remains negative because they remain exposed

Table D5: Welfare, preferences, and incidence: Public Investment

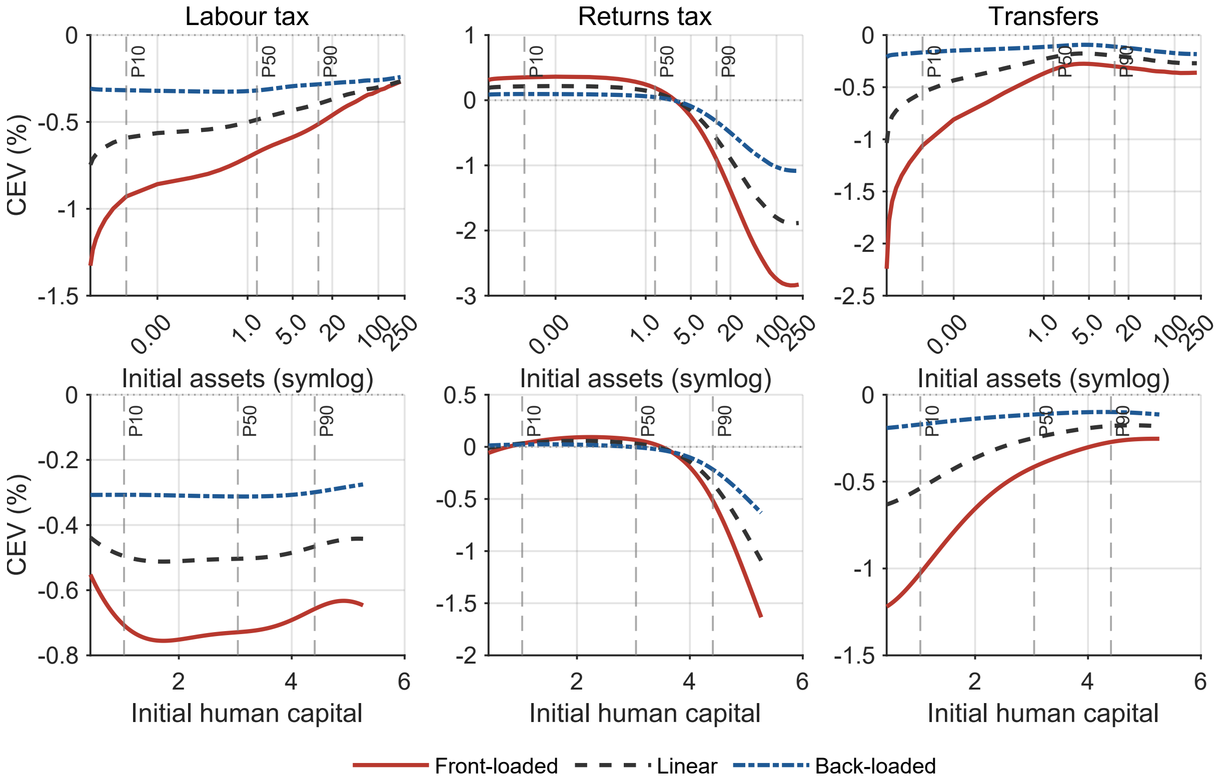
	CEV			Preferred share		Initial assets			Initial HC		
Timing path	Mean	Rel. disp.	> 0 share	Pref. policy	Pref. timing	Bottom 10%	Top 10%	Δ	Bottom 10%	Top 10%	Δ
Panel A: Labour tax											
Front-loaded	-0.710	0.335	0.1	4.4	4.9	-1.073	-0.478	0.595	-0.636	-0.679	-0.043
Linear	-0.494	0.208	0.0	0.7	0.0	-0.649	-0.377	0.272	-0.470	-0.471	-0.002
Back-loaded	-0.308	0.059	0.0	0.0	95.1	-0.314	-0.278	0.037	-0.307	-0.296	0.012
Panel B: Returns tax											
Front-loaded	-0.058	9.579	63.3	74.5	63.6	0.336	-1.355	-1.691	-0.012	-0.636	-0.624
Linear	-0.045	7.892	63.1	74.6	1.2	0.205	-0.879	-1.084	0.013	-0.433	-0.446
Back-loaded	-0.040	4.739	61.3	73.2	35.2	0.092	-0.492	-0.584	0.019	-0.265	-0.283
Panel C: Transfers											
Front-loaded	-0.521	0.881	0.0	21.1	0.0	-1.458	-0.312	1.146	-1.163	-0.272	0.891
Linear	-0.298	0.699	0.0	24.7	0.0	-0.718	-0.212	0.507	-0.603	-0.181	0.422
Back-loaded	-0.123	0.294	0.0	26.8	100.0	-0.184	-0.123	0.061	-0.184	-0.101	0.083

Notes: CEVs are reported as percentages of baseline consumption. Relative dispersion is the weighted standard deviation of state-level CEV divided by the absolute weighted mean CEV. CEV > 0 share, preferred policy, and preferred timing are percentages. Preferred policy is the weighted share of households for whom the fiscal instrument gives the highest CEV among the three instruments, holding the timing path fixed. Preferred timing is the weighted share of households for whom the timing path gives the highest CEV among the three timing paths, holding the fiscal instrument fixed. Bottom and top 10% columns report weighted mean CEVs for households in the corresponding deciles of the initial asset or human-capital distribution. The Δ column is the top-decile mean CEV minus the bottom-decile mean CEV and is measured in percentage points.

to the returns-tax burden.

The same mechanism shapes timing preferences. Under returns taxation, 63.3 percent of households have positive CEV in the front-loaded path and 63.1 percent in the linear path, both well above the Fiscal Discipline and Additional Transfers cases. Front-loaded debt reduction becomes the preferred timing path for 63.6 percent of households under returns taxation, because faster deleveraging brings the public-investment path forward: public capital is built sooner, and the associated productivity and wage gains arrive earlier in the transition.

Figure D9: Public Investment: CEV incidence by initial assets and human capital.



Note: The top row conditions on initial assets and the bottom row on initial human capital. Columns correspond to the three fiscal instruments. Dashed vertical lines mark selected percentiles of the initial distribution; the horizontal dotted line denotes zero CEV.

D.5 Robustness to Public-Capital Productivity

We assess the sensitivity of the Public Investment results to a lower productivity effect of public capital. The baseline sets $\phi_g = 0.1354$, so that a sustained increase in public investment equal to 1 percent of initial output raises long-run output by 2.5 percent. The robustness exercise instead sets $\phi_g = 0.1086$, implying a 2.0 percent long-run output gain, while holding the remaining model parameters, debt paths, and fiscal closures fixed.

Table D6 reproduces the welfare, preference, and incidence analysis for this lower-productivity case. Returns taxation remains the preferred financing instrument for between 71.6 and 73.9 percent of the initial population, depending on debt timing, and is the only instrument that produces gains for a majority of incumbents. Front-loading remains the modal timing choice under returns taxation, preferred by 58.8 percent. Its distributional incidence is also unchanged in direction: initial low-asset households gain, while high-asset and high-human-capital households bear the larger losses.

Table D7 reports the corresponding panel of the intergenerational welfare comparison. Returns taxation maximises welfare under every social discount factor. With $\Delta = 0.94$, its front-loaded and linear paths deliver positive all-cohort CEVs of 0.106 and 0.037 percent. At the benchmark $\Delta = 0.96$, all three returns-tax paths are positive, reaching 0.404 percent under front-loading; back-loaded transfers also produces a small gain of 0.022

Table D6: Welfare, preferences, and incidence: Public Investment with lower productivity

	CEV			Preferred share		Initial assets			Initial HC		
Timing path	Mean	Rel. disp.	> 0 share	Pref. policy	Pref. timing	Bottom 10%	Top 10%	Δ	Bottom 10%	Top 10%	Δ
Panel A: Labour tax											
Front-loaded	-0.868	0.273	0.0	3.2	2.3	-1.221	-0.612	0.609	-0.790	-0.827	-0.037
Linear	-0.600	0.169	0.0	0.1	0.0	-0.745	-0.470	0.275	-0.572	-0.572	-0.000
Back-loaded	-0.367	0.051	0.0	0.0	97.7	-0.366	-0.334	0.032	-0.363	-0.354	0.009
Panel B: Returns tax											
Front-loaded	-0.167	3.528	57.7	73.9	58.8	0.264	-1.550	-1.814	-0.103	-0.790	-0.688
Linear	-0.121	3.133	56.8	73.5	1.4	0.156	-1.016	-1.172	-0.050	-0.541	-0.491
Back-loaded	-0.086	2.379	53.0	71.6	39.8	0.063	-0.574	-0.637	-0.019	-0.330	-0.311
Panel C: Transfers											
Front-loaded	-0.624	0.739	0.0	22.9	0.0	-1.564	-0.393	1.171	-1.273	-0.363	0.910
Linear	-0.366	0.570	0.0	26.3	0.0	-0.786	-0.268	0.518	-0.674	-0.242	0.432
Back-loaded	-0.160	0.218	0.0	28.4	100.0	-0.218	-0.157	0.060	-0.220	-0.137	0.084

Notes: The lower-productivity specification sets $\phi_g = 0.1086$, corresponding to a 2.0 percent long-run output gain from a sustained increase in public investment equal to 1 percent of initial output. All other model parameters, debt paths, and fiscal closures are unchanged. CEVs are reported as percentages of baseline consumption. Relative dispersion is the weighted standard deviation of state-level CEV divided by the absolute weighted mean CEV. CEV > 0 share, preferred policy, and preferred timing are percentages. Preferred policy is the weighted share of households for whom the fiscal instrument gives the highest CEV among the three instruments, holding the timing path fixed. Preferred timing is the weighted share of households for whom the timing path gives the highest CEV among the three timing paths, holding the fiscal instrument fixed. Bottom and top 10% columns report weighted mean CEVs for households in the corresponding deciles of the initial asset or human-capital distribution. The Δ column is the top-decile mean CEV minus the bottom-decile mean CEV and is measured in percentage points.

percent. With $\Delta = 0.98$, every policy path is positive because the future output gains receive greater weight, but front-loaded returns taxation remains the welfare-maximising policy at 1.332 percent. Lower public-capital productivity therefore reduces the gains without changing the main financing or timing conclusions.

Table D7: Intergenerational welfare: Public Investment with lower productivity

Instrument	Debt path	Incumbents	All cohorts		
			$\Delta = 0.94$	$\Delta = 0.96$	$\Delta = 0.98$
Panel A: Public Investment, lower productivity					
Labour tax	Front-loaded	-0.899	-0.523	-0.132	1.000
Labour tax	Linear	-0.614	-0.383	-0.075	0.917
Labour tax	Back-loaded	-0.370	-0.273	-0.042	0.814
Returns tax	Front-loaded	-0.070	**0.106**	**0.404**	**1.332**
Returns tax	Linear	-0.058	0.037	0.275	1.108
Returns tax	Back-loaded	**-0.052**	-0.024	0.154	0.892
Transfers	Front-loaded	-0.698	-0.442	-0.128	0.640
Transfers	Linear	-0.399	-0.279	-0.037	0.635
Transfers	Back-loaded	-0.165	-0.154	0.022	0.604

Notes: The lower-productivity specification sets $\phi_g = 0.1086$, corresponding to a 2.0 percent long-run output gain from a sustained increase in public investment equal to 1 percent of initial output. All other model parameters, debt paths, and fiscal closures are unchanged. All three social discount factors are calculated from the saved cohort utility components for each completed path. Entries are consumption-equivalent variations in per cent. The first column aggregates date-0 incumbent lifetime utility; the remaining columns also include future entrants discounted by Δ. Household lifetime utility uses $\beta = 0.96$. Bold entries identify the welfare-maximising policy within each panel and column.

E Two-State EGM Algorithm

This appendix describes the stationary endogenous-gridpoint algorithm used for the household problem with liquid assets and human capital as endogenous state variables. The algorithm extends the one-dimensional EGM of Carroll (2006) along the two-state logic used in Auclert et al. (2021), but adapts it to the case in which the second endogenous state is human capital rather than an illiquid financial asset. The transition-path solver uses the same logic in backward induction, but here we focus only on the stationary problem.

E.1 The Households' Problem

For the purposes of the algorithm, it is convenient to write the household problem in current-state notation. Let current states be (a, h, e), where a denotes liquid assets, h human capital, and e the exogenous productivity state. The household chooses consumption c, next-period assets a', labour supply l, and next-period human capital h' so as to solve

$$V(a,h,e) = \max_{\{c,a',h',x,l\}} \{u(c,l) + \beta E\left[(1-\varpi)V(a',h',e') + \varpi b(a') \mid e\right]\} \tag{42}$$

$$\text{s.t.}$$

$$c + a' + x = R(a)a + \tau_1 \left(w\, e\, l\, g(h)\right)^{1-\tau_2} + \tau_0,$$

$$h' = \delta_h h + \chi x^{\gamma},$$

$$a' \geq a_{\min}, \qquad h' \geq \delta_h h, \qquad c - \psi \frac{l^{1+\theta}}{1+\theta} > 0, \qquad x \geq 0, \qquad l \geq 0.$$

Here $g(h) = \log(1+h)$ in the baseline specification, and the gross return on current liquid assets is piecewise because the model allows both an asset-income tax on positive positions and a borrowing wedge on debt:

$$R(a) = \begin{cases} 1 + r(1-\tau_a) & \text{if } a \geq 0, \\ 1 + r + r^{\text{pen}} & \text{if } a < 0. \end{cases} \tag{43}$$

First rewrite the human-capital investment function in implicit form. In the benchmark model,

$$x = \mathcal{X}(h', h) = \left(\frac{h' - \delta_h h}{\chi}\right)^{1/\gamma}. \tag{44}$$

Let $\mathcal{X}_1(h', h)$ and $\mathcal{X}_2(h', h)$ denote its partial derivatives with respect to next-period and current human capital. The non-negativity restriction $x \geq 0$ is equivalent to the lower bound $h' \geq \delta_h h$. The first-order conditions below allow for this bound through a Kuhn–

Tucker multiplier; the interior algorithm applies when the multiplier is zero.

Next note that, because preferences are of the GHH form, labour supply is pinned down statically as a function of (h, e) once prices and tax parameters are given. In particular, labour supply solves

$$l(h,e) = \left[\frac{(1-\tau_2)\tau_1\left(w\,e\,g(h)\right)^{1-\tau_2}}{\psi}\right]^{1/(\theta+\tau_2)}. \tag{45}$$

Hence the dynamic problem can be reduced to one in the two endogenous state variables (a, h) only. Define after-tax labour income net of the static labour choice by

$$z(h,e) = \tau_1\left(w\,e\,l(h,e)\,g(h)\right)^{1-\tau_2} + \tau_0, \tag{46}$$

and let

$$D(h,e) = \psi\frac{l(h,e)^{1+\theta}}{1+\theta} \tag{47}$$

denote the labour-disutility term implied by the static labour rule.

After substituting out labour supply, define the reduced flow-utility function

$$\widetilde{u}(\tilde{c}) = \frac{\tilde{c}^{1-\sigma}}{1-\sigma}, \tag{48}$$

where

$$\tilde{c}(a,h,e,a',h') = R(a)a + z(h,e) - a' - \mathcal{X}(h',h) - D(h,e), \tag{49}$$

and

$$\mathcal{W}(a',h',e) = \beta E\left[(1-\varpi)V(a',h',e') + \varpi b(a') \mid e\right]. \tag{50}$$

The reduced Bellman equation is therefore

$$V(a,h,e) = \max_{\{a',h'\}}\left\{\widetilde{u}(\tilde{c}(a,h,e,a',h')) + \mathcal{W}(a',h',e)\right\} \tag{51}$$

subject to $a' \geq a_{\min}$, $h' \geq \delta_h h$, and $\tilde{c} > 0$.

For the first-order conditions, let ξ_a and ξ_h be the Kuhn–Tucker multipliers on the asset and human-capital lower bounds. The associated Lagrangian is

$$\mathcal{L} = \widetilde{u}(\tilde{c}) + \mathcal{W}(a',h',e) + \xi_a(a'-a_{\min}) + \xi_h(h'-\delta_h h), \tag{52}$$

with

$$\xi_a \geq 0, \quad a' - a_{\min} \geq 0, \quad \xi_a(a'-a_{\min}) = 0, \tag{53}$$

$$\xi_h \geq 0, \quad h' - \delta_h h \geq 0, \quad \xi_h(h'-\delta_h h) = 0. \tag{54}$$

It is useful to define the derivatives of the continuation object as

$$W_a(a', h', e) = \beta E\left[(1-\varpi)V_a(a', h', e') + \varpi b_a(a') \mid e\right], \tag{55}$$

$$W_h(a', h', e) = \beta(1-\varpi)E\left[V_h(a', h', e') \mid e\right]. \tag{56}$$

The death event therefore affects the continuation derivative with respect to assets, through the bequest term, but not the continuation derivative with respect to human capital.

The first-order conditions are

$$\widetilde{u}'(\tilde{c}(a, h, e, a', h')) = \xi_a + W_a(a', h', e), \tag{57}$$

and

$$\widetilde{u}'(\tilde{c}(a, h, e, a', h'))\, \mathcal{X}_1(h', h) = \xi_h + W_h(a', h', e). \tag{58}$$

Since $\widetilde{u}'(\tilde{c}) = \tilde{c}^{-\sigma}$, the corresponding interior Euler equations are

$$\tilde{c}(a, h, e, a', h')^{-\sigma} = W_a(a', h', e), \tag{59}$$

and

$$\tilde{c}(a, h, e, a', h')^{-\sigma} \mathcal{X}_1(h', h) = W_h(a', h', e). \tag{60}$$

Dividing the two conditions yields the key EGM relationship

$$\frac{1}{\mathcal{X}_1(h', h)} = \frac{W_a(a', h', e)}{W_h(a', h', e)}, \tag{61}$$

which implicitly characterizes $h'(a', h, e)$ on the endogenous grid.

Away from the kink in the return schedule at $a = 0$, the envelope conditions are

$$V_a(a, h, e) = R(a)\widetilde{u}'(\tilde{c}(a, h, e, a', h')), \tag{62}$$

and

$$V_h(a, h, e) = [z_h(h, e) - D_h(h, e) - \mathcal{X}_2(h', h)]\, \widetilde{u}'(\tilde{c}(a, h, e, a', h')) - \delta_h \xi_h. \tag{63}$$

At $a = 0$, the asset envelope is interpreted using the corresponding one-sided return.

E.2 Stationary Algorithm

The stationary algorithm follows Auclert et al. (2021) and proceeds as follows.

1. **Initial guess.** Make initial guesses for the derivatives of the value function, $V_a(a', h', e')$ and $V_h(a', h', e')$, on the full (e, a, h) grid.

2. **Common $e' \to e$ step.** Compute the discounted expectation using the exogenous transition matrix:

$$W_a(a', h', e) = \beta E\left[(1-\varpi)V_a(a', h', e') + \varpi b_a(a') \mid e\right], \tag{64}$$

$$W_h(a', h', e) = \beta(1-\varpi)E\left[V_h(a', h', e') \mid e\right]. \tag{65}$$

3. **Unconstrained $h' \to h$.** Assume first that both lower bounds are slack, so $\xi_a = \xi_h = 0$. The two Euler equations imply

$$\tilde{c}^{-\sigma} = W_a(a', h', e), \tag{66}$$

$$\tilde{c}^{-\sigma}\mathcal{X}_1(h', h) = W_h(a', h', e). \tag{67}$$

Dividing the two equations gives

$$\frac{1}{\mathcal{X}_1(h', h)} = \frac{W_a(a', h', e)}{W_h(a', h', e)}. \tag{68}$$

Define

$$F(h, h', a', e) = \frac{W_a(a', h', e)}{W_h(a', h', e)} - \frac{1}{\mathcal{X}_1(h', h)} = 0. \tag{69}$$

This defines an implicit mapping $h'(a', h, e)$, which is obtained by interpolation over the human-capital grid. Once this mapping is known, effective consumption is

$$\tilde{c}(a', h, e) = W_a(a', h', e)^{-1/\sigma}, \tag{70}$$

and goods consumption is recovered as

$$c(a', h, e) = \tilde{c}(a', h, e) + D(h, e). \tag{71}$$

4. **Unconstrained $a' \to a$.** Use the budget constraint together with $h'(a', h, e)$ and $c(a', h, e)$ from the previous step to construct the endogenous current-asset mapping:

$$R(a)a = a' + c(a', h, e) + \mathcal{X}(h'(a', h, e), h) - z(h, e). \tag{72}$$

Inverting this relationship by interpolation yields the unconstrained policy rules $a'(a, h, e)$ and $h'(a, h, e)$. Since $R(a)$ is piecewise, the inversion is carried out over the relevant current-asset region implied by the return schedule.

5. **Liquidity-constrained $h' \to h$.** This branch proceeds analogously, but now set $a' = a_{\min}$ and allow for a positive multiplier $\xi_a > 0$, while maintaining $\xi_h = 0$.

Define the scaled multiplier

$$\kappa \equiv \frac{\xi_a}{W_a(a_{\min}, h', e)}. \tag{73}$$

The first-order conditions become

$$\tilde{c}^{-\sigma} = (1+\kappa) W_a(a_{\min}, h', e), \tag{74}$$

$$\tilde{c}^{-\sigma} \mathcal{X}_1(h', h) = W_h(a_{\min}, h', e). \tag{75}$$

Dividing again gives

$$\frac{1}{\mathcal{X}_1(h', h)} = \frac{(1+\kappa) W_a(a_{\min}, h', e)}{W_h(a_{\min}, h', e)}. \tag{76}$$

Define

$$F(h, h', \kappa, e) = \frac{(1+\kappa) W_a(a_{\min}, h', e)}{W_h(a_{\min}, h', e)} - \frac{1}{\mathcal{X}_1(h', h)} = 0. \tag{77}$$

Solving this equation by interpolation yields $h'(\kappa, h, e)$ and

$$\tilde{c}(\kappa, h, e) = \left[(1+\kappa) W_a(a_{\min}, h', e)\right]^{-1/\sigma}, \tag{78}$$

from which goods consumption is

$$c(\kappa, h, e) = \tilde{c}(\kappa, h, e) + D(h, e). \tag{79}$$

6. **Liquidity-constrained $\kappa \to a$.** Use $h'(\kappa, h, e)$ and $c(\kappa, h, e)$ from the previous step together with the budget constraint to construct the mapping

$$R(a)a = a_{\min} + c(\kappa, h, e) + \mathcal{X}(h'(\kappa, h, e), h) - z(h, e). \tag{80}$$

Inverting this relationship yields $\kappa(a, h, e)$ and therefore the constrained human-capital policy $h'(a, h, e)$ at the borrowing limit. By construction, the asset policy in this branch is $a'(a, h, e) = a_{\min}$.

7. **Human-capital lower bound.** In the calibrated solution, the interpolated policy satisfies $h' \geq \delta_h h$ at all occupied states. The human-capital lower bound is therefore inactive there, so the two branches above set $\xi_h = 0$. If the bound were active, the complementary-slackness conditions would require an additional branch.

8. **Update guesses.** The final asset policy is the element-wise maximum of the unconstrained and borrowing-constrained asset choices. At the same grid points, the human-capital policy is replaced by the constrained branch whenever the borrowing

constraint binds. Effective consumption is then recovered from

$$\tilde{c}(a,h,e) = R(a)a + z(h,e) - a'(a,h,e) - \mathcal{X}(h'(a,h,e),h) - D(h,e), \tag{81}$$

and the envelope conditions imply

$$V_a(a,h,e) = R(a)\tilde{c}(a,h,e)^{-\sigma}, \tag{82}$$

$$V_h(a,h,e) = \left[z_h(h,e) - D_h(h,e) - \mathcal{X}_2(h'(a,h,e),h)\right]\tilde{c}(a,h,e)^{-\sigma}. \tag{83}$$

9. **Iterate.** Return to step 2 and repeat until the derivative updates converge.

F Asset Market Equilibrium

F.1 Asset market equilibrium in the benchmark model

This appendix derives the asset-market equilibrium condition for the benchmark model with endogenous human capital.

We start from the interest-rate schedule

$$r = \bar{r} + \psi_r\left[\exp\left(\frac{K+B-A}{Y}\right) - 1\right], \tag{84}$$

where A denotes aggregate household asset holdings, K is the capital stock, B is government debt, and Y is output. Thus $NFA \equiv K + B - A$ is the liabilities-positive external borrowing position used in the main text.

Rearranging (84) gives aggregate asset demand:

$$A^d = K + B - Y\ln\left(\frac{\psi_r + r - \bar{r}}{\psi_r}\right). \tag{85}$$

Dividing through by effective labour L yields

$$\left(\frac{A}{L}\right)^d = \frac{K}{L} + \frac{B}{L} - \frac{Y}{L}\ln\left(\frac{\psi_r + r - \bar{r}}{\psi_r}\right). \tag{86}$$

Using the production function,

$$Y = ZK^{\alpha}L^{1-\alpha}, \tag{87}$$

we have

$$\frac{Y}{L} = Z\left(\frac{K}{L}\right)^{\alpha}, \tag{88}$$

so that

$$\left(\frac{A}{L}\right)^d = \frac{K}{L} + \frac{Y}{L}\left[\frac{B}{Y} - \ln\left(\frac{\psi_r + r - \overline{r}}{\psi_r}\right)\right]. \tag{89}$$

Letting $\mathfrak{d} \equiv B/Y$ denote the public-debt ratio, this can be written as

$$\left(\frac{A}{L}\right)^d = \frac{K}{L} + \frac{Y}{L}\left[\mathfrak{d} - \ln\left(\frac{\psi_r + r - \overline{r}}{\psi_r}\right)\right]. \tag{90}$$

From the firm's first-order condition,

$$\frac{K}{L} = \left(\frac{\alpha Z}{r + \zeta_p}\right)^{\frac{1}{1-\alpha}}, \tag{91}$$

which implies

$$\frac{Y}{L} = Z\left(\frac{\alpha Z}{r + \zeta_p}\right)^{\frac{\alpha}{1-\alpha}}. \tag{92}$$

Substituting (91) and (92) into (90) gives asset demand per unit of labour as a function of the interest rate:

$$\left(\frac{A}{L}\right)^d (r) = \left(\frac{\alpha Z}{r + \zeta_p}\right)^{\frac{1}{1-\alpha}} + Z\left(\frac{\alpha Z}{r + \zeta_p}\right)^{\frac{\alpha}{1-\alpha}}\left[\mathfrak{d} - \ln\left(\frac{\psi_r + r - \overline{r}}{\psi_r}\right)\right]. \tag{93}$$

On the supply side, aggregate household assets and effective labour are computed from the stationary distribution:

$$A(r) \equiv \int_i a_i \, d\lambda_{ss}(i, r), \qquad L(r) \equiv \int_i n_i l_i \, d\lambda_{ss}(i, r). \tag{94}$$

Hence asset supply per unit of labour is

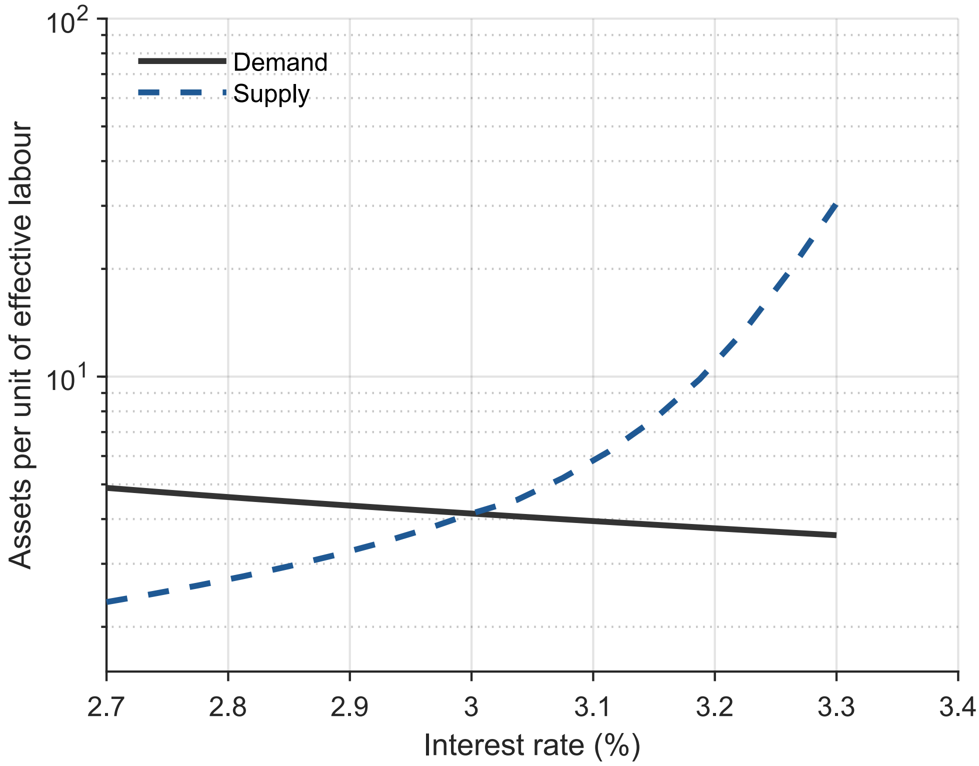
$$\left(\frac{A}{L}\right)^s (r) = \frac{A(r)}{L(r)}. \tag{95}$$

Asset-market equilibrium is defined by

$$\left(\frac{A}{L}\right)^s (r) = \left(\frac{A}{L}\right)^d (r). \tag{96}$$

Figure F1 plots the functions $\left(\frac{A}{L}\right)^d (r)$ and $\left(\frac{A}{L}\right)^s (r)$ for the benchmark model over a range of interest rates.

Figure F1: Asset demand and asset supply in the benchmark model.



Note: Both objects are expressed per unit of effective labour and plotted as functions of the interest rate.