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Abstract

Macroeconomic analyses of wealth taxes typically treat all household wealth as taxable, despite noted administrative difficulties with including owner-occupied housing and noncorporate equity in the tax base. In this paper, we quantify the macroeconomic and budgetary impact of avoidance due to these exclusions from a stylized, broad-based, top-wealth tax in the United States. We use a two-sector, large-scale overlapping generations model where, in the presence of exclusions, avoidance behavior arises endogenously through households' reallocation of wealth and firms' reallocation of economic activity. We find that while the macroeconomic and budgetary effects of the housing exclusion are insignificant, the noncorporate equity exclusion introduces a production-level distortion that results in a significant reallocation of economic activity from the corporate to noncorporate sector. We show that the federal revenue loss due to legal avoidance in the latter case can be similar to the amount lost due to illegal evasion via under-reporting wealth, but nonetheless have a quantitatively distinct path of macroeconomic aggregates. Finally, because interest in a wealth tax is linked to its potential for financing federal outlays, we show how variation in macroeconomic and budgetary effects across alternative expenditures affects the amount of new outlays availed by the tax itself. We find that while dedicating new revenue to public infrastructure investment leads to the largest increase in aggregate output, dedicating new revenue to federal debt reduction leads to the largest increase in outlays.

JEL Codes: E62, H26, H27

Keywords: dynamic scoring; wealth tax; avoidance; evasion;

*This research embodies work undertaken for the staff of the Joint Committee on Taxation, but as members of both parties and both houses of Congress comprise the Joint Committee on Taxation, this work should not be construed to represent the position of any member of the Committee. This work is integral to the Joint Committee on Taxation staff's work and its ability to model and estimate the macroeconomic effects of tax policy changes.

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1 Introduction

A renewed interest has recently developed for direct taxation of top household wealth in the United States. Among the goals claimed by proponents is the revenue-raising potential for the federal government (Leiserson, 2019; Leiserson et al., 2019; Wolff, 2019; Saez and Zucman, 2019a), which can be leveraged to finance new government projects, expand existing ones, or pay down debt. To quantify the possible macroeconomic and budgetary effects that may result from various wealth tax policies, researchers have relied on dynamic general equilibrium models as in DeBacker et al. (2018), Kaymak and Poschke (2019), Guvenen et al. (2019), PWBM (2019), PWBM (2020), Diamond and Zodrow (2020), Rotberg and Steinberg (2021), and Chari et al. (2021). Each of these analyses, however, do not allow for differential tax treatment of alternative types of wealth held by households.[1] This simplification precludes the ability to analyze the effects of exclusions from a wealth tax for certain asset classes — particularly for housing and privately-held businesses — which have existed in most countries that have had wealth taxes and are likely to be present in practice.[2,3] Because these exclusions provide opportunities for legal avoidance that can distort economic activity and undermine the revenue-raising ability of a wealth tax,[4] a significant gap exists in the literature.

In this paper we use a two-sector, large-scale overlapping generations model calibrated to the United States to quantify the macroeconomic and budgetary implications of providing exclusions for owner-occupied housing and noncorporate business equity from a stylized top-wealth tax. Two important features of our framework allow for this contribution to the literature: First, households in our model choose their wealth composition across financial and housing assets, which enables us to endogenously capture household-level avoidance behavior induced by the presence of assets with preferential tax treatment. Second, our two-sector production specification enables us to endogenously capture firm-level avoidance behavior induced by the presence of business equity exclusions.

As our benchmark policy, we simulate the enactment of a 1% tax on all household wealth exceeding the top 1% individual-level threshold, where additional revenues generated by the policy are used to pay down existing federal debt. Relative to a 2017 economic and tax-law baseline, this broad-based wealth tax increases federal tax revenue by 6.9% and 3.7% in the first and thirtieth years, for cumulative and average annual revenue increases of \$5.5 trillion and \$184 billion respectively in 2018 dollars over three decades.

[1] Recent work on optimal taxation has distinguished between housing and nonhousing wealth such as Borri and Reichlin (2021) and Rotberg (2021).

[2] See OECD (2018) for a summary of asset classes excluded from past and current wealth taxes for countries in the OECD.

[3] These exclusions can result from the difficulty involved in valuing these assets at a high frequency (Batchelder and Kamin, 2019; Kopczuk, 2019; Advani et al., 2020; Wetzler, 2020; Cochrane, 2020) or for political reasons (Viard, 2019). Saez and Zucman (2019a) propose ways to overcoming these difficulties.

[4] See Alvaredo and Saez (2010), Durán-Cabré et al. (2019), and Scheuer and Slemrod (2021).

We then simulate two alternative policies that provide exclusions from the wealth tax for owner-occupied housing and noncorporate business equity in a static revenue-consistent fashion. We find that while avoidance due to the housing exclusion fails to generate quantitatively meaningful macroeconomic and budgetary effects, avoidance due to the noncorporate equity exclusion generates a long-run 1.8 percentage point reallocation of economic activity from the corporate to noncorporate sector because of a distortion to the financial market. Relative to our benchmark policy, avoidance from the noncorporate equity exclusion results in a reduction in the cumulative thirty-year revenue increase by about 15%. We show that while this revenue cost can be similar to the amount lost due to evasion via under-reporting, the noncorporate equity exclusion is associated with a quantitatively distinct path of macroeconomic aggregates.

Finally, we contextualize our benchmark quantitative results by showing how the macroeconomic and budgetary effects of a wealth tax are intimately linked to what expenditures the additional revenues finance. In doing so, we allow for new revenues to be spent on three alternatives to debt reduction: creation of a Universal Basic Income (UBI) program, an expansion of the standard deduction within the federal income tax system, and investment in public infrastructure. In the absence of evasion, the broad-based wealth tax may afford either a long-run (thirty years after implementation) decrease in federal debt of 31.8 percentage points of GDP, an annual UBI transfer of about $786 per taxpayer in 2018 dollars, an 79.2% increase in the federal standard deduction, or a net-of-depreciation increase in total public capital of 22.8% — each relative to our baseline. While an increase in annual tax revenue is sustained over three decades under each of these alternative scenarios, an increase in aggregate output is sustained only when additional revenues are used to finance investment in public infrastructure. From a budgetary standpoint, however, the largest increase in new outlays occurs under the debt-reduction scenario because the associated reduction in borrowing costs frees up additional resources.

This paper is organized as follows: Section 2 details the model that we use for our quantitative analysis; Section 3 describes our calibration strategy for parameterizing all tax instruments of our model; Section 4 uses the model to simulate presents the model simulations and effects of tax avoidance, evasion and spending choices; Section 5 concludes; additional modeling and calibration detail is described in the Appendices. These findings of this paper provide decision-makers with information about how the macroeconomic and budgetary effects of a wealth tax can vary with its design.

2 The Model

The modeling framework used in this paper is based on Moore and Pecoraro (2021): Economic agents include overlapping generations of heterogeneous and finitely-lived households, two representative firms, an overlapping generations of finitely-lived representative financial intermediaries, a federal government, and a state-local composite government. Households make labor, consumption, savings, and residential choices each year, holding wealth in both financial and housing assets. Firms, operating as corporate and noncorporate entities, finance their productive activity through a combination of debt and equity. Financial intermediaries pool households' financial assets and allocate investments across a portfolio of equity and bonds issued by firms, rental housing, consumer debt, mortgage debt, and federal bonds. Each government entity finances its consumption and investment expenditures by levying taxes at the household- and firm-level, with only the federal government issuing debt.

Because it is crucial for our model to reproduce the concentration of household wealth observed in the United States, we build on Moore and Pecoraro (2021) by adopting the 'capitalist spirit' specification of wealth-in-the utility-function (WIU) (Carroll, 2002) for top-wealth households.[5] In this setting, households with WIU receive a 'warm-glow' from their accumulated wealth, as it is a direct argument in their utility function. De Nardi and Fella (2017) demonstrate that the incorporation of utility from wealth resolves some of the difficulties involved with endogenously reproducing realistic wealth concentration within dynamic quantitative models.[6] While it is common to specify a bequest motive for this purpose (DeBacker et al., 2018; Jakobsen et al., 2020), we instead follow Francis (2009) and employ a generalized WIU specification so that we can remain agnostic about the specific reason for WIU to arise.[7]

2.1 Households

The economy is populated by overlapping generations of finitely-lived households, with the mass of new entrants growing exogenously at the gross rate of Υ_P. These households are ex ante heterogeneous by family composition of single or married $f = s, m$; age $j = 1, \ldots, J$; labor productivity type $z = 1, \ldots, Z$; and endowment level[8] $e = 1, \ldots, E$. Ex-post heterogeneity occurs by wealth and by residential status as a homeowner or renter. Adults within each household may choose market work up until age $j = R-1 < J$, which is a joint decision for married households who contain two potential workers; retirement is mandatory for ages $j \geq R$. While there is no mortality risk during working ages such

[5] In particular, expansions to the previous work described in this paper reflect a version of the Overlapping Generations model built by the authors for use by the Joint Committee on Taxation in providing the United States Congress with macroeconomic analyses of major tax legislation.

[6] Alternative methods for endogenously generating realistic wealth concentration typically involve a significant expansion of the state-space by incorporating stochastic earnings with a 'superstar' state (Castañeda et al., 2003), entrepreneurship Cagetti and Nardi (2006), or heterogeneous returns(Hubmer et al., 2020).

[7] In addition to a bequest motive, it has been argued that WIU may also arise from non-pecuniary benefits of entrepreneurship, social status, or political influence (Saez and Stancheva, 2018; Michaillat and Saez, 2021).

[8] To reduce notational clutter, we omit the e index on household variables.

that the conditional survival probability $\pi_{j<R} = 1$, households begin to face mortality risk upon retirement such that $\pi_{j>=R} < 1$ until certain death when $\pi_J = 0$. The measure of households for a given (f, z, j) demographic at time t is $\Omega_{t,j}^{f,z}$.

Households' value function $V_{t,j}^{f,z}$ is increasing in two state variables:[9] financial assets a_j; and real owner-occupied housing assets, h_j^o. Each household receives instantaneous utility through the function $U_{t,j}^{f,z}$ — which is increasing in the consumption composite[10] good x_j, and decreasing in the labor hours n_j for each adult in the household — and through the function O_t^z — which is increasing and non-homothetic in end-of-period total wealth, $y_{j+1} \equiv a_{j+1} + h_{j+1}^o$. Future utility is assumed to be discounted by the factor β. Abstracting from marriage and divorce, the objective functions for single and married households given a known policy regime are expressed as:

$$V_{t,j}^{s,z}(a_j, h_j^o) = \max_{\substack{a_{j+1}, h_{j+1}^o, x_j, \\ n_j \in \mathbb{N}}} U_{t,j}^{s,z}(x_j, n_j) + O_t^z(y_{j+1}) + \beta \pi_j V_{t+1,j+1}^{s,z}(a_{j+1}, h_{j+1}^o) \tag{2.1}$$

$$V_{t,j}^{m,z}(a_j, h_j^o) = \max_{\substack{a_{j+1}, h_{j+1}^o, x_j, \\ n_j^1, n_j^2 \in \mathbb{N}}} U_{t,j}^{m,z}(x_j, n_j^1, n_j^2) + O_t^z(y_{j+1}) + \beta \pi_j V_{t+1,j+1}^{m,z}(a_{j+1}, h_{j+1}^o) \tag{2.2}$$

To mitigate problems associated with the curse of dimensionality, we assume that labor hours are indivisible. We allow for each adult member of the household to choose-part time or full-time work, or no work: $n_j \in \mathbb{N} \equiv \{0, n^{PT}, n^{FT}\}$. Under this specification, the aggregate labor supply elasticity depends on the distribution of household reservation wages (Chang and Kim, 2006), not on the underlying preference parameters (Chang et al., 2011). We therefore attempt to capture salient features of workforce heterogeneity by incorporating differential costs to employment in the spirit of Guner et al. (2011). We include: (*i*) a monetary child-care cost, $\kappa_j^{f,z}$, as a function of a household's number of dependents $\nu_j^{f,z}$ and the market work hours of the single or married secondary adult; (*ii*) a separable term, $\varphi \nu_j^{f,z}$, present in the market-labor sub-utility function for single and married-secondary adults to capture lifecycle time costs of children; and (*iii*) a fixed utility cost, $F_j^{f,z}(n_j)$, which is greater than zero only when the single or married-secondary adult is employed. The functional forms for instantaneous utility over the consumption

[9] While prices, taxes and utility are time dependent, the household keeps track of choice variables over time using age. To reduce notational clutter, we omit the time subscript in what follows.

[10] So that we can model the tax detail involved with tax-preferred consumption choices as described in Section 3.1, the composite consumption good x_j includes endogenous optimal quantities for consumption of market goods, housing services from either a rental unit or an owned home, services produced at home using time not spent on market labor or child-care, and charitable giving. For purposes of exposition, we explain this consumption detail in Appendix A.

composite and labor hours are then:

$$U_{t,j}^{s,z}(x_j, n_j) \equiv \log(x_j) - \psi^s \frac{(n_j + \varphi\nu_j^{s,z})^{1+\zeta^s}}{1+\zeta^s} - F_j^{s,z}(n_j) \tag{2.3}$$

$$U_{t,j}^{m,z}(x_j, n_j) \equiv \log(x_j) - \psi^{m,1} \frac{(n_j^1)^{1+\zeta^{m,1}}}{1+\zeta^{m,1}} - \psi^{m,2} \frac{(n_j^2 + \varphi\nu_j^{m,z})^{1+\zeta^{m,2}}}{1+\zeta^{m,2}} - F_j^{m,z}(n_j^2) \tag{2.4}$$

which are chosen because to be consistent with a balanced growth path in the presence of fixed costs from employment.

We adopt a wealth-in-utility specification so that our model can reproduce the empirically observed level of wealth concentration (Carroll, 2002; Francis, 2009). In doing so we make two crucial assumptions on O_t^z: The function is (i) nonzero only for households with productivity at or above a threshold type $\underline{z}$; and (ii) non-homothetic in total wealth. Formally:

$$O_t^z(y_{j+1}) \equiv \begin{cases} \log\left((y_{j+1})/o_{t+1}^z + 1\right) & \text{if } z \geq \underline{z} \\ 0 & \text{if } z < \underline{z} \end{cases} \tag{2.5}$$

where the parameter o_t^z determines the extent to which wealth is a luxury good (De Nardi, 2004). It is assumed that o_t^z depends on time only through exogenous growth at the gross rate of technical progress, Υ_A.

Households choices are restricted by the following budget constraint (2.6), with initial conditions (2.7):

$$p_t^x x_j + a_{j+1} + h_{j+1}^o \leq (1 + r_t^p)a_j + (1 - \delta^o)h_j^o + i_{t,j}^{f,z} - \mathcal{T}_{t,j}^{f,z} - \kappa_j^{f,z} - \xi_j^H \tag{2.6}$$

$$h_1 = 0, \quad a_1 = a_1 \tag{2.7}$$

where expenditures on the left-hand side of the budget are the quantity consumed of the composite good x_j, which is valued at the implicit price p_t^x, plus the end-of-period stocks of financial assets a_{j+1} and owner-occupied housing assets h_{j+1}^o. Available resources on the right-hand side of the budget are the sum of the gross return to beginning-of-period financial assets $(1 + r_t^p)a_j$, beginning-of-period owner-occupied housing assets less economic depreciation $(1-\delta^o)h_j^o$, and non-capital income income $i_{t,j}^{f,z}$ less net tax liabilities $\mathcal{T}_{t,j}^{f,z}$, child-care costs $\kappa_j^{f,z}$, and housing transaction costs ξ_j^H which are nonzero only when a household changes residential status from a renter to homeowner and vice versa. Initial endowments of cohorts entering the economy a_1, which vary over the (f, z, e) dimensions are assumed to be exogenous and time-invariant.

Non-capital income is equal to labor income during working years and equal to social security payments $ss_j^{f,z}$ during retirement:

$$i_{t,j}^{f,z} \equiv \begin{cases} n_j w_t \mathrm{z}_j^{s,z} + ss_j^{s,z} & \text{if} f = s \\ (n_j^1 + \mu^z n_j^2) w_t \mathrm{z}_j^{m,z} + ss_j^{m,z} & \text{if} f = m \end{cases} \tag{2.8}$$

where w_t is the market real wage rate, $\mathrm{z}_j^{f,z}$ is demographic-specific labor productivity, and $0 < \mu^z \leq 1$ is an exogenous productivity wedge between the primary and secondary workers for married households.

A household's net tax liability $\mathcal{T}_{t,j}^{f,z}$ is equal to the sum of federal tax liabilities on income, $\mathcal{T}_t^{\boldsymbol{i}}(i_{t,j}^{f,z}, r_t^p a_j)$, federal tax liabilities on wealth, $\mathcal{T}_t^{\boldsymbol{w}}(h_j^o, a_j)$, state-local income tax and property tax liabilities, $slt_t(i_{t,j}^{f,z}, h_j^o)$, and federal transfer payments, trs_t:

$$\mathcal{T}_{t,j}^{f,z} = \mathcal{T}_t^{\boldsymbol{i}}(i_{t,j}^{f,z}, r_t^p a_j) + \mathcal{T}_t^{\boldsymbol{w}}(h_j^o, a_j) + slt_t(i_{t,j}^{f,z}, h_j^o) - trs_t \tag{2.9}$$

All households are permitted to borrow and accumulate debt in excess of savings. As in Gervais (2002), however, we allow for homeowners to use their housing as collateral for borrowing while maintaining a minimum equity ratio in their home:

$$a_j \geq \begin{cases} \underline{\mathrm{y}}^{f,z} & \text{if } h_j^o = 0 \\ (\gamma - 1) h_j^o & \text{if } h_j^o > 0 \end{cases} \tag{2.10}$$

where $\underline{\mathrm{y}}^{f,z} < 0$ is the lower-bound of the wealth support for non-homeowners, and the parameter $0 \leq \gamma \leq 1$ is the minimum equity ratio for homeowners.[11] We assume that there is an institutional minimum size of owner-occupied housing equal to $\underline{\mathrm{h}}^o$; households unable to afford at least $\underline{\mathrm{h}}^o$ will instead rent housing. Both owner-occupied and rental homes provide equivalent housing services from which the household gains utility through consumption of the composite good x_j as described in Appendix A.

In the period which a household dies, their estate is assumed to be apportioned among end-of-life expenditures, c_j^E, estate tax liabilities, and bequests to new cohorts entering the economy as their initial endowments a_1. Because the distribution of endowments is time-invariant, an intergenerational linkage through target bequests is implied. We describe the apportionment of estates in Appendix B.1.4.

2.2 Firms

Output of the numéraire good is produced by firms across two perfectly competitive sectors — corporate (c) and non-corporate (n) — and can be transformed by households into a market consumption good, owner-occupied housing assets, or a financial asset, by firms into productive capital, and by government into a consumption good or productive

[11] The parameter γ can also be interpreted as a minimum down-payment ratio.

capital. Identical firms within each sector finance capital expenditures using a combination of bonds and equity obtained from perfect financial markets, hire labor from perfect labor markets, and use these inputs to operate at value maximizing levels. There are sectoral differences in terms of tax treatment and the distribution of profits, as described below.

We define the real after-tax rate of return R_t^q on equity (firm value) V_t^q for the representative firm in each sector $q = c, n$ as the sum of aggregate net capital gains and net income to the marginal investor-household:

$$V_t^c R_t^c = (1 - \tau_t^g) gns_t^c + (1 - \tau_t^d) div_t \tag{2.11}$$

$$V_t^n R_t^n = (1 - \tau_t^g) gns_t^n + dst_t - txl^n \tag{2.12}$$

where τ_t^g is the aggregate accrual-equivalent tax rate on capital gains gns_t^q, τ_t^d is an aggregate effective marginal tax rate on corporate dividends div_t, and txl^n is the tax liability from non-corporate distributions dst_t. Pretax capital gains are equal to the change in firm value:

$$gns_t^c = V_{t+1}^c - V_t^c - shr_t \tag{2.13}$$

$$gns_t^n = V_{t+1}^n - V_t^n \tag{2.14}$$

While in the non-corporate sector funds not invested or passed back to investors through distributions are automatically realized as gains, the corporate firm can alternatively or additionally buy back shares of equity.

Each representative firm has objective of choosing the time path of private capital K_t^q and hire the quantity of effective labor input N_t^q that maximize the firm's value. Substituting equations (2.13) and (2.14) into equations (2.11) and (2.12) respectively, rearranging for V_t^q, and solving forward yields the following two objective functions:

$$V_t^c(K_t^c) = \max_{N_t^c, K_{t+1}^c} \frac{(1 - \tau_t^d) div_t - (1 - \tau_t^g) shr_t}{(R_t^c + 1 - \tau_t^g)} + \beta_t^c V_{t+1}^c(K_{t+1}^c) \tag{2.15}$$

$$V_t^n(K_t^n) = \max_{N_t^n, K_{t+1}^n} \left(\frac{dst_t - txl^n}{R_t^n + 1 - \tau_t^g} \right) + \beta_t^n V_{t+1}^n(K_{t+1}^n) \tag{2.16}$$

where $\beta_t^q \equiv \frac{(1-\tau_t^g)}{(R_t^q + 1 - \tau_t^g)}$ for $q = c, n$. Each firm is constrained by:

1. the cash flow restriction:

$$ern_t^c + B_{t+1}^c - B_t^c + shr_t = div_t + I_t^c + txl_t^c \tag{2.17}$$

$$ern_t^n + B_{t+1}^n - B_t^n = dst_t + I_t^n \tag{2.18}$$

2. the law of motion for capital:

$$K_{t+1}^q = (1-\delta^K)K_t^q + I_t^q - \Xi_t^q \quad \text{for } q = c, n \tag{2.19}$$

where Ξ_t^q is an adjustment cost function.

3. the debt issues rule:

$$B_t^q = \varkappa^{b,q} K_t^q \quad \text{for } q = c, n \tag{2.20}$$

where $\varkappa^{b,q}$ is time-invariant debt-to-capital ratio and B_t^q is the beginning-of-period stock of net debt held by the representative firm in sector.

4. the dividend payout rule for the corporate firm in equation (2.23) described below.

The cash flow restriction in equation (2.17) states that the corporate firm's intra-period inflows — earnings ern_t^c, new debt issues $B_{t+1}^c - B_t^c$, and new share issues shr_t — must be equal to outflows — dividend payments div_t, investment in productive capital I_t^c, and tax liabilities txl_t^c. Unlike the corporate firm, the non-corporate firm is not liable for taxes at the business-entity level so they do not enter their cash flow restriction in equation (2.18). Rather, non-corporate distributions are passed through to the household-level where they are taxed jointly with households' other income and remitted by the government.

Earnings for both firms are equal production of output, Y_t^q, less wages paid to sectoral labor input, $w_t N_t^q$ and interest paid on sectoral debt $i_t B_t^q$:

$$ern_t^q = Y_t^q - w_t N_t^q - i_t B_t^q \quad \text{for} \quad q = c, n \tag{2.21}$$

Output is produced using constant returns to scale, Cobb-Douglas technology:

$$Y_t^q = Z^q (G_t)^g (K_t^q)^\alpha (A_t N_t^q)^{1-\alpha-g} \quad \text{for} \quad q = c, n \tag{2.22}$$

where $G_t = G_t^{fed} + G_t^{sl}$ is beginning-of-period public capital from federal, state and local governments, K_t^q and N_t^q are beginning-of-period productive private capital and effective labor employed in each sector, Z^q is a scale parameter, and A_t is labor-augmenting technology that evolves identically within each sector according to $A_{t+1} = \Upsilon_A A_t$. The decreasing returns to scale for private factors of production allows for an interior solution with the two sector - single output good framework. In addition, the public factor input along with perfect financial and labor markets leads to economic rents which are fully captured by firms.

As in Zodrow and Diamond (2013) the dividend payout ratio $\varkappa^d$ is assumed to be exogenous, which is here expressed relative to earnings ern_t^c less tax liability txl_t^c:

$$div_t = \varkappa^d (ern_t^c - txl_t^c) \tag{2.23}$$

2.3 Financial Intermediary

The perfectly competitive financial sector is populated by overlapping two-period lived representative financial intermediaries which pool savings from households and invest in financial and real assets on their behalf. The representative intermediary entering the economy in any given period t collects end-of-period savings from households, D_{t+1}, and decides on an end-of-period portfolio allocation across corporate and noncorporate equity V^c_{t+1} and V^n_{t+1}, corporate and noncorporate bonds B^c_{t+1} and B^n_{t+1}, domestically-held federal government bonds B^g_{t+1}, and rental housing H^r_{t+1}. At the beginning of period $t+1$, this intermediary pays a rate of return of r^p_{t+1} to households on their deposits. Assets held by the old intermediary at the end of their life are costlessly transferred to the new intermediary that enters the economy in period $t+1$.

Corporate and noncorporate equity pay out dividends div_{t+1} or distributions dst_{t+1}, and accrue capital gains gns^c_{t+1} and gns^n_{t+1}. While corporate and noncorporate bonds yield a pretax rate of return of i_{t+1}, we assume that government bonds yield a low, "safe" pretax rate of return ρ_{t+1}, which depends positively on both the private bond rate and the total public debt-output ratio:

$$\rho_{t+1} = \varpi i_{t+1} + \varsigma \exp\left(\frac{B^{g,tot}_{t+1}}{Y_{t+1}}\right) \quad \forall t \tag{2.24}$$

Housing is rented out at a price of p^r_{t+1} and depreciates at rate δ^r. The total income received by the intermediary from its investment allocation is therefore:

$$Inc_{t+1} \equiv div_{t+1}+dst_{t+1}+gns^c_{t+1}+gns^n_{t+1}+(p^r_{t+1}-\delta^r)H^r_{t+1}+\rho_{t+1}B^g_{t+1}+i_{t+1}(B^c_{t+1}+B^c_{t+1}) \quad \forall t \tag{2.25}$$

Formally, the maximization problem for representative financial intermediary is:

$$\max_{\substack{V^c_{t+1},V^n_{t+1},\\ B^c_{t+1},B^n_{t+1},H^r_{t+1}}} \quad Inc_{t+1} - r^p_{t+1}D_{t+1} \tag{2.26}$$

subject to:

$$D_{t+1} = V^c_{t+1} + V^n_{t+1} + B^g_{t+1} + B^c_{t+1} + B^n_{t+1} + H^r_{t+1} \quad \forall t \tag{2.27}$$

where it is assumed that the financial intermediary has perfectly elastic demand for government bonds. Perfect competition in the financial market implies a zero-profit condition each period so that households receive a pretax portfolio return on their deposits equal to:

$$r^p_{t+1} = \frac{Inc_{t+1}}{D_{t+1}} \quad \forall t \tag{2.28}$$

which is equivalently the borrowing rate for households with negative financial assets.

A characteristic of the optimal allocation is that no arbitrage opportunities exist in equilibrium, which implies that the after-tax marginal rate of return from across all investment vehicles will be equalized:

$$R^c_{t+1} - \tau^{cw}_{t+1} = R^n_{t+1} - \tau^{nw}_{t+1} = (1 - \tau^i_{t+1}) i_{t+1} - \tau^{bw}_{t+1} = (1 - \tau^r_{t+1})(p^r_{t+1} - \delta^r) - \tau^{rw}_{t+1} \quad \forall t \tag{2.29}$$

where R^c_{t+1} and R^n_{t+1} are after-income-tax rate of return to corporate and noncorporate equity, τ^i_{t+1} and τ^r_{t+1} are aggregate effective marginal tax rates on interest and rental income, and τ^{cw}_{t+1}, τ^{nw}_{t+1}, τ^{bw}_{t+1}, τ^{rw}_{t+1} are aggregate effective marginal tax rates on corporate, noncorporate, bond, and rental housing obtained by aggregating over households.[12] Because this condition depends on the aggregate effective marginal rates, the portfolio allocation chosen by the financial intermediary is optimal for households in the aggregate.

The financial market no-arbitrage condition plays a crucial role in the manner by which a wealth tax can affect firm value in our model. In particular, while a broad-based tax on household wealth will imply equal aggregate effective marginal tax rates applied to all assets, exclusions to the wealth tax will generate a differential in aggregate effective marginal tax rates. Differential capital taxation arising in this manner that favors either the corporate or noncorporate setor will result in an equilibrium with a relatively higher pretax rate of return to the equity from that sector because of an endogenous shift in productive activity.

2.4 Government

2.4.1 Federal

Federal tax receipts, T^{fed}_t, and bond issues, $B^{g,tot}_{t+1} - B^{g,tot}_t$ are used to finance non-valued public consumption, C^{fed}_t, productive capital expenditures, I^{fed}_t, and transfer payments to households TR^{fed}_t. The recursive budget constraint of the federal government is then:

$$I^{fed}_t + C^{fed}_t + TR^{fed}_t \leq T^{fed}_t + B^{g,tot}_{t+1} - (1 + \rho_t) B^{g,tot}_t \tag{2.30}$$

The law of motion for federal public capital follows:

$$G^{fed}_{t+1} = (1 - \delta^g) G^{fed}_t + \sum_{s=1}^{S} \kappa^{fed}_s I^{fed}_{t-s+1} \tag{2.31}$$

where $\sum_{s=1}^{S} \kappa^{fed}_{s-1} = 1$. This specification incorporates the time-to-build properties of investment in public capital, whereby it takes multiple periods before a given amount of public investment is fully productive (Ramey, 2020; Leeper et al., 2010). New debt issued to domestic agents is assumed to be an exogenous fraction of total new debt issued:

[12] See Section 3.1 for details.

$$B_{t+1}^{g} - B_{t}^{g} = \kappa^{dom}(B_{t+1}^{g,tot} - B_{t}^{g,tot}) \tag{2.32}$$

where it is implied that foreign agents outside the model purchase the residual. To rule out explosive debt paths, we maintain the no-Ponzi condition:

$$\lim_{k\to\infty} \frac{B_{t+k}^{g,tot}}{\prod_{s=0}^{k-1}(1+\rho_{t+s})} = 0 \tag{2.33}$$

which implies that the current stock of net debt is equal to the present-discounted value of all future primary surpluses along any equilibrium path.

The federal government collects taxes from households, txl_t^{hh}, corporations, txl_t^{c}, and on estates txl_t^{beq}. Total taxes collected by the federal government are therefore:

$$T_t^{fed} \equiv txl_t^{hh} + txl_t^{c} + txl_t^{beq} \tag{2.34}$$

Total taxes collected by the federal government from households, txl_t^{hh} consist of tax liabilities on income and wealth:

$$txl_t^{hh} = \int_{\mathbb{Z}}\int_{\mathbb{J}} \sum_{f=s,m} \left(\mathcal{T}_t^{\boldsymbol{i}}(i_{t,j}^{f,z}, r_t^{p} a_j) + \mathcal{T}_t^{\boldsymbol{w}}(h_j^{o}, a_j)\right)\Omega_{t,j}^{f,z}\ dj\ dz \tag{2.35}$$

Taxes are collected on wealth left by deceased households. We specify that the tax rate τ_t^{beq} is linear and unrelated to either the benefactor or beneficiary household's other income. Taxes collected on estates can then be expressed as:

$$txl_t^{beq} = \tau_t^{beq}\int_{\mathbb{Z}}\int_{\mathbb{J}}(1-\pi_j)\sum_{f=s,m} y_{t+1,j+1}\Omega_{t,j}^{f,z}\ dj\ dz \tag{2.36}$$

In addition to social security payments to retirees, $ss_{t,j}^{f,z}$, households receive lump-sum transfer payments from the federal government, trs_t. Aggregate federal government transfers therefore can be expressed as:

$$TR_t^{fed} = \int_{\mathbb{Z}}\int_{\mathbb{J}} \sum_{f=s,m} \left(ss_{t,j}^{f,z} + trs_t\right)\Omega_{t,j}^{f,z}\ dj\ dz \tag{2.37}$$

2.4.2 State and Local

Composite state and local government tax receipts, T_t^{sl}, are used to finance non-valued consumption, C_t^{sl}, and productive capital expenditures I_t^{sl}. We specify an intraperiod balanced-budget constraint:

$$I_t^{sl} + C_t^{sl} = T_t^{sl} \tag{2.38}$$

State-local public capital follows the law of motion:

$$G_{t+1}^{sl} = I_t^{sl} + (1 - \delta^g) G_t^{sl} \tag{2.39}$$

Total tax revenue collected at the state-local level can be expressed as:

$$T_t^{sl} \equiv \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} slt(i_{t,j}^{f,z}, h_j^o) \Omega_{t,j}^{f,z} \; dj \; dz + slt^c \tag{2.40}$$

2.5 Equilibrium

Equilibrium is informally defined as a collection of decision rules that are the solutions to households' and firms' optimization problems; a collection of economic aggregates that are consistent with household and firm behavior; a set of prices that facilitate cross-sector factor-price equalization and clearing in factor, asset, and goods markets; and an associated set of policy aggregates that are consistent with government budget constraints. Equilibrium is formally defined in Appendix C in terms of a trend-stationary transformation of the model.

3 Calibration

The initial steady-state balanced growth path is calibrated at an annual frequency to approximate the 2017 economic environment and tax system, which is the baseline against which our policy experiments are measured.[13] The choice of parameter values largely follows from Moore and Pecoraro (2021), which makes use of long-run historical data, recent observations, micro-studies, and projections. In particular, most projections used in our calibration procedure are either obtained from the Joint Committee on Taxation's Individual Tax Model (JCT-ITM)[14] or *The Budget and Economic Outlook: 2018 to 2018* from the Congressional Budget Office (CBO). In the following section, we describe our initial steady-state calibration strategy for tax-related parameters and the process by which we fit of our distributions for household wealth and taxable labor and capital income to the data. Our initial state-state calibration strategy for non-tax parameters is described in Appendix B.

[13] In doing so, we do not incorporate the tax provisions contained in PL 115-97, also known as the 'Tax Cuts and Jobs Act', or the economic consequences of the Covid-19 pandemic and related policy measures such as the CARES Act of 2020, the Consolidated Appropriations Act of 2021, or the American Rescue Plan of 2021.

[14] Joint Committee on Taxation's Individual Tax Model is in principle similar to NBER's TAXSIM model. However, while TAXSIM makes use of the SOI division public use files, the JCT-ITM generally uses a more recent, confidential sample of tax returns from the SOI division that contains a broader set of variables than do the public use data. For more information, see JCT (2015).

3.1 Household Taxation

Each household is assumed to be an individual tax unit. Federal tax liabilities on a household's income is composed of two pieces:

$$\mathcal{T}_t^{\boldsymbol{i}}(i_{t,j}^{f,z}, r_t^p a_j) = fit_{t,j}^{f,z} + prt_{t,j}^{f,z}$$

where $fit_{t,j}^{f,z}$ is federal income taxes and $prt_{t,j}^{f,z}$ is payroll taxes. To determine $fit_{t,j}^{f,z}$, we use the Moore and Pecoraro (2021) internal tax calculator framework, which is a mapping from a household's adjusted gross income (AGI) to their federal income tax liabilities that explicitly models major individual tax provisions of the Internal Revenue Code in a statutory fashion.[15] In particular, it accounts for the joint taxation of ordinary capital and labor income, the special taxation of preferential capital income, as well as a households' tax-preferred consumption choices and demographic structure. This module was developed for purposes of incorporating a high-level of individual tax detail within the Overlapping Generations model used by the Joint Committee on Taxation in providing the United States Congress with macroeconomic analyses of major tax legislation.

To obtain a household's AGI, we scale personal labor and capital income using 'calibration ratios'. Adjusted gross labor income, $\hat{i}_{t,j}^{f,z}$, is equal to wages and self-employment income, or social security income for retired households, scaled by calibration ratio $\chi_j^{\boldsymbol{i};f,z}$, which is a function of family type, productivity type and age group (working or retired):

$$\hat{i}_{t,j}^{f,z} \equiv \chi_j^{\boldsymbol{i};f,z} i_{t,j}^{f,z}$$

These calibration ratios are exogenous, time- and policy-invariant, and computed using the JCT-ITM as the ratio of income included in AGI for each (f, z, j) demographic group described in Appendix B.1. Table 1 shows the fit of adjusted gross labor income and the federal tax liabilities attributable to wage income produced by the internal tax calculator for working-age households in our baseline.

The ratio of total capital income that is included in AGI varies a great deal across households. Most working-aged taxpayers hold the majority of financial assets in tax-deferred retirement accounts for example. One innovation in this model over previous work is an accounting for this through an additional adjustment to households' capital income. We introduce an age-group- and family-type-specific mapping from the asset distribution for that group $\boldsymbol{f}(a|f,j)$ to a calibration ratio $\chi_j^{\boldsymbol{a};f}$, which determines the share of a household's capital income that is included in AGI. There are four time- and

[15] The tax calculator explicitly models the following provisions as specified in the Internal Revenue Code for 2017: *the statutory tax rate schedule for ordinary income, statutory tax rate schedule for preferential income, special treatment of social security income, personal and dependent exemptions, standard deduction, earned income credit, child tax credit, home mortgage interest deduction, state and local income, sales, and property tax deductions, charitable giving deduction, net investment income surtax, and the dependent care credit.*

policy- invariant adjustment functions — one for each age group (working and retired), and one for each family type (single and married), to calculate capital income included in AGI.[16] The ratio $\chi_j^{\boldsymbol{a};f}$ is assumed to be bounded below by zero. Total adjusted gross capital income, $r_t^p \hat{a}_j^{f,z}$, can then be obtained from personal economic capital income as follows:

$$r_t^p \hat{a}_j^{f,z} \equiv r_t^p \chi_j^{\boldsymbol{a};f} a_j^{f,z}$$

Ordinary capital income is taxed jointly with labor income as a single base, while the portion of capital income that is treated as preferential is taxed separately at lower rates, so they must be decomposed. Let $s_t^{\boldsymbol{o}}$ denote the endogenous share of a household's ordinary capital income at time t, which is uniform across households because portfolios of financial assets are homogeneous. A household's ordinary and preferential capital income in AGI can be expressed as $r_t^p \hat{a}_{t,j}^{\boldsymbol{o}} \equiv s_t^{\boldsymbol{o}} \chi^{\boldsymbol{o}} r_t^p \hat{a}_j$ and $r_t^p \hat{a}_{t,j}^{\boldsymbol{p}} \equiv (1 - s_t^{\boldsymbol{o}}) \chi^{\boldsymbol{p}} r_t^p \hat{a}_j$ respectively, where the time- and policy-invariant calibration ratios $\chi^{\boldsymbol{o}}$ and $\chi^{\boldsymbol{p}}$ are internally calibrated to match the aggregate revenue targets shown in Table 3.[17]

To determine payroll tax liability $prt_{t,j}^{f,z}$, we assume that all working-age individuals are directly liable for the combined (employee- and employer-side) payroll tax rate of $\tau^{\boldsymbol{\mathcal{P}}} =$ 12.4% on their labor earnings covered by Old Age, Survivors, and Disability Insurance. This applies to a portion of their wages up to the 2017 tax-law threshold of $\bar{\mathcal{P}} = \$127,200$ for each working-age individual:[18]

$$prt_{t,j}^{f,z} = \begin{cases} \tau^{\boldsymbol{\mathcal{P}}} \times \min\left(\chi^{\boldsymbol{\mathcal{P}}} n_j w_t z_j^{f,z}, \bar{\mathcal{P}}\right) & \text{for } f = s,\ j < R \\ \tau^{\boldsymbol{\mathcal{P}}} \times \left(\min\left(\chi^{\boldsymbol{\mathcal{P}}} n_j^1 w_t z_j^{f,z}, \bar{\mathcal{P}}\right) + \min\left(\chi^{\boldsymbol{\mathcal{P}}} \mu^z n_j^2 w_t z_j^{f,z}, \bar{\mathcal{P}}\right)\right) & \text{for } f = m,\ j < R \\ 0 & \text{for } f = s, m,\ j \geq R \end{cases}$$

where $\chi^{\boldsymbol{\mathcal{P}}}$ is internally calibrated so that payroll tax receipts relative to output are about 4.4%, as estimated by CBO for 2017.

We specify that direct wealth taxes apply to households' beginning-of-period stock of assets.[19] At a proportional, statutory tax rate of $\tau^{\boldsymbol{w}}$ on a broad base, a household's

[16]Each adjustment function is assumed to be piecewise-linear over nine nodes for each demographic group. The eight nonzero nodes are calibrated internally so that the amount of capital income included in AGI on average for each percentile class ordered by capital income matches those values estimated by the JCT-ITM for calendar year 2017 as shown in Table 2.

[17]See Appendix C.2 of Moore and Pecoraro (2021) for a description of how adjusted gross capital income and attributable tax liabilities may be decomposed by capital income type (e.g. noncorporate distributions, corporate dividends, capital gains, and interest), and for how the endogenous ratio $s_t^{\boldsymbol{o}}$ may be obtained from our model.

[18]Unlike the federal income tax, which treats income from spouses filing a joint return as a single base, the payroll tax base for each spouse is independent.

[19]While financial assets accrue to explicit gains in our model, owner-occupied housing does not. To be consistent across asset classes, we therefore exclude the contemporaneous return to financial assets from the wealth tax base in this manner

wealth tax liability is:

$$\mathcal{T}_t^{\boldsymbol{w}}(h_j^o, a_j) = \max\left(\tau^{\boldsymbol{w}}(a_j + (1 - \kappa^{dur})h_j^o - \bar{y}), 0\right) \tag{3.1}$$

where $\bar{y}$ is the exogenous wealth tax threshold, κ^{dur} is the assumed share of consumer durables contained in housing, and $\tau^{\boldsymbol{w}} = 0$ only in the initial steady state. We set $\kappa^{dur} = 0.283$, which is the average share of consumer durables in the stock of residential capital over 2007-2016 as measured by the Bureau of Economic Analysis. We exclude the consumer-durable share of housing from the wealth tax to be consistent with our calibration of the wealth distribution as described Appendix B.1.3. For our simulations in Section 4, housing and noncorporate equity exclusions to the wealth tax are made by subtracting $(1 - \kappa^{dur})h_j^o$ and $\omega_t^{nw} a_j$ respectively from the wealth tax base, where ω_t^{nw} is the endogenous and time-varying portfolio share of financial assets held in the form of noncorporate equity.[20]

It is assumed that the state-local government collects taxes from households in a linear fashion on non-capital income and owner-occupied housing property:

$$slt_{t,j}^{f,z}(i_{t,j}^{f,z}, h_j^o) \equiv \tau^{sli}\hat{i}_{t,j}^{f,z} + \tau^{slp}h_j^o$$

The linear state and local tax rate τ^{sli} is exogenously set to an effective rate of 5.81% on labor income, which represents the greater of state and local tax income or sales tax liabilities for each tax unit as computed by the JCT-ITM for 2017. The state and local property tax rate τ^{slp} is set to $0.0105 \times 0.7174 = 0.0075$, which is the product of the national average property tax rate computed using state-level estimates from the National Association of Homebuilders for 2010-2014, and the average portion of total residential capital that is not consumer durables as reported by NIPA for 2007-2016.

Finally, federal transfer payments are equal to a uniform lump-sum net transfer, trs, which is set to be equal to 0.40% of aggregate output to represent federal transfers (less those for Old Age and Survivors Insurance, Medicare, Medicaid, and the outlay portion of tax credits) less federal excise and miscellaneous taxes.

3.2 Firm Taxation and the Financial Intermediary

We specify that tax liabilities for both corporate and noncorporate firms, txl_t^q, take the following form:

$$txl_t^q = \tau_t^q\,(Y_t^q - ded_t^q) - crd_t^q \quad \text{for } q = c, n$$

where τ_t^q is an aggregate effective marginal tax rate (EMTR) on net business income, ded_t^q are deductions from gross income, and crd_t^q is a credit against gross tax liability.

[20] The portfolio share of a noncorporate equity may be computed directly as $\omega_t^{nw} \equiv V_t^{nc}/D_t$.

The aggregate EMTR on corporate income is exogenously set to $\tau_t^c = 0.277$, which is the return-weighted[21] rate computed by the JCT Corporate Model[22] for calendar year 2017. The aggregate EMTR on noncorporate distributions is exogenously set to the time invariant $\tau_t^{nc} = 0.333$, which is the income-weighted value computed by the JCT-ITM for calendar year 2017.

Deductions from income allowed for firms include wage expense, interest expense, tax depreciation of capital, and state and local tax liabilities (for corporate sector only). We therefore set:

$$ded_t^q = w_t N_t^q - i_t B_t^q - \left(\varrho^q I_t^q + \hat{\delta}^q da_t^q\right) - slt_t^c \left(\boldsymbol{I}_{q=c}\right) \quad \text{for } q = c, n$$

where ϱ^q is the capital investment expense ratio, $\hat{\delta}^q$ is tax depreciation rate of capital, $da_t^q \equiv (1 - \hat{\delta}^q) da_{t-1}^q + (1 - \varrho^q) I_t^q$ is current depreciation allowances. We exogenously set $\varrho^q = 0$ for simplicity and calibrate $\hat{\delta}^c = \hat{\delta}^n = 0.0067$ internally so that our initial steady state baseline reproduces a ratio of depreciation allowances to aggregate output consistent with that computed by the JCT Depreciation Model[23] for calendar year 2017.[24]

We endogenously calibrate the lump-sum credits crd_t^q in a time-invariant fashion so that corporate and noncorporate tax liabilities relative to output each match an empirical counterpart for 2017. For the corporate firm we target the tax liability to output ratio of 1.68% estimated by the Congressional Budget Office (CBO) in the *The Budget and Economic Outlook: 2017 to 2027*, and for the noncorporate firm we target a ratio of 1.36% estimated by the JCT-ITM. Although the noncorporate firm is not liable for taxes and the entity level, the noncorporate firm's behavior must be consistent with the tax liabilities on distributions to households. This is achieved through the calibration ratio $\chi^{\boldsymbol{K}}$, which as described earlier is set so that household tax liabilities for each capital income type, including noncorporate distributions, matches the target ratio.

Tax liabilities owed by corporations at the state-local level are assumed to be proportional to the representative corporation's income:

$$slt_t^c = \tau^{slc} ern_t^c$$

The linear state and local tax rate on corporate income τ^{slc} is internally set to target a ratio of state and local corporate income tax receipts to output 0.0038, which is the 2007-2016 average computed from NIPA estimates.

The aggregate EMTR on dividends and interest income, as well as the accrual-equivalent tax rate on gains, enter the expression for firm value. We exogenously set

[21] We choose return weights over income weights for this computation so that we can include C-corporations with zero taxable income.

[22] See JCT (2011) for a description of the JCT Corporate Model.

[23] See JCT (2011) for a description of the JCT Depreciation Model.

[24] The steady state expression for depreciation allowances is $da^q = \left((1 - \varrho^q)/(1 - (1 - \hat{\delta}^q))\right) I^q$.

$\tau_t^d = 0.203$, and $\tau_t^i = 0.279$ in a time-invariant fashion, which are the income-weighted values computed by the JCT-ITM for calendar year 2017. We internally calibrate $\tau_t^g = 0.0521$ so that aggregate capital gains tax revenue is 0.67% of aggregate output.

Finally, since the financial intermediary internalizes the average tax implications for households when allocating deposits into investment portfolios, we must specify the nature of aggregation. Let $\omega_t^{\mathcal{W}}$ be the time-varying endogenous portfolio share of financial assets held in the form of corporate equity ($\mathcal{W} = cw$), noncorporate equity, ($\mathcal{W} = nw$), bonds ($\mathcal{W} = bw$), or rental housing ($\mathcal{W} = rw$).[25] The aggregate effective marginal wealth tax rates applicable to each financial asset type, $\tau_t^{\mathcal{W}}$, are computed as an asset-weighted effective marginal wealth tax rate over households:

$$\tau_t^{\mathcal{W}} = \frac{\int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \Omega_{t,j}^{f,z} \left(\tau_{t,j}^{\mathcal{W};f,z} \omega_t^{\mathcal{W}} a_j \right) \, dj \, dz}{\int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \Omega_{t,j}^{f,z} \left(\omega_t^{\mathcal{W}} a_j \right) \, dj \, dz} \quad \text{for } \mathcal{W} = cw, nw, bw, rw$$

where $\tau_{t,j}^{\mathcal{W};f,z}$ is the effective marginal wealth tax rate on a given implied financial asset type for a household of (f, z, j) demographic.[26]

3.3 Baseline Wealth Distribution

In order for us to obtain reliable quantitative estimates of the macroeconomic and budgetary effects of a top-wealth tax in the United States, it is crucial that the endogenous wealth distribution in our model reflects key empirical properties. In particular, the portion of total wealth held by top-wealth classes and the thresholds for each class should be externally valid, so that a top-wealth tax in our model generates a static[27] revenue effect that aligns with empirical estimates. The top panel of Table 4 shows that wealth concentration at the household-level within our model closely matches the top 10%, 1%, and 0.1% targets from Smith et al. (2020), which are less concentrated than the corresponding estimates from Saez and Zucman (2020a).[28,29] The bottom panel of Table 4 shows the thresholds for each respective class as estimated by Smith et al. (2020) at the individual-adult level and Saez and Zucman (2020a) at the tax-unit level. Although each are at different units observation, our household-level thresholds within the model are

[25] Since each household has the same portfolio of financial assets chosen by the financial intermediary, endogenous portfolio shares $\mu_t^{\mathcal{W}}$ are uniform across households.

[26] A household's effective marginal tax rate is computed by increasing the holdings of a given financial asset type by 1%.

[27] We refer to the 'static' revenue change as the revenue change that would occur holding constant private behavior and prices at their initial levels.

[28] The top-wealth shares estimated by Smith et al. (2020) are expressed at the individual-adult level under the assumption that wealth is equally split among spouses. As argued by Saez and Zucman (2020b), this is broadly comparable to units at the household level (as in our model) because a vast majority of the wealthiest households are married.

[29] The Saez and Zucman (2020a) estimates reflect an update to the Saez and Zucman (2016) estimates, which are maintained at https://gabriel-zucman.eu/uswealth/.

broadly consistent with these estimates.

When quantifying the effects of providing exclusions to the wealth tax for owner-occupied housing and noncorporate equity, the composition of total household wealth within our model becomes important. We report this in two pieces: First, we show in Table 5 the endogenous composition of financial wealth in our initial steady state baseline, which is homogeneous across households because the portfolio allocation is determined at the financial intermediary level as described in Section 2.3. Second, we show in Table 6 the endogenous portion of total household wealth held as financial assets in our baseline, which is heterogeneous across households because owner-occupied housing is chosen at the household level as described in Section 2.1. Since financial assets represent a greater portion of total household wealth at higher points in the wealth distribution, the housing-financial asset composition of wealth in our model varies across households.

While we do not explicitly target the composition of total household wealth by class, our model endogenously produces figures that are broadly consistent with empirical estimates. Consider the top 1% of households by wealth, for example. The average household in this class holds 86.8% of their wealth in financial assets, with the 13.2% residual held in owner-occupied housing. Given that 27.3% of financial assets are held in the form of noncorporate equity, the average household in the top 1% holds $27.3\% \times 86.8\% = 23.7\%$ of their wealth in noncorporate equity. This compares to Smith et al. (2020), where it is estimated that 13.6% and 31.7% of wealth for the average individual in the top 1% is held in owner-occupied housing and noncorporate equity respectively. To the extent that the portfolio allocation of the wealthiest individuals is comparable to that of the wealthiest households, our owner-occupied share closely matches their estimate while our noncorporate equity share is somewhat understated.

4 Policy Experiments

We simulate the unexpected enactment of a broad-based top-wealth tax in the United States, the revenues from which are used for federal debt reduction. Treating this as our benchmark policy, we then simulate two alternatives where exclusions to the wealth tax are provided in turn for owner-occupied housing and noncorporate equity in a static revenue-consistent fashion. To draw comparison with the legal avoidance behavior that endogenously occurs in our model when exclusions to the wealth tax are present, we separately simulate an additional broad-based policy scenario where illegal evasion occurs through under-reporting. Finally, we contextualize our quantitative results by showing how the projected macroeconomic and budgetary effects of our broad-based wealth tax depend both quantitatively and qualitatively on how the additional revenues are spent. Towards this end, we consider the following fiscal closing assumptions as alternatives to federal debt reduction: increased investment in public infrastructure, the creation of an annual UBI transfer, and a permanent expansion of the federal standard deduction.

4.1 Benchmark Policy: Broad-Based Wealth Tax

A household's wealth tax liability under the broad-based policy, specified in equation (3.1), is parameterized with a single tax rate of $\tau^{\boldsymbol{w}} = 0.01$ applied to household wealth exceeding the fixed top 1% threshold of $\bar{y} = \$3.249$ million in 2018 dollars from Smith et al. (2020). Because this is an individual-adult level threshold — rather than a household-level threshold — this policy generates wealth tax liabilities for the top 1.8% of households within our model before accounting for behavioral effects. As such, this policy increases federal tax revenue by $235 billion in 2018 (about 1.1% of measured GDP) in a static environment.[30] For our dynamic analysis, all federal revenue raised from this policy, inclusive of net revenue changes from existing sources, is used to pay down federal debt for the first 40 years following implementation. After 40 years, we allow non-valued government consumption to change as needed to stabilize the path of debt so that the no-Ponzi condition (2.33) holds.[31] The macroeconomic and budgetary effects for the first three decades following enactment of this policy are described below, expressed in terms relative to the initial steady state baseline path.

Effect on Household Wealth: The benchmark policy, labeled 'No Exclusion' in Figure 1, results in a monotonic decline in aggregate financial assets (deposits), reaching a level about 2.3% below its baseline level at the end of three decades.[32] Aggregate owner-occupied housing instead reaches a trough of about 1.1% below its baseline level after one decade and somewhat recovers thereafter. Although the broad-based wealth tax is levied on both financial and housing assets, the path of each aggregate differs because of variation in behavioral responses across households. Wealth taxpayers[33] are affected both by first-order tax distortions and second-order price effects, while others are only affected by price changes. Since housing is a smaller portion of wealth for wealth taxpayers, their reduction of this asset is eventually offset by the behavior of other households in the aggregate. Since they own such a large share of financial assets, aggregate deposits do not recover despite other households increasing their savings as much as 7.3% in response to favorable interest rates. That both groups of households respond to the policy change

[30] This approach follows the 'mechanical' wealth tax revenue estimates in Smith et al. (2020) and Saez and Zucman (2019b)

[31] See Moore and Pecoraro (2020a) for a discussion of fiscal closing assumptions.

[32] If we restrict the wealth taxpayer group to only those with a positive wealth tax liability every year under the wealth tax, total wealth falls by 17.4% after 30 years. This implies a 30-year elasticity of taxable wealth with respect to the after-tax rate of return of 1.07, which is broadly consistent with long-run elasticity estimated by Jakobsen et al. (2020).

[33] To be consistent across time, our 'wealth taxpayer' group are those with who, in the absence of the wealth tax, would have had total wealth in excess of the tax threshold.

by altering their housing assets relatively less than their financial assets is consistent with the findings of Brülhart et al. (2019).[34]

Effect on Productive Activity: As the wealth tax applies equally to all types of wealth under the benchmark policy, the financial market equilibrium condition (2.29) implies that the associated relative after-tax rates of return are not directly affected. Absent additional distortions to the financial intermediary's portfolio allocation decision the time paths of the private factors of production (Figure 2) reflect this symmetry. As households reduce savings and the cost of borrowing increases, the capital stock falls below baseline levels in both sectors, reaching a trough of -0.9% after fifteen years. This trend is reversed however, as borrowing rates fall due to the 60% reduction in public debt after three decades, and private capital is crowding-in. Similarly, labor used and output created in both sectors decrease by about 0.7% and 0.4% respectively relative to baseline level after three decades.

Effect on Tax Revenue: Figure 3 shows the path of projected revenue changes under the broad-based wealth tax, with cross-sections highlighted in Table 7. Annual wealth tax revenue is equal to about \$232 billion in the first year and \$315 billion in the thirtieth year, both in 2018 dollars. Despite the large amount of revenue raised from this new source, decreases in revenue from other sources are offsetting. Figure 4 shows that while annual total tax revenue increases by about 7.0% over its baseline value in the first year of the policy, this gain falls by nearly half to 3.7% after three decades as a result of base erosion on all other revenue sources. Because of overall population growth and technological progress present in both the baseline and the benchmark policy, however, the total revenue gains in the first and thirtieth years are less disparate at \$220 and \$200 billion respectively in 2018 dollars.

4.2 Alternative Tax Bases: Exclusions and Evasion

4.2.1 Exclusions

We now simulate two alternative policies, where exclusions are provided for owner-occupied housing and noncorporate equity. These exclusions are made in our model by subtracting $(1 - \kappa^{dur})h^o_j$ and $\omega^{nw}_t a_j$ respectively from the wealth tax base in equation (3.1), where ω^{nw}_t is the endogenous and time-varying portfolio share of financial assets held in the form of noncorporate equity. Holding constant the top-1% threshold of $\bar{y} = \$3.249$ million, we internally calibrate the tax rate in these two alternative scenarios so that static revenue-consistency with the benchmark policy is maintained. This

[34] Consumption of housing services is optimally chosen in proportion to consumption of non-housing market goods in our model; households attempt to smooth both over their lifecycles. See Appendix A.

is achieved at $\tau^{w} = 0.0155$ and $\tau^{w} = 0.0119$ for the noncorporate exclusion and housing exclusion policies respectively. As in the benchmark policy, all revenue raised from a given policy change is used to pay down federal government debt for the first 40 years following implementation.

Effect on Household Wealth: The deccumulation of household wealth held in the excluded asset class is attenuated under each alternative policy as shown in Figure 1. Relative to the benchmark policy, aggregate housing is 0.3% larger on average over three decades under the housing exclusion, while aggregate deposits are 0.7% larger under the noncorporate equity exclusion.[35] Each exclusion policy generates endogenous avoidance behavior where relatively more wealth is held in the preferential asset class. When housing is excluded, wealth taxpayers[36] hold 6.9% more housing on average than is held under the broad-based policy. Similarly, when noncorporate equity is excluded from the tax base, wealth taxpayers save 4.7% more on average than under the benchmark. Other households respond to price effects: more deposits from high-wealth households implies a smaller increase in the portfolio rate of return, and these lower-wealth households increase savings by less than they do under the benchmark. With a smaller increase in permanent income, the households also increase housing by less.

Effect on Productive Activity: While the time paths of the private factors of production are relatively uniform across sectors when housing is excluded from the wealth tax, they differ significantly when noncorporate equity is excluded, as shown in Figure 2. Only the exclusion for noncorporate equity distorts the financial intermediary's portfolio allocation decision: with relatively cheaper equity to finance operations, the noncorporate sector expands while the corporate sector shrinks, consistent with the findings of Alvaredo and Saez (2010). This reallocation of economic activity amounts to a 1.8 percentage point increase in the noncorporate sector's share of total output (from 29.1% to 30.9%) after three decades. Because this sectoral shift acts as a drag on total tax revenue (discussed below), a relatively higher path of public debt puts upward pressure on the firm borrowing rate and weakens the crowding-in effect from debt reduction. Consequentially, the aggregate capital stock remains 0.3% below its baseline level after three decades under this policy alternative despite nearly reverting to baseline under the other policies. Because of differences in aggregate capital-labor substitution across each policy, however, the paths of aggregate output do not significantly differ.

[35] Relative to the benchmark policy, aggregate deposits differ by less than 0.03% on average over three decades under the housing exclusion, while aggregate housing differs by less than 0.1% under the noncorporate equity exclusion.

[36] Our 'wealth taxpayer' group remains constant across policies for consistency.

Effect on Tax Revenue:[37] Figures 3 and 4 show that while the paths of tax revenue under the housing exclusion differ only negligibly from the broad-based policy, significantly less tax revenue is raised when noncorporate equity is excluded from the wealth tax. Table 7 shows that annual revenue raised directly from the wealth tax is about $10 billion less under the noncorporate equity exclusion policy than the broad-based policy in the first year, a figure which grows to about $29 billion in the thirtieth year. This occurs because the reallocation of economic activity from the corporate sector to the noncorporate sector substantially reduces corporate income tax revenue while only moderately increasing noncorporate income tax revenue. The insufficient offset results in $27 billion less total tax revenue collected on average over three decades, and a cumulative (undiscounted) thirty year revenue cost for excluding noncorporate equity of about $801 billion in 2018 dollars.

4.2.2 Evasion

Recent empirical studies emphasize that, in addition to legal avoidance, illegal evasion via the under-reporting of assets and/or over-reporting of liabilities is an important component of the overall household behavioral response to wealth taxation (Seim (2017), Durán-Cabré et al. (2019), and Brülhart et al. (2019)). PWBM (2019), PWBM (2020), and Diamond and Zodrow (2020) incorporate evasion into their macroeconomic analyses of wealth tax proposals using a simplified reduced-form approach, whereby households misreport taxable wealth according to an exogenous semi-elasticity.[38] To draw contrast with the avoidance behavior highlighted in this paper, we simulate our broad-based policy while allowing for evasion using the same reduced-form approach. This involves the respecification of equation (3.1) to:

$$\mathcal{T}_t^{\boldsymbol{w}}(h_j^o, a_j) = (1 + \varepsilon\tau^{\boldsymbol{w}}) \left(\max\left(\tau^{\boldsymbol{w}}(a_j + (1 - \kappa^{dur})h_j^o - \bar{y}), 0\right)\right)$$

where ε is the semi-elasticity of reported wealth with respect to the tax rate. Following previous studies, we choose a value of $\varepsilon = -13$ for our simulation.[39]

Figure 1 shows that the decummulation of household wealth is relatively attenuated for both asset classes with the under-reporting wealth.[40] Under the assumption that unreported assets remain productive,[41] savings fall by less, and firms are able to borrow at a relatively lower rate. Absent sector-specific financial distortions, the capital stock

[37] All dollar figures are in 2018 dollars.

[38] Rotberg and Steinberg (2021) allow for endogenous evasion responses that vary across households.

[39] This is the central estimate chosen by PWBM (2019) in their review of existing estimates.

[40] While Brülhart et al. (2019) points out that financial assets are under-reported at a greater frequency than housing assets, we assume uniform evasion rates to maintain simplicity and consistency with previous analyses.

[41] This assumption is maintained in PWBM (2019), PWBM (2020), Diamond and Zodrow (2020), and Rotberg and Steinberg (2021).

recovers from its initial decline to reach a level 0.2% above baseline after three decades, both in the aggregate and across sectors, as shown in Figure 2. As firms begin to increase labor input along with capital, output reaches about 0.2% above baseline at the end of three decades.

Figures 3 and 4 show the time paths of wealth tax revenue and tax revenue from other sources. When evasion occurs at our specified intensity, revenue raised directly from the wealth tax is relatively lower than the benchmark policy by $45 and $51 billion in the first and thirtieth years following implementation (in 2018 dollars), differentials larger than any other policy alternative. Total revenue collected varies less however; table 7 shows that the $159 billion raised annually on average with evasion is remarkably similar to the $157 billion raised on average each year under the noncorporate equity exclusion. In spite of different implications for the allocation of household wealth and pattern of productive activity, under-reporting of wealth at this intensity implies a similar cumulative thirty-year revenue cost to providing an exclusion for noncorporate equity.

4.3 Alternative Closing Assumptions: Expenditures

We now discuss how the projected macroeconomic and budgetary effects of our broad-based wealth tax depend on how the additional revenues are used. From a technical standpoint, closing the model involves an unavoidable assumption about how changes to government revenues are offset elsewhere in the budget so that the flow constraint (2.30) holds. From a positive standpoint, in our non-Ricardian framework these assumptions have meaningfully different economic impacts over the long-run. Towards this end, we consider the following uses for additional revenues as alternatives to federal debt reduction: (*i*) the creation of an annual UBI transfer, (*ii*) a permanent expansion of the federal standard deduction,[42] and (*iii*) increased investment in public infrastructure. That is, rather than allowing $B^{g,tot}_{t+1}$ to take on the residual value of the federal government's recursive budget constraint each period along the transition path, we instead allow the residual value to determine trs_t, $\mathcal{T}^{\boldsymbol{i}}_t(i^{f,z}_{t,j}, r^p_t a_j)$, and I^{fed}_t respectively.

Effect on Productive Activity: Figure 5 shows that when additional revenues under the broad-based wealth tax are used to expand the standard deduction, an increase of 211.6% and 79.2% in the deduction amount are availed in the first and thirtieth years. Although the expanded deduction is inframarginal for high-income households who remain within the top statutory income tax bracket, it is an incentive to increase labor supply for low- and middle-income households who fall into a lower statutory tax bracket. The

[42]The standard deduction is a specific dollar amount that reduces the amount of income on which a household is taxed. Since our model is calibrated to the 2017 economic and tax-law environment, our baseline standard deduction is equal to $6,457 and $12,915 for single and married households (expressed in 2018 dollars). This provision is modeled explicitly within our internal tax calculator.

resulting low path for wage rate shown in Figure 6 causes firms to substitute labor for capital in production. While the path of aggregate labor remains elevated over three decades. Figure 7 shows that the relatively smaller capital stock eventually diminishes its positive effect on productivity. Aggregate output therefore reverts 0.2% below baseline after three decades.

When used for investment in public infrastructure, additional revenues under broad-based wealth tax allow for a net-of-depreciation 165.2% increase in federal public capital (22.8% increase in total public capital) after three decades, which is equivalent to about $5 trillion in 2018 dollars. While firms increase their use of both private capital and labor in response to productivity gains, the resulting high path for the real wage rate causes firms to substitute capital for labor in production. Despite the absence of crowding-in, this causes aggregate private capital to be higher than it is in the debt-reduction scenario. Due to these effects, aggregate output is higher than any alternative scenario at 1.4% above baseline after three decades.[43]

When additional revenues are used to finance the creation of an annual UBI scenario, the broad-based wealth tax allows for transfers of $1771 per taxpayer in the first year, falling to $786 per taxpayer in the thirtieth year.[44] Because these transfers have a positive income effect on all households, there is a relatively large reduction in labor supply. Since this drives up the real wage rate without the positive total factor productivity effects of infrastructure investment, firms reduce investment and use less of both labor and capital in production. This results in the lowest aggregate output, which is about 0.9% below baseline after three decades.

Effect on Household Wealth: Figure 8 shows that the standard deduction expansion results in the largest decrease in aggregate deposits and the largest increase in aggregate housing after three decades, relative to other alternative expenditure scenarios. Because this policy induces low- and middle-income taxpayers to increase labor supply, they are as a group able to afford a relatively large stock of financial and housing assets. The relatively low paths for the real wage rate and portfolio rate of return, however, encourages high-income households to do the opposite. Since financial assets are highly concentrated among wealth taxpayer households, the drag this has on aggregate deposits is sufficiently large to outweigh the increase in financial assets by other households. As housing is less concentrated among these households, the drag this has on aggregate housing fails to outweigh the increase in housing by other households.

While aggregate deposits and housing initially fall in all alternative expenditure scenarios, the early losses from both asset classes are largely recovered when additional

[43] Implicit in our parmaterization of public capital productivity is a state-local offset of changes to federal investment. See Appendix B.3.3 for more details.

[44] In computing this figure, we assume that the 144.3 million tax units who filed federal returns grows at our assumed annual population growth factor of $\Upsilon_P = 1.0076$

revenues are used to finance public infrastructure investment. The positive effect of public infrastructure on factor returns builds over time, generating a relatively high wage rate that encourages labor supply and a relatively high portfolio rate of return that encourages saving. Because high-wealth households hold a disproportionate share of overall wealth, the attenuating effect this has on the deccumulation of their wealth translates into a large positive effect on the the path of each aggregate wealth source.

Like the standard deduction expansion, the creation of an annual UBI transfer has opposing effects on the aggregate paths of financial and housing assets. Unlike the standard deduction expansion, however, these effects are strongest early after the policy change. This occurs because the positive income effect from transfers weakens over time as the size of transfers falls by more than half over three decades. In particular, although aggregate deposits fall quicker than under any other alternative expenditure scenario, they do not remain the lowest since the saving disincentive weakens. Conversely, aggregate housing remains elevated over the first decade as the consumption incentive causes households to increase housing. Because transfers represent a greater portion of lower-income household's permanent income, this behavior is largely driven by households who do not have a wealth tax liability.

Effect on Tax Revenue: Changes to federal income and wealth tax revenues are shown in Figures 9 and 10 for all expenditure scenarios. The standard deduction expansion appears to be an outlier, however, as all additional revenue raised from the policy is passed back to households via an equivalent income tax reduction, there is a zero net effect on total revenues. The expanded standard deduction mostly reduces tax liabilities attributed to labor income, as most households do not have taxable capital income. Households that do have taxable ordinary capital income also experience reduced tax liabilities on both due to the joint taxation of labor and ordinary capital income in the model. It is for this reason that the path of noncorporate tax revenue and 'other' capital tax revenue falls below those from the other policy experiments.

With the exception of the standard deduction expansion, the changes in total tax revenue are positively correlated with the changes in aggregate output. However, the increase in federal government outlays afforded in each scenario do not follow this pattern: In the UBI scenario, each taxpayer was able to receive transfers of about \$1,021 on average each year for three decades in 2018 dollars. Expressing the additional amount of outlays made by the federal government on a per-taxpayer basis, we find average annual 'transfer-equivalents' of about \$2,380, \$1,250, and \$1,685 for the federal debt reduction, standard deduction expansion, and public infrastructure investment scenarios respectively.

Variation in transfer-equivalents show that there is not a perfect mapping between economic outcomes and budgetary feedback. This is because budgetary feedback includes not only the difference in total tax revenue changes, but also endogenous changes to interest payments on federal debt.[45] For example, under the public investment scenario, the time path for every component of income tax and wealth tax revenue is higher than the other scenarios, but a relatively high interest rate on public debt over the first decade causes federal debt service to increase even as federal debt remains constant. Higher interest payments by the federal government reduce the portion of additional revenues that may be dedicated to infrastructure investment. Similar interest rate effects are seen under the UBI and standard deduction expansion scenarios in the third decade, while the interest rate on public debt continuously falls under the debt-reduction scenario. Thus, even though the path of total tax revenue under the debt-reduction scenario is lower than the public infrastructure scenario, lower interest payments free up more resources that allow the federal government to expand outlays towards further paying down debt.

5 Conclusion

We have quantified the macroeconomic and budgetary effects of avoidance due to exclusions from a top-wealth tax in the United States. Analyzing exclusions for owner-occupied housing and noncorporate equity, we find that the short- and long-run projected effects differ significantly from a broad-based policy only when noncorporate equity is excluded from the wealth tax. We show that while the revenue loss due to legal avoidance in this case can be similar to the revenue loss due to illegal evasion via under-reporting wealth, the path of macroeconomic aggregates was distinct.

Because recent interest in a federal wealth tax for the United States is closely related its revenue-raising potential, we contextualized our benchmark quantitative results by showing how the macroeconomic and budgetary effects depend on what outlays the additional revenues finance. In doing so, we specified that revenue generated under a broad-based wealth tax were dedicated to debt-reduction, an annual UBI transfer, an expansion of the standard deduction, and public infrastructure investment. As each scenario was associated with different paths of macroeconomic aggregates, variation in budgetary feedback implied different amounts of new outlays were afforded by the same wealth tax. We find that the rank ordering by budgetary feedback and macroeconomic effects respectively differ due to variation in changes to the cost of federal debt service.

Our findings provide decision-makers with information pertinent to the design of a wealth tax and the potential uses for the associated revenue increase. Exclusions for owner-occupied housing and noncorporate equity, which are likely to be considered because of the administrative difficulties involved with valuing these assets at a high-frequency, provide opportunities for avoidance that can undermine revenue goals. While

[45]Budgetary feedback also depends on changes to endogenous outlays, such as social security payments to retirees. However, this explains only a relatively small portion of the difference in our model and takes decades to materialize.

we analyzed avoidance and evasion separately to distinguish particular effects, the likely presence of both in practice poses further challenges to sustaining increased revenues from a wealth tax. Finally, as each of the alternative uses for additional revenues have a significantly different impact on macroeconomic activity and the federal budget, our findings should be weighed against the welfare goals associated with expanding or creating a particular federal government initiative.

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6 Tables and Figures

Table 1: Baseline Average Adjusted Gross Labor Income and Federal Labor Income Tax Liabilities (in thousands of 2018$)

	Income				Taxes			
	Target	**Model**	**Target**	**Model**	**Target**	**Model**	**Target**	**Model**
Productivity	Single		Married		Single		Married	
1	3.0	3.0	16.8	16.7	-0.4	-0.4	-2.8	-2.8
2	15.0	15.1	52.0	52.1	-2.5	-2.5	0.1	0.1
3	28.5	28.8	83.3	83.4	-0.2	-0.2	5.4	5.4
4	44.6	44.6	123.3	123.8	3.0	3.0	12.2	12.3
5	64.8	64.9	176.1	176.4	6.8	6.8	23.8	23.8
6	105.8	105.7	318.7	320.1	15.6	15.6	64.5	64.9
7	276.8	276.3	1,459.6	1,465.8	61.0	60.9	409.7	412.1
8	1,450.7	1,450.1	5,522.6	5.583.8	419.2	419.6	1,776.1	1,788.8

Table 2: Baseline Average Adjusted Gross Capital Income (in thousands of 2018$)

	Working-Age				Retired			
	Target	**Model**	**Target**	**Model**	**Target**	**Model**	**Target**	**Model**
Percentile	Single		Married		Single		Married	
0 – 20	0.0	0.0	0.0	0.0	0.3	0.0	1.6	0.0
20 – 40	0.0	0.0	0.0	0.0	1.6	1.6	7.7	5.9
40 – 60	0.0	0.0	0.0	0.0	7.0	7.0	24.0	24.1
60 – 80	0.0	0.0	1.4	1.4	21.5	21.5	48.9	49.0
80 – 90	0.8	0.8	7.9	7.9	43.2	43.2	83.9	84.0
90 – 99	9.9	9.9	73.0	73.1	93.0	93.1	165.5	165.5
99 – 99.9	129.8	129.8	770.4	769.7	330.6	330.6	628.8	627.0
99.9 – 100	2,469.2	2,468.4	1,013.3	1.006.8	2,594.2	2,593.4	4,938.2	4,934.7

Table 3: Baseline Aggregate Household Capital Income Tax Ratios

Target Ratio	**Target**	**Model**
Ordinary Capital Income Tax Revenue to Aggregate Output Ratio	0.0153	0.0153
Preferential Capital Income Tax Revenue to Aggregate Output Ratio	0.0079	0.0079

Table 4: Baseline Top Wealth Shares and Thresholds

Shares			
Wealth Group	**Data (Target)**, 2016 (Smith et al., 2020)	**Data**, 2016 (Saez and Zucman, 2020a)	**Model**
Top 10%	65.6%	77.5%	63.7%
Top 1%	29.6%	38.8%	30.6%
Top 0.1%	14.3%	19.8%	14.0%
Thresholds (in thousands of 2018$)			
Wealth Group	**Data**, 2016 (Smith et al., 2020)	**Data**, 2016 (Saez and Zucman, 2020a)	**Model**
Top 10%	$683	$931	$745
Top 1%	$3,249	$5,034	$4,267
Top 0.1%	$14,637	$25,120	$23,802

- Figures inflation-adjusted from 2016 using a C-CPI-U factor of 1.038.
- Smith et al. (2020) estimates are at the individual-adult level under an equal-split assumption; Saez and Zucman (2020a) estimates are at the tax-unit level; Each household within the model is assumed to be an individual tax-unit.
- The Saez and Zucman (2020a) estimates reflect an update to the Saez and Zucman (2016) estimates, and are maintained at https://gabriel-zucman.eu/uswealth/.

Table 5: Baseline Financial Assets Composition

% of Financial Assets	Corporate Equity	Noncorporate Equity	Fixed-Income Wealth	Rental Housing Wealth
	51.2%	27.3%	18.5%	3.0%

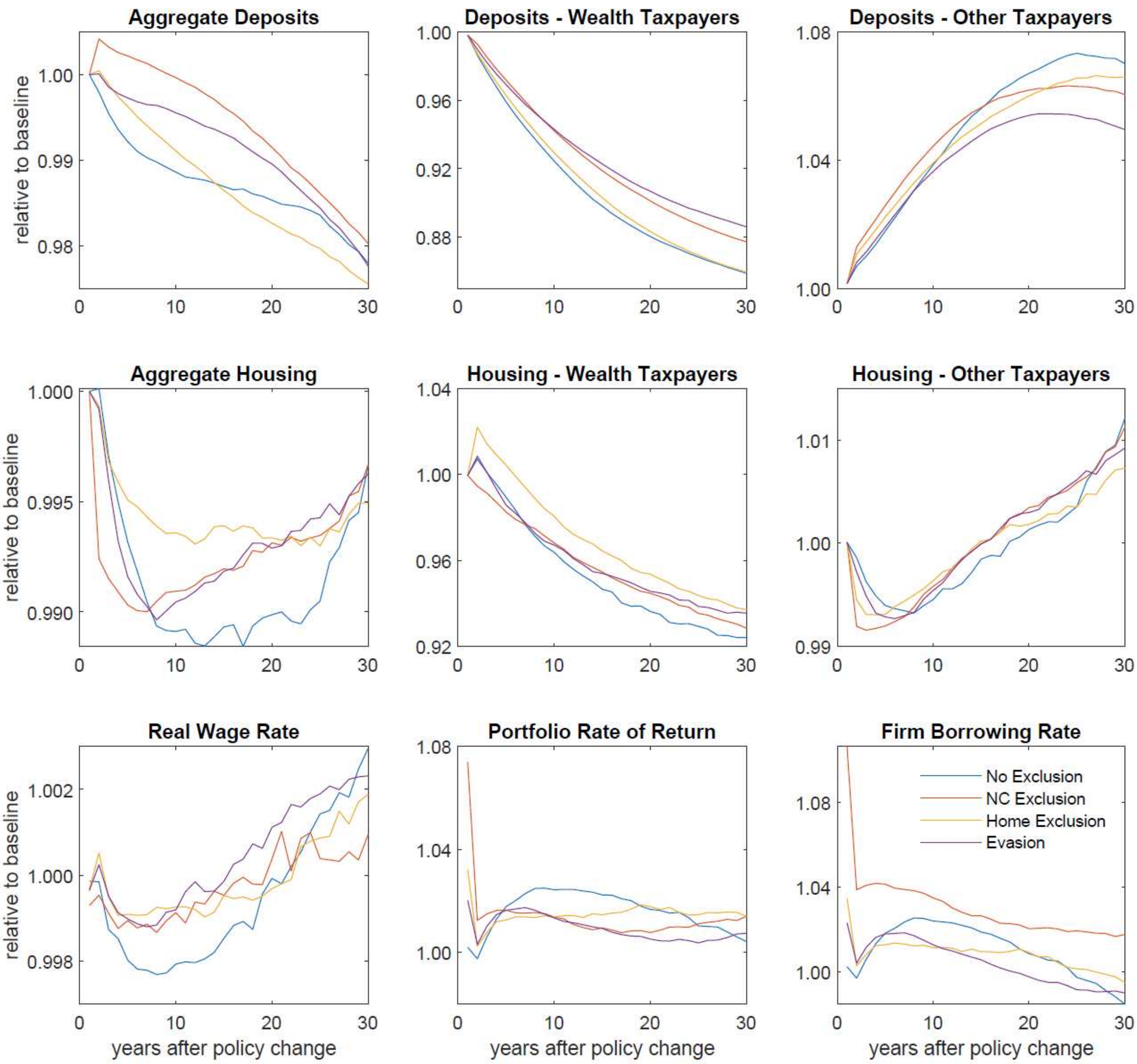
Table 6: Baseline Total Wealth Composition

Wealth Group	Financial Assets as % of Total Wealth
Top 10%	81.0%
Top 1%	86.8%
Top 0.1%	90.9%

Table 7: Annual Revenue Increase (in billions of 2018$)

Annual Wealth Tax Revenue Increase	Year 1	Year 15	Year 30	30-Year Average	30-Year Total
Benchmark Policy	232	256	315	263	7,901
Housing Exclusion Policy	232	255	309	262	7,845
Noncorporate Equity Exclusion Policy	222	243	286	248	7,425
Broad-based Policy with Evasion	187	213	263	218	6,545
Annual Total Tax Revenue Increase	Year 1	Year 15	Year 30	30-Year Average	30-Year Total
Benchmark Policy	220	172	200	184	5,519
Housing Exclusion Policy	225	173	187	186	5,567
Noncorporate Equity Exclusion Policy	178	153	145	157	4,718
Broad-based Policy with Evasion	169	152	175	159	4,767

Figure 1: Wealth Tax Base Alternatives: Household Wealth and Market Prices



Note: 'Wealth Taxpayers' are those households with initial wealth above the wealth tax threshold of $3.249 million, while 'Other Taxpayers' are those households with initial wealth below the threshold.

Figure 2: Wealth Tax Base Alternatives: Productive Activity by Sector

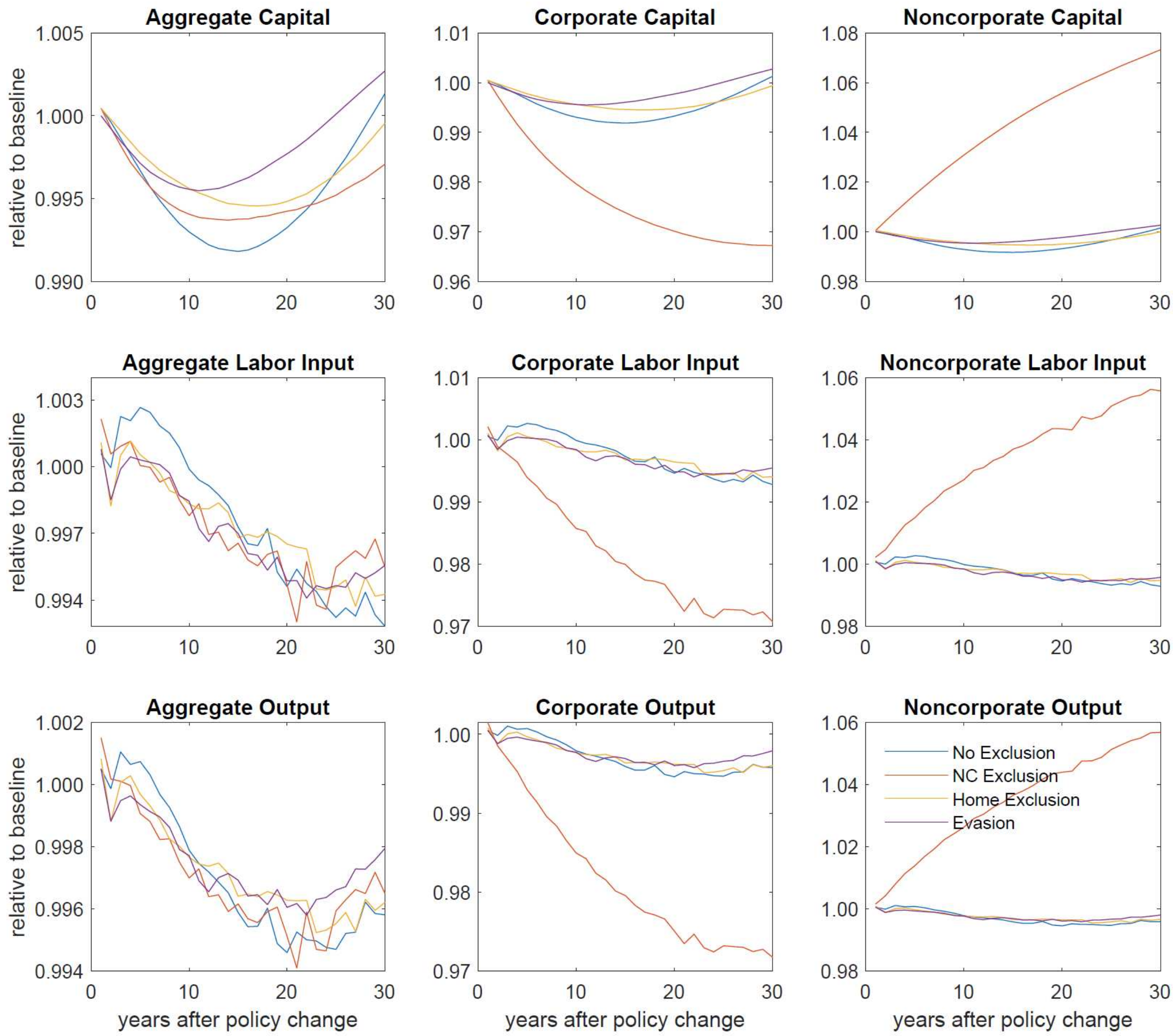


Figure 3: Wealth Tax Base Alternatives: Wealth Tax Revenue

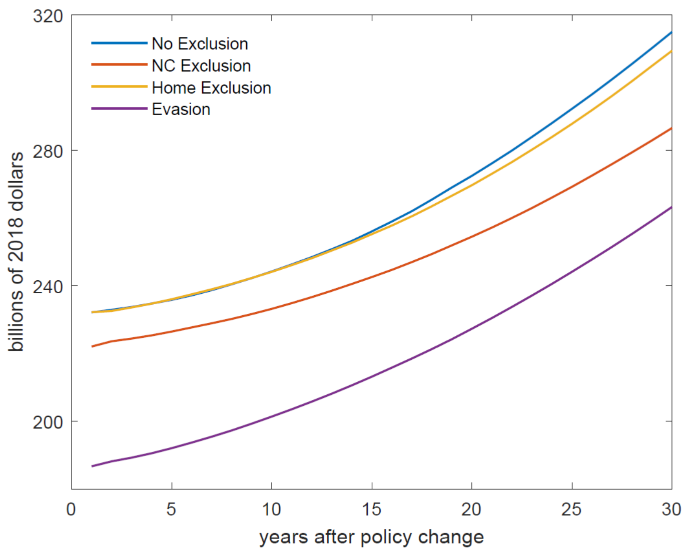
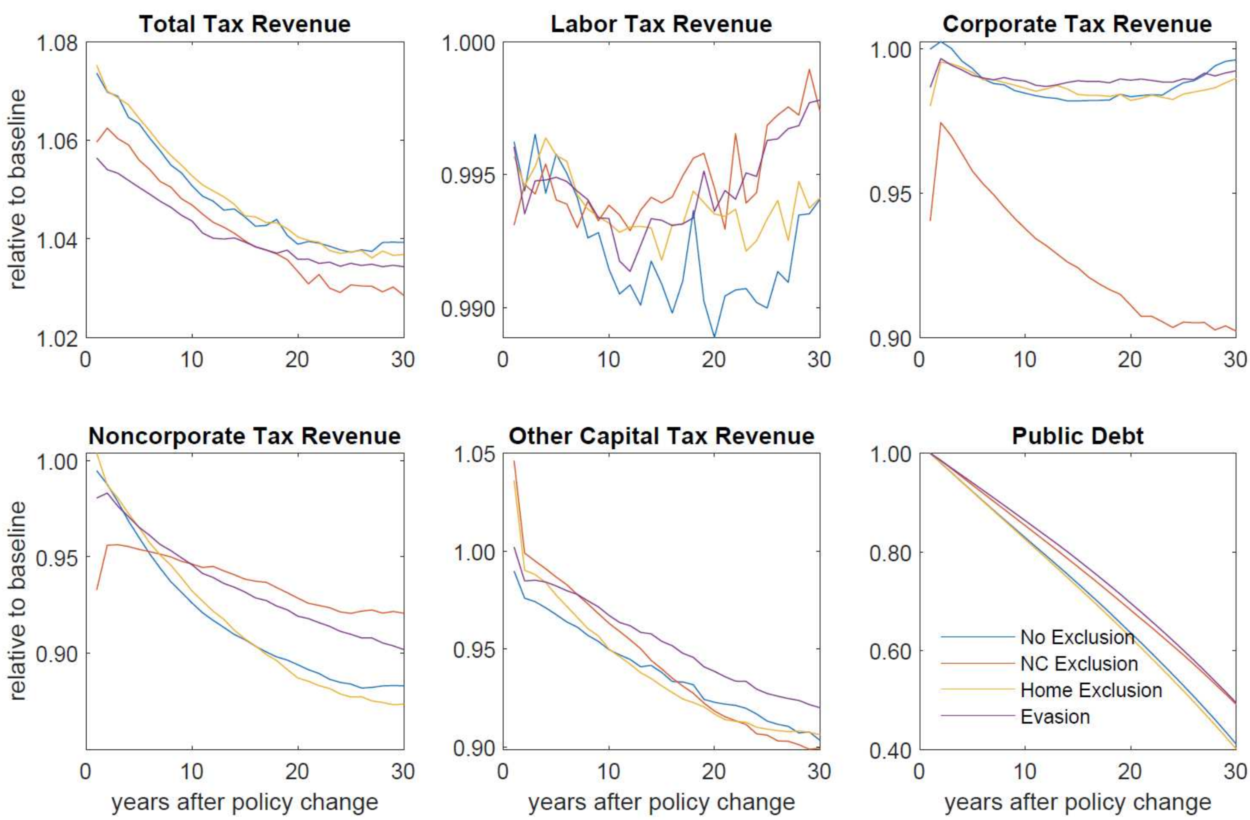


Figure 4: Wealth Tax Base Alternatives: Federal Income Tax Revenue Sources and Debt



Note: 'Labor Income Tax Revenue' includes revenue from payroll taxes in addition to income taxes on wages and Social Security benefits. 'Other Capital Income Tax Revenue' includes revenue from the taxation of dividends, interest, capital gains, and estates.

Figure 5: Expenditure Alternatives

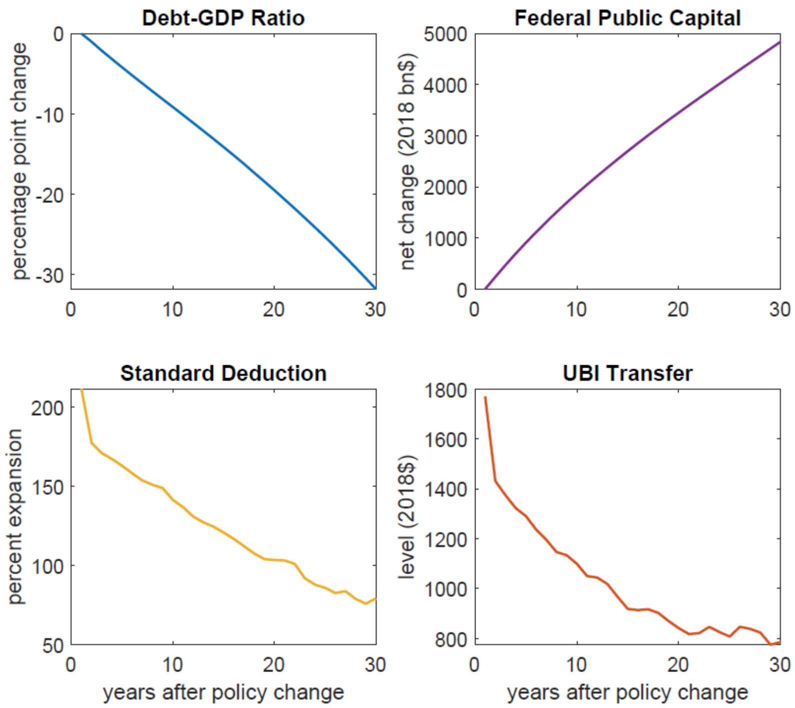


Figure 6: Expenditure Alternatives: Prices

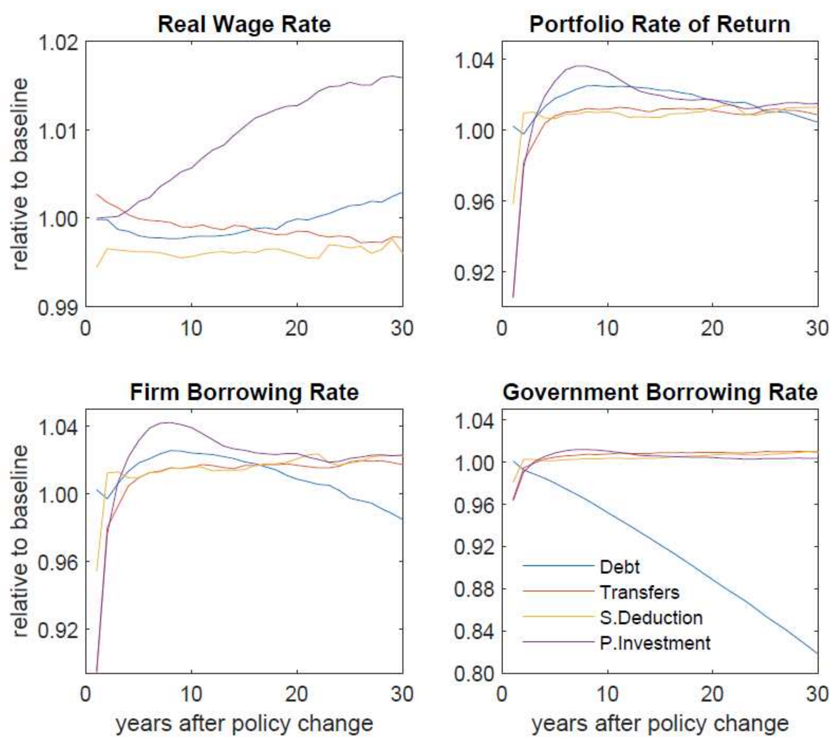


Figure 7: Expenditure Alternatives: Aggregates

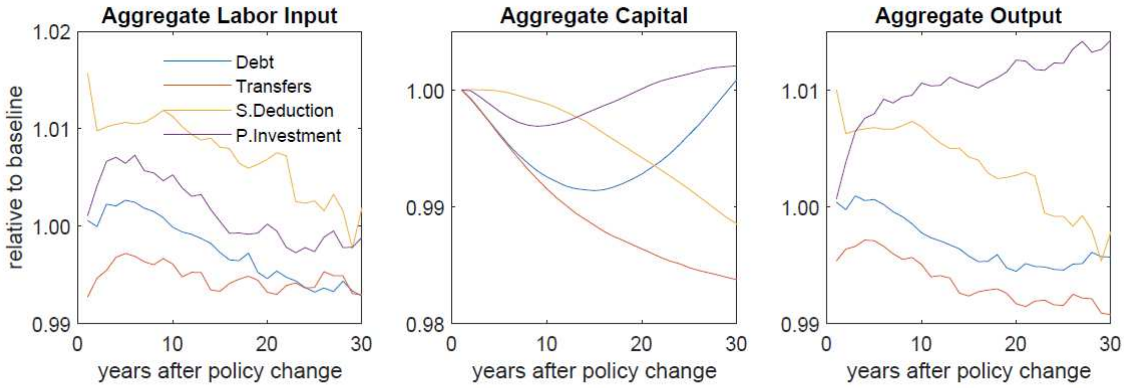
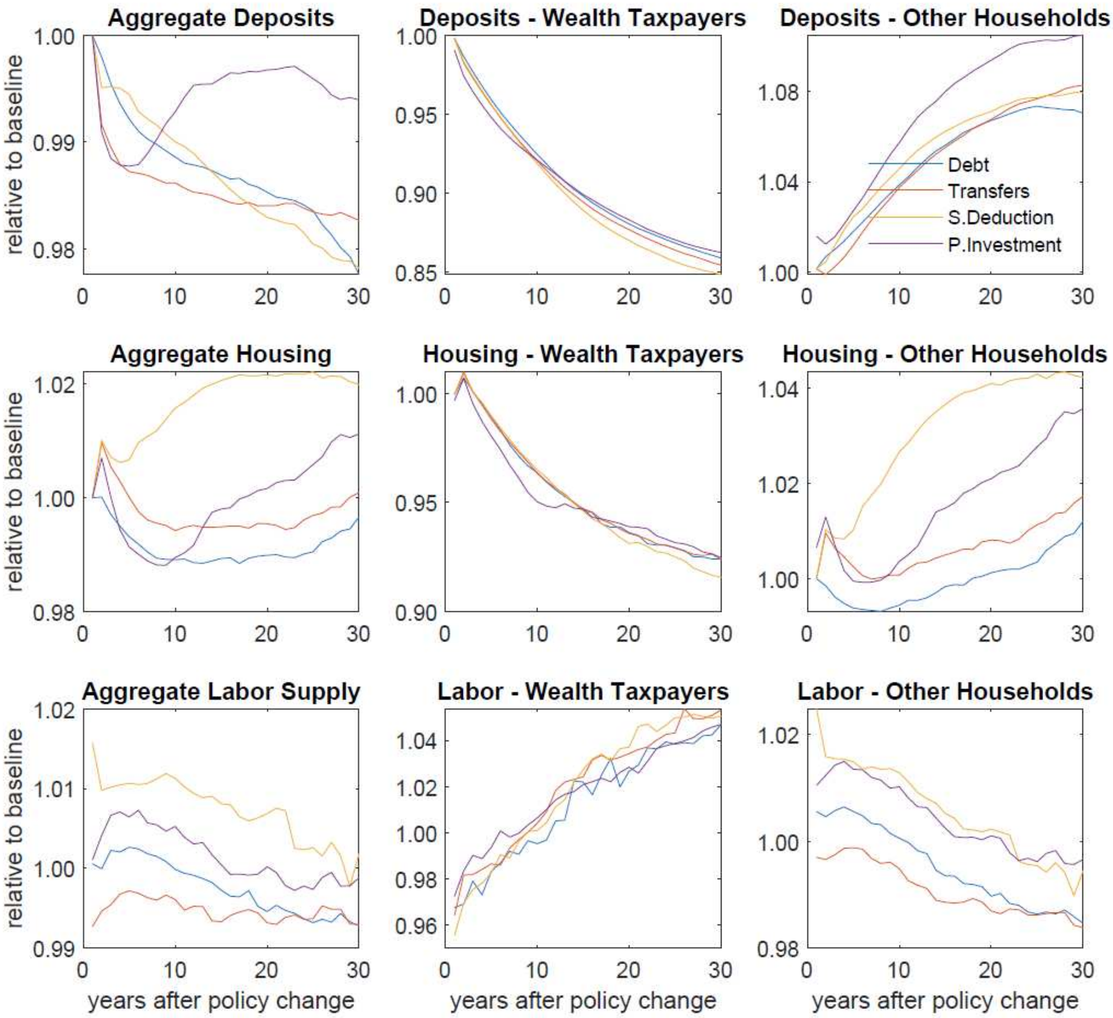


Figure 8: Expenditure Alternatives: Household Wealth and Labor Supply



Note: 'Wealth Taxpayers' are those households with initial wealth above the wealth tax threshold of $3.249 million, while 'Other Taxpayers' are those households with initial wealth below the threshold.

Figure 9: Expenditure Alternatives: Wealth Tax Revenue

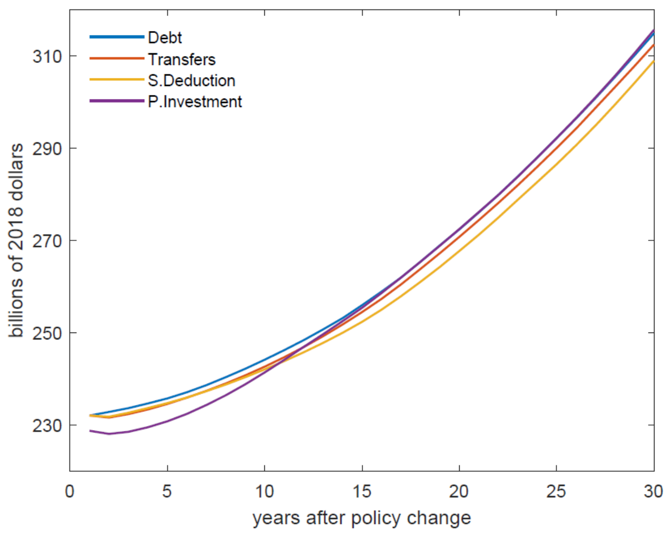
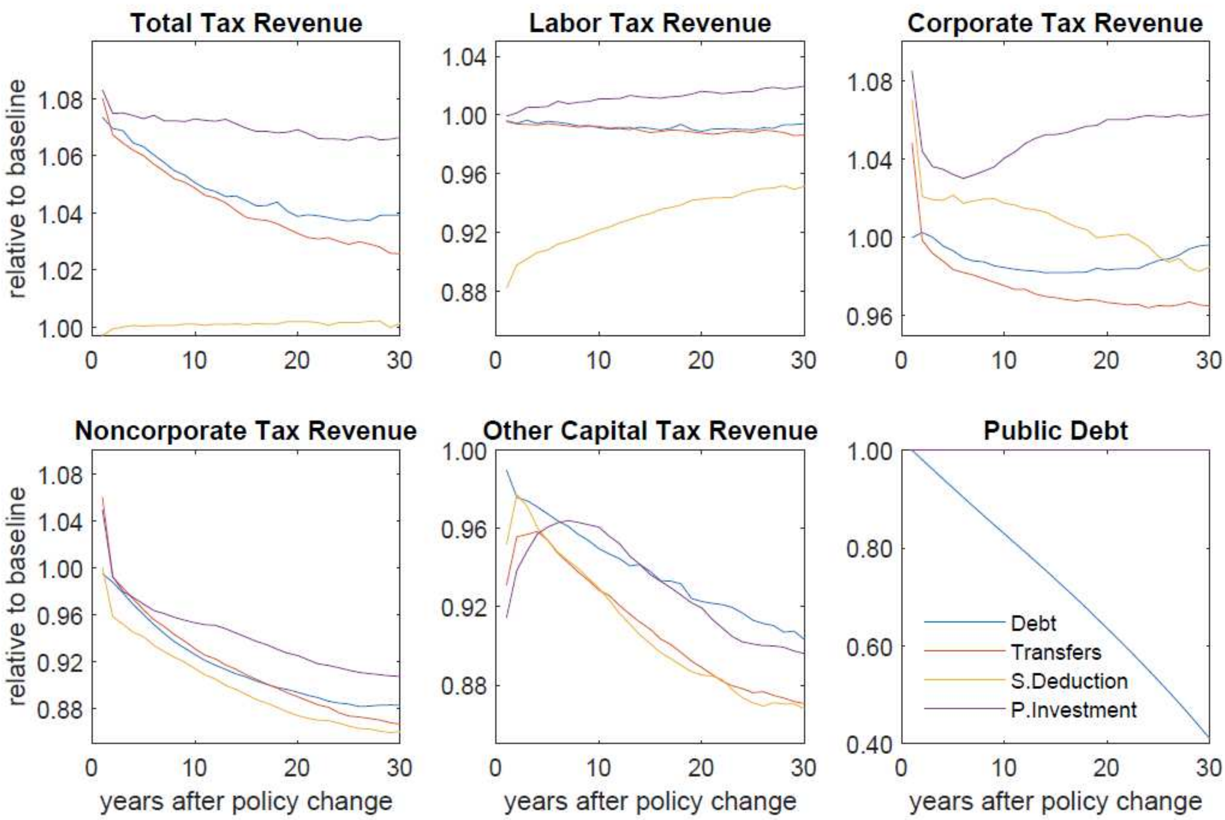


Figure 10: Expenditure Alternatives: Federal Income Tax Revenue Sources and Debt



Note: 'Labor Income Tax Revenue' includes revenue from payroll taxes in addition to income taxes on wages and Social Security benefits. 'Other Capital Income Tax Revenue' includes revenue from the taxation of dividends, interest, capital gains, and estates.

A Consumption Detail

As described in Section 2.1, the consumption-composite good x_j enters the households' budget constraint valued at the implicit price p_t^x. The composite good is an endogenous combination for consumption of market goods, housing services obtained from a residence, services produced at home from time use, and charitable giving. This detail is incorporated for so that we can model a high-level of individual tax detail within our framework. In this section, we describe how each component is nested in x_j, and how we arrive at an expression for the implicit price p_t^x.

Nested directly within x_j are non-housing consumption c_j and housing service consumption hs_j in a CES fashion:

$$x_j \equiv \left(\sigma c_j^\eta + (1-\sigma) hs_j^\eta\right)^{1/\eta} \tag{A.1}$$

For housing service consumption we assume that owner-occupied homes h_j^o and rental homes h_j^r provide equivalent housing services from which utility is derived, and therefore specify preferences for both as perfect substitutes:

$$hs_j \equiv \max\{h_j^o, h_j^r\} \tag{A.2}$$

so that each household has a residential status of homeowner or renter, but not both. Next, we assume that non-housing consumption is itself a Cobb-Douglas composite of different non-durable consumption types. The first sub-component is 'warm-glow' (Andreoni, 1989) charitable giving, c_j^g, which is assumed to be made in terms of final goods and received by agents outside of the model. The second sub-component, c_j^i, is the sum of market-produced consumption c_j^M and home-produced consumption services $c_j^{f,H}$:

$$c_j \equiv (c_j^i)^{\theta^{f,z}} (c_j^g)^{(1-\theta^{f,z})} \tag{A.3}$$

$$c_j^i \equiv \begin{cases} c_j^M + c_j^{s,H}(\bar{n}_j) & \text{if} f = s \\ c_j^M + c_j^{m,H}(\bar{n}_j^1, \bar{n}_j^2) & \text{if} f = m \end{cases} \tag{A.4}$$

where home-produced consumption services are assumed to be an exogenously decreasing, time-invariant function of the market labor hours supplied by each adult in the household. Substitution of market-produced and home-produced consumption services is thus limited by time use in this fashion. This simple structure of home production is included because it helps to replicate the heterogeneity in market hours across demographics at older ages as documented by Kuhn and Lozano (2008). Because variance in market labor productivity grows as households age while home productivity remains constant, the net benefit of time use for market labor grows by relatively more for higher productivity households of a given age.

Given this consumption detail, we can express the households' budget constraint at the disaggregated level as follows:

$$c_j^M + c_j^g + p_t^r h_j^r + a_{j+1} + h_{j+1}^o \leq (1 + r_t^p) a_j + (1-\delta^o) h_j^o + i_{t,j}^{f,z} - \mathcal{T}_{t,j}^{f,z} - \kappa_j^{f,z} - \xi_j^H$$

where it is assumed that market consumption and charitable giving are in terms of the numérair, and p_t^r is the relative price of rental housing. To express the optimization problem in terms of the consumption composite x_j and the implicit price p_t^x, we first collapse the two state-state variables into one by defining a household's total net worth as:

$$y_j \equiv h_j^o + a_j$$

Using this expression into the budget constraint, we obtain:

$$c_j^M + c_j^g + p_t^r h_j^r + (r_t^p + \delta^o) h_j^o + y_{j+1} \leq (1 + r_t^p) y_j + i_{t,j}^{f,z} - \mathcal{T}_{t,j}^{f,z} - \kappa_j^{f,z} - \xi_j^H \tag{A.5}$$

Next, we optimize equations (A.1) and (A.3) over $\{c_j^M, c_j^g, h_j^o\}$ when $h_j^r = 0$ and $\{c_j^M, c_j^g, h_j^r\}$ when $h_j^o = 0$ subject to the budget constraint (A.5) to obtain the following for any (f, z, j) demographic:

$$c_j^M = \left(\left(\vartheta_{t,j}^{f,z} \right)^{(\theta^{f,z} - 1)} \varphi_{t,j}^{f,z} \Phi_{t,j}^{f,z} \right) x_j - c_j^{f,H} \tag{A.6}$$

$$c_j^g = \left(\left(\vartheta_{t,j}^{f,z} \right)^{\theta^{f,z}} \varphi_{t,j}^{f,z} \Phi_{t,j}^{f,z} \right) x_j \tag{A.7}$$

$$h_j^o = \left(\Phi_{t,j}^{f,z} \right) x_j \ \text{ if } h_j^r = 0 \tag{A.8}$$

$$h_j^r = \left(\Phi_{t,j}^{f,z} \right) x_j \ \text{ if } h_j^o = 0 \tag{A.9}$$

$$p_t^x x_j + y_{j+1} = (1 + r_t^p) \, y_j + i_{t,j}^{f,z} - \mathcal{T}_{t,j}^{f,z} - \kappa_j^{f,z} - \xi_j^H \tag{A.10}$$

where:

$$p_t^x = \begin{cases} \Phi_{t,j}^{f,z} \left(\varphi_{t,j}^{f,z} \Theta_{t,j}^{f,z} + r_t^p + \delta^o \right) - (c_j^{f,H} / x_j) & \text{if } h_j^r = 0 \\ \Phi_{t,j}^{f,z} \left(\varphi_{t,j}^{f,z} \Theta_{t,j}^{f,z} + p_t^r \right) - (c_j^{f,H} / x_j) & \text{if } h_j^o = 0 \end{cases} \tag{A.11}$$

$$\Phi_{t,j}^{f,z} = \left(\sigma \left(\varphi_{t,j}^{f,z} \right)^{\eta} + (1 - \sigma) \right)^{-1/\eta} \tag{A.12}$$

$$\varphi_{t,j}^{f,z} = \begin{cases} \left(\left(\dfrac{1 - \sigma}{\sigma} \right) \left(\dfrac{\Theta_{t,j}^{f,z}}{r_t^p + \delta^o + \partial \mathcal{T}_{t,j}^{f,z} / \partial h_j^o} \right) \right)^{1/(\eta - 1)} & \text{if } h_j^r = 0 \\ \left(\left(\dfrac{1 - \sigma}{\sigma} \right) \left(\dfrac{\Theta_{t,j}^{f,z}}{p_t^r} \right) \right)^{1/(\eta - 1)} & \text{if } h_j^o = 0 \end{cases} \tag{A.13}$$

$$\Theta_{t,j}^{f,z} = (\vartheta_{t,j}^{f,z})^{(\theta^{f,z} - 1)} + (\vartheta_{t,j}^{f,z})^{(\theta^{f,z})} \tag{A.14}$$

$$\vartheta_{t,j}^{f,z} = \left(\frac{1 - \theta^{f,z}}{\theta^{f,z}} \right) \left(\frac{1 + \partial \mathcal{T}_{t,j}^{f,z} / \partial c_j^M}{1 + \partial \mathcal{T}_{t,j}^{f,z} / \partial c_j^g} \right) \tag{A.15}$$

The optimal residential choice at any age j can be obtained by evaluating equation (A.2) conditional on the optimal choices for all of the other endogenous household variables through $J + 1$ as described in Section 2.1, but over the collapsed state space with the terminal condition $V^{f,z}_{t,J+1}(y_{J+1}) = 0$. Upon solving the household's complete optimization problem numerically using backwards induction, the optimal level of financial wealth at any age j can be obtained as the residual to equation A.5.

B Calibration

In this section, we describe our calibration strategy for non-tax parameters. Select exogenous parameters are summarized in Table A1.

B.1 Households

B.1.1 Demographics

The population is assumed to grow exogenously at the gross average annual rate of $\Upsilon_P = 1.0076$ computed for the United States over years 2017-2027 from the Census Bureau. Households entering the economy at model age $j = 1$, (actual age 25), and can live for a maximum of $J = 66$ (actual age 90). Over their lifecycle individuals in households may choose to work for their first $R - 1 = 40$ model years, over which time they are assumed to survive with certainty so that their conditional survival probability is $\pi_j = 1$ for $j = 1, ..., R - 1$. All individuals must be retired by model age $j = R$ (actual age 66), at which time they face mortality risk so that $\pi_j < 1$ for $j = R, ..., J$ with $\pi_J = 0$. The conditional survival probabilities corresponding to ages 41 through 89 are computed from the Social Security Administration's *2013 Actuarial Life Table* as a weighted average of males and females.

The stationary age profile of households is computed to account for population growth and mortality risk such that $\Omega_{t,j+1} = (\Omega_{t,j}\pi_j)/\Upsilon_P$, and is normalized to a unit measure $\sum_{j=1}^{J} \Omega_j = 1$. The family composition-age profile $\Omega^f_{t,j}$ is computed for $f = s, m$ as the share of non-joint and joint tax filing units respectively out of total tax units using the ITM. Letting $\Omega^z_{t,j}$ be the population share of each labor productivity type, we compute the measure of households as $\Omega^{f,z}_{t,j} = \Omega^f_{t,j}\Omega^z_{t,j}\Omega_{t,j}$.

B.1.2 Labor Characteristics

We define economic labor income in the model to be the NIPA-comparable wage income concept introduced in Moore and Pecoraro (2020b) plus self-employment income.[1] Letting each productivity type $z = 1, ..., 8$ correspond to the notion of a lifetime labor income class for each family composition type $f = s, m$, we use the ITM to distribute the cross-sectional labor income of non-dependent tax filers with age of primary between 25-64.[2] Each for non-joint and joint tax filers, the $nz = 8$ productivity types represent the following percentile classes: $\{0 - 20; 21 - 40; 41 - 60; 61 - 80; 81 - 90; 91 - 99; 99 - 99.9; 99.9 - 100\}$.

Individual labor productivity for each (z, f) demographic, $\mathrm{z}^{z,f}_j$, is the product of a demographic-independent age-varying component, z_j, and a demographic-dependent

[1]The 'NIPA-comparable' measure used here is the sum of (*i*) AGI wage income (*ii*) combat pay, (*iii*) employers' share of the FICA tax, (*iv*) deferred 401k compensation, (*v*) employers share of 401k compensation, (*vi*) employer provided dependent care, (*vii*) employer health-insurance compensation, (*viii*) employer HSA compensation, and (*ix*) employer life-insurance compensation.

[2]The BEA does not report distributional characteristics of NIPA wage income.

age-invariant component, $\mathrm{z}^{z,f}$. The age-varying component is exogenously set to the smoothed wage profiles estimated by Rupert and Zanella (2015) for all individuals. The age-invariant component is calibrated internally for each (z, f) demographic so that average annual labor income over working ages $j = 1, .., R-1$ in the initial steady state matches average annual labor income target, $\bar{\imath}^{f,z}$, computed for their respective percentile class from the ITM. While both individuals in married households face the same productivity term $\mathrm{z}_j^{z,m}$, there is an exogenous productivity wedge μ^z between primary and secondary workers. We compute this wedge as the relative hourly earnings of secondary workers from the 2015 Medical Expenditures Panel Survey for each income quintile of married couples.

The individual labor supply choice set has three discrete employment options — unemployment, part-time, and full-time — with each option corresponding inversely to time spend on home production. Using the 2017 American Time Use Survey from the U.S. Bureau of Labor Statistics, we compute the average hours that an employed individual spends working in full-time and part-time jobs respectively, and the 2013-2017 average for hours spent on 'household activities' for unemployed, part-time, and full-time single, married primary, and married secondary individuals respectively. Assuming that individuals in the model sleep on average 8.8 hours per day, we map normalized waking-time spent on market work to home production as follows:

$$\mathbb{N} = [0.000, 0.211, 0.422] \rightarrow \begin{cases} \mathbb{NH} & = [0.180, 0.135, 0.101] \text{ if } f = s \\ \mathbb{NH} & = [0.153, 0.109, 0.084] \text{ if } f = m, 1 \\ \mathbb{NH} & = [0.252, 0.181, 0.124] \text{ if } f = m, 2 \end{cases}$$

Monetary child-care costs, $\kappa_j^{z,f}$, depend on a household's number of dependents $\nu_j^{f,z}$ and the market work hours of the single or married secondary adult so that:

$$\kappa_j^{z,f} \equiv \begin{cases} cc^{z,s}\nu_j^{z,s}n_j & \text{if } f = s \\ cc^{z,m}\nu_j^{z,m}n_j^2 & \text{if } f = m \end{cases} \tag{B.1}$$

where $cc^{z,f}$ is a scale parameter. We exogenously set $\nu_j^{f,z}$ to the average number of dependents under the age of 6 for a given (f, z, j) demographic, which are calculated using the JCT-ITM for 2017. Given the distribution of dependents, we then set the scale parameter so that childcare expenses on average for each (z, f) demographic match those values imputed by the ITM for 2017 when labor supply is evaluated as the employment targets in Table A2.

The lifecycle time cost of child-rearing, $\varphi\nu_j^{f,z}$, enters the market-labor sub-utility function for single and married-secondary adults. Given the exogenous distribution of $\nu_j^{f,z}$ as described above, the parameter φ is set equal to 0.094 so that parents spend about 520 hours per child each year (Hotz and Miller, 1988), which is broadly consistent with the time value specified by Guner et al. (2011).

B.1.3 Preferences

We use two preference parameters — households' subjective discount factor, β, and the wealth-in-utility (WIU) parameter, o_t^z — in targeting the measured aggregate household wealth accumulation and top wealth shares from Smith et al. (2020).[3,4] First, we set $\beta = 0.9518$ for all households to target an aggregate wealth to output ratio of 4.7. Second, given that the deterministic labor productivity profiles of our model imply that households within the top 10% of lifetime income classes will largely make up the top 10% of households in the wealth distributions, we calibrate the WIU parameters with $\underline{z} = 6$ to match the measured wealth shares of the top 10%, 1% and 0.1% of households respectively. Assuming that o_t^z grows at the gross rate of technological progress, we set $o_t^z/A_t = 175$ for $z = 6, 7$ and $o_t^z/A_t = 5$ for $z = 8$ to target our top wealth concentration targets as shown in Table 4.

We internally calibrate the variable labor disutility coefficients $\psi^s, \psi^{m,1}, \psi^{m,2}$, and fixed labor disutility parameters ϕ^s, ϕ^m, to target the distribution of employment statuses across earner types observed in the Medical Expenditures Panel Survey for 2015,[5] the fit of which is reported in Table A2. With specification of indivisible labor, the labor disutility curvature parameters $\zeta^s, \zeta^{m,1}, \zeta^{m,2}$ are largely unrelated to the intensive margin elasticity (Chang et al., 2011).[6] Rogerson and Wallenius (2009) and Keane and Rogerson (2012) argue that higher values of these parameters instead imply that aggregate employment fluctuations depend more heavily on changes in the duration of working life, rather than changes in hours worked while employed. Since changes to the pattern of retirement in response to tax changes can be quite large (Alpert and Powell, 2020), we set these parameters to relatively high and uniform[7] values $\zeta^s = \zeta^{m,1} = \zeta^{m,2} = 5$.

The curvature parameter for the consumption-composite good x_j is exogenously set to $\eta = -1.0534$, which implies an elasticity of substitution for housing and non-housing consumption of 0.487 (Li et al., 2016). The non-housing consumption preference parameter σ is then calibrated internally to target the ratio of private business investment to total private investment of 0.465 as calculated from the NIPA for 2016.

In calibrating the curvature parameter for the non-housing consumption composite, $\theta^{f,z}$, we make use of the optimality condition:

$$\frac{c_j^g}{c_j^i} = \left(\frac{1 - \theta^{z,f}}{\theta^{z,f}}\right)$$

which holds under the assumption that the marginal tax rates for each consumption type is zero. Letting $\left(\overline{c^{g;f,z}/i^{f,z}}\right)$ denote average charitable giving as a proportion of labor income targets for each (f, z) combination as computed from the ITM for 2018 for working-ages, we substitute this into the optimality condition above and re-arrange for

[3] To be consistent with our targets from Smith et al. (2020), we exclude the implicit portion of housing assets that represents consumer durables when these computing figures. We approximate consumer durables as 28.3% of housing assets in our model, which is the average share of consumer durables in the stock of residential capital over 2007-2016 as measured Bureau of Economic Analysis.

[4] The top-wealth shares estimated by Smith et al. (2020) are expressed at the individual-adult level under the assumption that wealth is equally split among spouses. As argued by Saez and Zucman (2020b), this is broadly comparable to units at the household level (as in our model) because a vast majority of the wealthiest households are married.

[5] We use the Medical Expenditures Panel Survey because market work hours are reported for both individuals in a married couple, and therefore allows for us to avoid erroneously using gender as a proxy for primary or secondary earners. We consider full-time work to correspond with hours greater than or equal to 35 per week, and part-time work to correspond with positive hours less than 35 per week.

[6] Chang and Kim (2006) show that the in a model of indivisible labor choices, the intensive and extensive labor elasticities are determined endogenously by the distribution of reservation wages.

[7] In a series of simulations, Chang et al. (2011) show that estimated Frisch elasticities for secondary earners are systematically higher despite having the same curvature parameter as the primary earner.

$\theta^{f,z}$:

$$\theta^{f,z} = \left(1 + \left(c^{g;\bar{f},z}/\bar{i}^{f,z}\right) \frac{\sum_{j=1}^{R-1} i_j^{f,z}}{\sum_{j=1}^{R-1} c_j^{i;f,z}}\right)^{-1}$$

which can be calibrated internally so that the model reproduces charitable giving targets on average for the working-age population in the initial steady state.

Following the approach used by (Bridgman, 2016), we impute a value of home production for households as a function of home-work hours:

$$ch(nh_j^f) = \begin{cases} w_t \bar{z}^{s,1} nh_j^s & \text{if } f = s \\ w_t \bar{z}^{s,1}(nh_j^{m,1} + nh_j^{m,2}) & \text{if } f = m \end{cases}$$

where $w_t \bar{z}^{s,1}$ is the average wage rate for the lowest productivity type single household.

B.1.4 Endowments and Estates

Households enter the economy at age $j = 1$ with endowments of initial financial assets a_1^e, where the endowment index $e = \{1, \ldots, ne\} \in \mathbb{E}$ is now made explicit. To derive the exogenous distribution of endowments across (f, z) demographics, we compute the mean and standard deviation of each net worth[8] class for 24-26 year old single and married individuals respectively from a truncated sample of the 1989-2016 waves of the *Survey of Consumer Finances*.[9] We obtain the following mean and standard deviations for single and married household in net worth percentile classes of $\{0-20;\ 21-40;\ 41-60;\ 61-80;\ 81-90;\ 91-99;\ 99-99.9;\ 99.9-100\}$:

$$\bar{x}^s = \{-2,304;\ 1,677;\ 8,409;\ 25,800;\ 67,330;\ 211,920;\ 861,207;\ 7,591,840\}$$
$$\bar{x}^m = \{2,169;\ 8,702;\ 20,449;\ 48,789;\ 110,283;\ 289,544;\ 888,472;\ 3,007,143\}$$

$$s^s = \{1,537;\ 1,198;\ 2,839;\ 9,209;\ 14,204;\ 98,201;\ 409,003;\ 3,088,560\}$$
$$s^m = \{1,597;\ 2,352;\ 5,110;\ 12,696;\ 24,668;\ 117,580;\ 396,588;\ 1,020,090\}$$

For each net worth percentile class and marital status combination, we draw $ne = 20$ pseudorandom numbers from standard normal distribution with the associated mean and standard deviations for each class-status combination. The distribution of initial

[8]We define the financial component of net worth as financial assets (balances of checking accounts, savings accounts, money market mutual accounts, call accounts at brokerages, prepaid cards, certificates of deposits, total directly-held mutual funds, stocks, savings and other bonds, IRAs, thrift accounts, future pensions, cash value of whole life insurance, trusts, annuities, managed investment accounts with equity interest and miscellaneous other financial assets) less debt (credit card balances, educations loans, installment loans, loans against pensions and/or life insurance, margin loans and other miscellaneous loans).

[9]We truncate the sample by disregarding all observations in the bottom 20% and top 0.1% of the original sample. We truncate the sample from the bottom because the magnitude of negative net worth of held by households in the bottom 20% of the original sample prevents the corresponding model agents from feasibly earning enough income to pay off their endowment of debt given the deterministic labor productivity path, thereby violating the no-Ponzi condition. We truncate the sample from the top because the variation in positive net worth held by agents in the top 0.1% of the distribution requires that the net worth grid be impractically large, generating untenable curse of dimensionality issues.

endowments for each (f, z) demographic is then obtained from an inverse hyperbolic sine transformation to these draws. The distribution of initial endowments is assumed to be time-invariant and aggregates to:

$$\bar{\Gamma} = \sum_{f=s,m} \int_{\mathbb{Z}} \int_{\mathbb{E}} a_{j=1}^{f,z,e} \Omega_{t,j=1}^{f,z,e} \; de \; dz$$

Initial endowments to households are assumed to come out of the estates from the newly deceased along with end-of-life expenditures c_j^E and taxes:

$$c_t^E + txl_t^{beq} + \bar{\Gamma} = \int_{\mathbb{Z}} \int_{\mathbb{J}} \int_{\mathbb{E}} (1 - \pi_j) \sum_{f=s,m} \Omega_{t,j}^{f,z,e} \left(a_{t+1,j+1} + h_{t+1,j+1}^o \right) \; dj \; dz \; de$$

Given the exogenous distribution of initial endowments that aggregates to $\bar{\Gamma}$, and taxes txl_t^{beq} defined in Equation (2.36), c_j^E can be computed as a residual. The linear federal tax rate on estates, τ_t^{beq}, is set internally so that the ratio of aggregate estate taxes to output is 0.0012, which is the estimated ratio of estate (and gift) taxes to GDP from the CBO for 2017. To the extent that we understate the intergenerational transmission of wealth by targeting the wealth distribution of young households, the ratio of end-of-life consumption to wealth transfers will be overstated.

Finally, we link the lower-bound of the wealth support (the noncollaterized borrowing limit) to the distribution of initial endowments by specifying that the lower-bound is the minimum of either the lowest drawn value of endowments for each (f, z) demographic, or negative 10% of the initial steady state target for average annual labor income $\bar{i}^{f,z}$:

$$\underline{y}^{f,z} = \min(\min(a_1^{f,z,e}), -0.1 \times \bar{i}^{f,z})$$

B.2 Firms and Housing

We build from the method of Cooley and Prescott (1995) to compute capital shares of output.[10] Using data from the National Income and Product Accounts (NIPA), we compute 2007-2016 average GDP shares of 0.3617 for private and public capital jointly. Under the restriction $\alpha + g = 0.3617$, we internally calibrate private and public capital shares of output so that the marginal product of federal public capital net of a state-local government offset is about one half the marginal product of private capital (CBO, 2016).[11] This results in a share parameter for public capital of $g = 0.07$ which is at the lower end of the range preferred by Ramey (2020), and slightly below the range preferred by Bom and Ligthart (2014).

Since the aggregate laws of motion for all forms of capital in our model follow the same structure, rates of economic depreciation δ^κ for $\kappa = K, G, o, r$ are computed to satisfy the same steady state expression for the aggregate investment to capital ratio,

[10] While Cooley and Prescott (1995) calculate factor income share of GNP, we follow their methodology to instead calculate factor income shares in GDP. Furthermore, we include proprietor's income, the statistical discrepancy, taxes on production and imports, and the current surplus of government enterprises less subsidies as ambiguous components of output so that the aggregate income-output equivalence in the model implies a level of output consistent with measured GDP.

[11] "CBO (2016) estimates that for every 1 dollar increase in federal investment, state and local governments reduce their investment by 33 cents. Our parameterization captures the net effect this has on the productivity of federal investment."

$\iota^{\kappa} = (\Upsilon_A\Upsilon_P - 1 + \delta^{\kappa})$. Using the average annual investment flows and stocks of private and public non-residential fixed assets as reported by NIPA for years 2007-2016 yields $\delta^K = 0.0799$ and $\delta^G = 0.0317$. Using the average annual investment flows and stocks of private residential fixed assets and consumer durables as reported by NIPA over the same period, we obtain $\delta^o = 0.0662$ for owner-occupied fixed assets and $\delta^r = 0.1230$ for tenant-occupied fixed assets.

We assume that firms face adjustment costs when they deviate from the steady state investment-capital ratio. Adjustment costs are assumed to be convex cost and given by the function:

$$\Xi_t^q = \frac{\xi^K}{2}(\frac{I_t^q}{K_t^q} - \Upsilon_P\Upsilon_A + 1 - \delta^K)^2 K_t^q \quad \text{for } q = c, n$$

Given the rates of population growth technological progress, and economic depreciation this adjustment cost function is parameterized by ξ^K, which for purposes of the simulations is set to 6.

We target the relative size of output produced by the corporate and noncorporate sector by making use of time-invariant scale parameters Z^q for $q = c, n$ on the firms' production functions. We set $Z^c = 1.05$ and $Z^n = 1$ to target the ratio of corporate gross receipts to total business gross receipts equal to 0.692 as computed from the SOI for 2016. Corporate and noncorporate representative firms are assumed to maintain constant debt to capital ratios of $\varkappa^{b,c} = 0.435$ and $\varkappa^{b,n} = 0.085$, which target sector-specific interest expense to aggregate output ratios of 0.039 and 0.003 as computed from the SOI and NIPA for 2016. In addition, the corporate firm distributes dividends to households as a $\varkappa^d$ portion of after-tax earnings. We set this parameter to $\varkappa^d = 0.155$, which targets the ratio of net dividends of domestic C-corporations to aggregate output of 0.031 as measured by NIPA for 2016.

Following Gervais (2002), Fernánez-Villaverde and Krueger (2010), and Cho and Francis (2011), we set the minimum owner-occupied housing equity to $\gamma = 0.20$.[12] Furthermore, we assume that there is a lower bound on the support of owner-occupied housing $\underline{\mathrm{h}}^o$. We calibrate this value internally to target a homeownership ratio of 0.637 as reported for 2015 by the *American Housing Survey*.

We assume that housing transaction costs take the form:

$$\xi_j^H = \begin{cases} \phi^o h_{j+1}^o & \text{if } h_j^o = 0 \\ \phi^r h_{j+1}^r & \text{if } h_j^o > 0 \end{cases} \tag{B.2}$$

where h_{j+1}^r is the quantity of housing rental by a household.[13] Following Gruber and Martin (2003), we assume symmetric transaction costs and set $\phi^o = \phi^r = 0.05$.

B.3 Government

B.3.1 Social Security

Social Security benefits depend on a retiree's past earnings covered under Old Age, Survivors and Divisibility Insurance (OASDI), which are those subject to the payroll tax

[12]This closely corresponds to the median loan-to-value ratio of 77% for owner-occupied housing units manufactured between 2010-2015 as reported in the Census Bureau's 2015 *American Housing Survey*.

[13]See Appendix A for an explanation of the rental housing choice.

in our model. We therefore specify that an individual's annual benefits are a function of average lifetime OASDI-covered earnings according to the benefit calculator available from the Social Security Administration.[14] Moreover, since we explicitly model married households, we account for 'spousal benefits'.[15]

To save on state variables, we assume that households do not contemplate the effects on their future social security benefits when making labor supply decisions over their working life. Modeling this expectations channel requires households to consider off-equilibrium paths with respect to social security benefits when labor supply decisions are made. Nonetheless, for the on-equilibrium path, an individual's labor supply choices — and hence their OASDI-covered earnings — are consistent with the actual social security benefits they receive in retirement.

B.3.2 Public Debt and Interest Rate

We internally calibrate the federal debt-output ratio to be 54.2% in the initial steady state, which reflects federal debt held by the public less financial assets and debt held by the Federal Reserve at the end of 2017.[16] We then assume that 61.2% of this debt is held by foreign entities outside of the model (Department of Treasury). We exogenously set $\kappa^{dom} = 0.60$ so that 40% of new federal debt issues are assumed to be purchased by exogenous foreign-entities (PWBM, 2016).

The real rate of interest on federal government debt is assumed be linear in the real interest rate on private debt and nonlinear in the federal debt-output ratio, the latter of which includes foreign-held debt. We exogenously set the coefficient on the exponentiated debt-output ratio to $\varsigma = 0.1910$ so that the real interest rate on public debt increases by 2.5 basis points for every 1 percent increase in the debt-output ratio from its steady state value (Gamber and Seliski, 2019). We calibrate the coefficient on the private real interest rate, ϖ, internally to target a ratio of net federal interest payments relative to output equal to 2.1%, which is the average projected value over 2017-2027 in *The Budget and Economic Outlook: 2017 to 2027.*

For both the federal and state-local governments, our specification of debt (zero in the case of the state-local government), the tax-and-transfer system, and public capital ()below), the flow budget constraints in equations (2.30) and (2.38) hold in the initial steady state by allowing consumption expenditures to take on the residual value.

B.3.3 Public Capital

For purposes of accounting, we allow for the stock of productive public capital to be split between the federal and state-local government. We follow Ramey (2020) and include only non-defense public capital, which we calibrate internally to the 2007-2016 average from NIPA of 63.85% of aggregate output. Of this public capital, we attribute the 2007-2016 average from NIPA of 13.79% to the federal government, with the residual attributed to

[14]While in practice, OASDI-covered earnings from the highest 35 years are used in the benefit calculation, for simplification purposes we assume benefits depend on the full 40 years of working life for households. See https://www.ssa.gov/pubs/EN-05-10070.pdf for a description of the benefit calculation.

[15]'Spousal Benefits' allow for the low-earning member of a married household to claim one-half of their spouses' benefit when it is greater than their own.

[16]We calibrate to a level of federal debt held by the public less financial assets of relative to output of 69.3%, which is the value projected for 2017 in *The Budget and Economic Outlook: 2017 to 2027* by the CBO. We then net out the 21.7% of debt held by the public was held by Federal Reserve Banks at the beginning of fiscal year 2018.

the state-local government. We follow CBO (2016) and set the time-to-build parameters for federal investment to $S = 20$ and:

$$\kappa^{fed} |_{s=1}^{S} = \{0.05, 0.20, 0.15, 0.10, 0.05, 0.05, 0.05, 0.05, 0.05, 0.05, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02, 0.02\}$$

This timing of productivity effects incorporates physical infrastructure, education, and research and development, the latter two of which take longer to become fully productive (CBO, 2021).

B.4 Tables

Table A1: Select Exogenous Parameters

Demographics		
Terminal ages	R, J	40, 66
Rate of population growth	υ_P	0.0076
Production		
Rate of technological progress	υ_A	0.0108
Private capital share of output	α	0.2917
Public capital share of output	g	0.07
Private capital depreciation rate	δ^K	0.0799
Corporate dividend payout ratio	$\varkappa^d$	0.155
Debt-capital ratio	$\varkappa^{b,c}$, $\varkappa^{b,n}$	0.435, 0.085
Output scale parameter	Z^c, Z^n	1.05, 1.00
Private capital adjustment cost parameter	ξ^K	6
Housing		
Owner-occupied housing minimum down-payment	γ	0.20
Housing status adjustment cost	ϕ	0.05
Housing services depreciation rate	δ^o, δ^r	0.0662, 0.1230
Owner-occupied housing minimum	$\underline{\mathrm{h}}^o$	0.70
Preferences		
Subjective discount factor	β	0.9518
Non-housing consumption share of composite	σ	0.415
Housing/non-housing consumption substitution parameter	η	-1.053
Utility curvature parameter	$\zeta^{f,\epsilon}$	5
Intensive labor margin disutility	ψ^s,$\psi^{m,1}$,$\psi^{m,2}$	$400.5, 270.0, 130.0$
Extensive labor margin fixed cost	ϕ^s, ϕ^m	$0.395, 0.099$
Children disutility parameter	φ^f	0.094
Government		
Public capital depreciation rate	δ^g	0.0317
Interest rate response to debt	ς	0.0145

Table A2: Targeted and Baseline Actual Employment Status by Type of Worker

Type of Worker	**Data** (MEPS)			**Model**		
	FT	**PT**	**U**	**FT**	**PT**	**U**
Single	0.61	0.24	0.15	0.61	0.24	0.15
Married Primary	0.90	0.08	0.02	0.90	0.10	0.00
Married Secondary	0.42	0.32	0.26	0.43	0.32	0.25

C Trend-Stationary Equilibrium

The model is transformed into trend-stationary form as described in Appendix B.1 of Moore and Pecoraro (2020b) so that a stationary solution method can be used to solve the model. That is, variables with the tilde accent denote those that have been de-trended for technological and/or population growth. In addition, as described in Appendix B.2 of Moore and Pecoraro (2020b) we perform a change of variables to mitigate the curse-of-dimensionality problem by reducing the two-dimensional household state space to a single dimension of net worth $\tilde{y} \equiv \tilde{a} + \tilde{h}^o$. The solution method used here generally follows the algorithm described in Appendix C of Moore and Pecoraro (2020b). We define our equilibrium in terms of the transformed model.

For each age cohort, j, productivity type, z, and family composition f, households have market consumption, $\tilde{c}^M$, charitable giving, $\tilde{c}^g$, market labor hours, n, n^1, and n^2, owner-occupied housing assets, $\tilde{h}^o$, rental housing $\tilde{h}^r$, financial assets $\tilde{a}$, and future net worth $\tilde{y}'$, as control variables. Households have current net worth $\tilde{y}$ as their endogenous individual state variable, and their age, productivity type, as family composition as their exogenous state variables. Household choices of home production $\tilde{c}^h$ and child-care costs $\tilde{\kappa}$ depend exogenously on a household's contemporaneous choice of market labor supply. End-of-life expenditures $\tilde{c}^E$ are determined by the net worth left by households who die at the end each period after taxes and bequests. Bequests are distributed in an exogenous, time-invariant fashion and aggregate to $\tilde{\bar{\Gamma}}$.

Corporate and non-corporate firms, valued at $\tilde{V}^c$ and $\tilde{V}^n$, have effective labor inputs $\tilde{N}^c$ and $\tilde{N}^n$, and future private capital stocks $\tilde{K}^{c'}$ and $\tilde{K}^{n'}$ as control variables, with current private capital stocks $\tilde{K}^c$ and $\tilde{K}^n$ as state variables.

Endogenous aggregate state variables are effective market labor supply $\tilde{N}$, owner-occupied housing capital $\tilde{H}^o$, rental housing capital $\tilde{H}^r$, deposits $\tilde{D}$, private consumption $\tilde{C}_t$, financial intermediary income $\tilde{Inc}$, private business capital $\tilde{K}$, public capital $\tilde{G}$, private bonds $\tilde{B}$, public bonds $\tilde{B}^g$, and federal, state, and local tax instruments and transfer payments associated with given tax system, the set of which are denoted by $\mathbb{T}$.

Definition 1. *A* ***perfect-foresight trend-stationary recursive equilibrium*** *is comprised of a measure of households* $\tilde{\Omega}_{t,j}^{f,z}$*, a household value function* $V_{t,j}^{f,z}(\tilde{y})$*, a collection of household decision rules* $\{\tilde{c}_{t,j}^{M;f,z}(\tilde{y}),\ \tilde{c}_{t,j}^{g;f,z}(\tilde{y}),\ n_{t,j}^{z,s}(\tilde{y}),\ n_{t,j}^{z,m,1}(\tilde{y}),\ n_{t,j}^{z,m,2}(\tilde{y}),\ \tilde{h}_{t,j}^{o;f,z}(\tilde{y}),\ \tilde{h}_{t,j}^{r;f,z}(\tilde{y}),\ \tilde{a}_{t,j}^{f,z}(\tilde{y});\ \tilde{y}_{t+1,j+1}^{f,z}(\tilde{y})\}$*, a set of firm values* $\{\tilde{V}_t^c(\tilde{K}_t^c), \tilde{V}_t^n(\tilde{K}_t^n)\}$*, a collection of firm decision rules*
$\{\tilde{N}_t^c(\tilde{K}_t^c), \tilde{N}_t^n(\tilde{K}_t^n); \tilde{K}_{t+1}^c(\tilde{K}_t^c), \tilde{K}_{t+1}^n(\tilde{K}_t^n)\}$*, prices* $\{\tilde{w}_t, p_t^r, R_t^c, R_t^n, i_t, \rho_t, r_t^p\}$*, aggregates*
$\{\tilde{N}_t, \tilde{H}_t^o, \tilde{H}_t^r, \tilde{D}_t, \tilde{C}_t, \tilde{Inc}_t, \tilde{K}_t, \tilde{G}_t, \tilde{B}_t, \tilde{B}_t^g\}$*, and the set of tax instruments and transfers* $\mathbb{T}$ *associated with given tax system such that:*

1. *Household' decision rules are solutions to their constrained optimization problem.*

2. *Macroeconomic aggregates are consistent with household behavior such that:*

$$\tilde{N}_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} \tilde{\Omega}^{z,s}_{t,j} z^{z,s}_j n^{z,s}_{t,j}(\tilde{y}) + \tilde{\Omega}^{z,m}_{t,j} z^{z,m}_j \left(n^{z,1}_{t,j}(\tilde{y}) + n^{z,2}_{t,j}(\tilde{y}) \right) \; dj \; dz$$

$$\tilde{H}^o_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \tilde{\Omega}^{f,z}_{t,j} \tilde{h}^{o;f,z}_{t,j}(\tilde{y}) \; dj \; dz$$

$$\tilde{H}^r_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \tilde{\Omega}^{f,z}_{t,j} \tilde{h}^{r;f,z}_{t,j}(\tilde{y}) \; dj \; dz$$

$$\tilde{D}_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \tilde{\Omega}^{f,z}_{t,j} \tilde{a}^{f,z}_{t,j}(\tilde{y}) \; dj \; dz$$

$$\tilde{C}_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \tilde{\Omega}^{f,z}_{t,j} \left((\tilde{c}^{M;f,z}_{t,j}(\tilde{y}) + \tilde{c}^{g;f,z}_{t,j}(\tilde{y}) + \tilde{\kappa}^{f,z}_{t,j} \right) \; dj \; dz + \tilde{c}^E_t$$

3. *Firms' decision rules are solutions to their constrained optimization problem.*

4. *Macroeconomic aggregates are consistent with firm behavior such that:*

$$\tilde{N}_t = \sum_{q=c,n} \tilde{N}^q_t(\tilde{K}_t^{\,q})$$

$$\tilde{K}_{t+1} = \sum_{q=c,n} \tilde{K}^q_{t+1}(\tilde{K}_t^{\,q})$$

$$\tilde{B}_t = \sum_{q=c,n} \varkappa^{b,q} \tilde{K}_t^{\,q}$$

5. *Perfectly competitive labor markets clear so that the marginal product of effective labor is equalized across sectors:*

$$\tilde{w}_t = (1-\alpha-g)\tilde{G}^g_t(\tilde{K}^c_t)^{\alpha}(\tilde{N}^c_t)^{-\alpha-g} = (1-\alpha-g)\tilde{G}^g_t(\tilde{K}^n_t)^{\alpha}(\tilde{N}^n_t)^{-\alpha-g}$$

6. *The asset market clears such that:*

$$\tilde{D}_t = \tilde{V}^c_t + \tilde{V}^n_t + \tilde{B}^c_t + \tilde{B}^n_t + \tilde{B}^g_t + H^r_t$$

where assets are priced to eliminate any arbitrage opportunities:

$$R^c_t - \tau^{cw}_t = R^n_t - \tau^{ncw}_t = (1-\tau^i_t)i_t - \tau^{bw}_t = (1-\tau^r_t)(p^r_t - \delta^r) - \tau^{rw}_t$$

and the financial intermediary is willing to accept 'safe-asset' pricing of federal government bonds so that:

$$\rho_t = \varpi i_t + \varsigma \exp\left(\frac{\tilde{B}^g_t}{\tilde{Y}_t} \right)$$

Furthermore, the rate of return paid to households on deposits is determined by application of a zero profit condition so that:

$$r_t^p = \tilde{D}_t^{-1} \tilde{Inc}_t$$

7. *The goods market clears such that:*

$$\sum_{q=c,n} Z^q (G_t)^g (K_t^q)^\alpha (A_t N_t^q)^{1-\alpha-g} = \tilde{C}_t + \tilde{I}_t + \tilde{\mathcal{G}}_t$$

where private aggregate investment is defined as:

$$\tilde{I}_t \equiv \tilde{I}_t^c + \tilde{I}_t^n + \tilde{I}_t^o + \tilde{I}_t^r + \tilde{\Phi}_t^H$$

with:

$$\begin{aligned}
\tilde{I}_t^c &= \tilde{K}_{t+1}^c (\Upsilon_P \Upsilon_A) - (1-\delta^K)\tilde{K}_t^c + \Xi_t^c \\
\tilde{I}_t^n &= \tilde{K}_{t+1}^n (\Upsilon_P \Upsilon_A) - (1-\delta^K)\tilde{K}_t^n + \Xi_t^n \\
\tilde{I}_t^o &= \tilde{H}_{t+1}^o (\Upsilon_P \Upsilon_A) - (1-\delta^o)\tilde{H}_t^o \\
\tilde{I}_t^r &= \tilde{H}_{t+1}^r (\Upsilon_P \Upsilon_A) - (1-\delta^r)\tilde{H}_t^r \\
\tilde{\Phi}_t^H &= \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \tilde{\Omega}_{t,j}^{f,z} \phi\left(\tilde{h}_{t+1,j+1}^{o;f,z}(\tilde{y}) + \tilde{h}_{t+1,j+1}^{r;f,z}(\tilde{y})\right) \, dj \; dz
\end{aligned}$$

and where aggregate government expenditures is defined as:

$$\tilde{\mathcal{G}}_t \equiv \tilde{C}_t^{fed} + \tilde{C}_t^{sl} + \tilde{I}_t^{fed} + \tilde{I}_t^{sl}$$

with:

$$\begin{aligned}
\tilde{I}_t^{fed} &= \tilde{G}_{t+1}^{fed} (\Upsilon_P \Upsilon_A) - (1-\delta^g)\tilde{G}_t^{sl} \\
\tilde{I}_t^{sl} &= \tilde{G}_{t+1}^{sl} (\Upsilon_P \Upsilon_A) - (1-\delta^g)\tilde{G}_t^{sl}
\end{aligned}$$

8. *The federal government's debt follows the law of motion:*

$$\tilde{B}_{t+1}^g (\Upsilon_P \Upsilon_A) = \tilde{C}_t^{fed} + \tilde{I}_t^{fed} + \tilde{TR}_t^{fed} - (\tilde{txl}_t^{hh} + \tilde{txl}_t^c + \tilde{txl}_t^{beq}) + (1+\rho_t)\tilde{B}_t^g$$

and maintains a fiscally sustainable path so that:

$$\lim_{k\to\infty} \frac{\tilde{B}_{t+k}^g}{\prod_{s=0}^{k-1}(1+\rho_{t+s})} = 0$$

where federal tax receipts from households, firms, and bequests are:

$$\tilde{txl}_t^{hh} = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \left(\tilde{\mathcal{T}}_{t,j}^{f,z} + \tilde{trs}_{t,j}^{f,z} - \tilde{slt}_{t,j}^{f,z}\right) \tilde{\Omega}_{t,j}^{f,z} \, dj \; dz$$

$$\tilde{txl}_t^c = \tau_t^c \left(\tilde{Y}_t^c - \tilde{w}_t \tilde{N}_t^c - \tilde{ded}_t^c\right) - \tilde{crd}_t^c$$

$$\tilde{txl}_t^{beq} = \tau_t^{beq}(\Upsilon_A) \int_{\mathbb{Z}} \int_{\mathbb{J}} (1-\pi_j) \sum_{f=s,m} \tilde{\Omega}_{t,j}^{f,z} \tilde{y}_{t+1,j+1} \; dj \; dz$$

and transfers are:

$$\tilde{TR}_t^{fed} = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \left(\tilde{ss}_{t,j}^{f,z} + \tilde{trs}_{t,j}^{f,z} \right) \tilde{\Omega}_{t,j}^{f,z} \; dj \; dz$$

9. *The state and local composite government maintains a balanced budget:*

$$\tilde{slt}_t^{hh} + \tilde{slt}_t^{c} = \tilde{C}_t^{sl} + \tilde{I}_t^{sl}$$

where net state and local tax receipts from households and corporations are:

$$\tilde{slt}_t^{hh} = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \left(\tau_t^{sl} \hat{i}_{t,j}^{f,z} + \tau_t^{slp} h_{t,j}^{o} \right) \Omega_{t,j}^{f,z} \; dj \; dz$$

$$\tilde{slt}_t^{c} = \tau_t^{slc} \left(\tilde{Y}_t^c - \tilde{w}_t \tilde{N}_t^c - i_t \tilde{B}_t^c \right)$$

10. *The measure of households is time-invariant:*

$$\tilde{\Omega}_{t+1,j}^{f,z} = \tilde{\Omega}_{t,j}^{f,z}$$

11. *The net worth of households that die before reaching the maximum age J is allocated to end-of-life consumption expenditures, estate taxes, and bequests such that:*

$$\tilde{c}_t^E + \tilde{txl}_t^{beq} + \tilde{\tilde{\Gamma}} = (\Upsilon_A) \int_{\mathbb{Z}} \int_{\mathbb{J}} (1-\pi_j) \sum_{f=s,m} \tilde{\Omega}_{t,j}^{f,z} \tilde{y}_{t+1,j+1} \; dj \; dz$$

Definition 2. *A* ***steady-state perfect-foresight trend-stationary recursive equilibrium*** *is a perfect-foresight stationary recursive equilibrium, where every growth-adjusted aggregate variable is time invariant.*