Appendices: Quantitative Analysis of a Wealth Tax for the United States: Exclusions and Expenditures

A Nested Consumption Detail in Households' Problem

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. So that we can incorporate consumption of tax-preferred goods within our framework, the composite good is an endogenous consumption bundle of market goods, housing services, home-produced goods, childcare expenses and charitable giving. In this section, we describe how each sub-component is nested in x_j, and how a numerical solution to the household's problem is obtained.

Nested directly within x_j in a CES fashion are non-housing consumption c_j and housing service consumption hs_j. Consumption is reduced by a monetary cost of working, which we represent by child-care expenses, $\frac{\kappa_j^{f,z}(n_j^f)}{p_t^x}$:

$$x_j \equiv \left(\sigma c_j^{\eta} + (1-\sigma) hs_j^{\eta}\right)^{1/\eta} - \frac{\kappa_j^{f,z}(n_j^f)}{p_t^x} \tag{A.1}$$

For housing service consumption, we assume that a unit of owner-occupied housing h_j^o and rental housing h_j^r provide equivalent durable housing services from which utility is derived. Further, since we restrict a household's residential status to a binary choice of renting or owning, preferences take the form:

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

For non-housing consumption, we assume c_j 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 $c_j^{f,H}$:

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

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

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 for home-produced consumption services is thus limited by time use.[1]

With the above consumption detail, we can express a given household's budget constraint at the disaggregated level as follows:

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

[1] 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.

where market consumption and charitable giving are in terms of the numéraire, and p_t^r is the relative price of rental housing. The above budget constraint (A.5) is equivalent to budget constraint (2.6) when the nested choice variables $\{c_j^M, c_j^g, h_j^o, h_j^r\}$ are evaluated are their optimal levels.

We approach the solution to this problem as follows: First, we employ a change of variables to reduce the state space from (a_j, h_j^o) to (y_j). Using the definition of net worth, $y_j \equiv a_j + h_j^o$, budget constraint (A.5) can be expressed as:

$$c_j^M + c_j^g + p_t^r h_j^r + (r_t^p + \delta^o) h_j^o + y_{j+1} = (1 + r_t^p) y_j + i_{t,j}^{f,z} + inh_{t,j}^{f,z} - \mathcal{T}_{t,j}^{f,z} - \kappa_j^{f,z}(n_j) - \xi_j^H \quad \text{(A.6)}$$

Next, we discretize the state-space over current and future net worth so that analytical solutions for each choice variable can be expressed in terms of some combination of (y_j, y_{j+1}), discrete labor nodes $n_j \in \mathbb{N}$, and the binary residential status. Maximizing the objective functions (A.1) and (A.3) subject to (A.2), (A.4), and (A.6), yields the following analytical interior solutions for $\{c_j^{M*}, c_j^{g*}, h_j^{o*}\}$ when $hs_j = h_j^o$ and $\{c_j^{M*}, c_j^{g*}, h_j^{r*}\}$ when $hs_j = h_j^r$:

$$c_j^{M*} = \left(\left(\vartheta_{t,j}^{f,z} \right)^{(\theta^{f,z}-1)} \varphi_{t,j}^{f,z} \Phi_{t,j}^{f,z} \right) x_j - c_j^{f,H} \tag{A.7}$$

$$c_j^{g*} = \left(\left(\vartheta_{t,j}^{f,z} \right)^{\theta^{f,z}} \varphi_{t,j}^{f,z} \Phi_{t,j}^{f,z} \right) x_j \tag{A.8}$$

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

$$h_j^{r*} = \left(\Phi_{t,j}^{f,z} \right) x_j \qquad \text{if} \;\; hs_j = h_j^r, \;\; h_j^o = 0 \tag{A.10}$$

where:

$$p_t^x = \begin{cases} \Phi_{t,j}^{f,z} \left(\varphi_{t,j}^{f,z} \left((\vartheta_{t,j}^{f,z})^{(\theta^{f,z}-1)} + (\vartheta_{t,j}^{f,z})^{(\theta^{f,z})} \right) + r_t^p + \delta^o \right) - (c_j^{f,H}/x_j) & \text{if} \;\; hs_j = h_j^o, \;\; h_j^r = 0 \\ \Phi_{t,j}^{f,z} \left(\varphi_{t,j}^{f,z} \left((\vartheta_{t,j}^{f,z})^{(\theta^{f,z}-1)} + (\vartheta_{t,j}^{f,z})^{(\theta^{f,z})} \right) + p_t^r \right) - (c_j^{f,H}/x_j) & \text{if} \;\; hs_j = h_j^r, \;\; h_j^o = 0 \end{cases} \tag{A.11}$$

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

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

$$\vartheta_{t,j}^{f,z} = \left(\frac{1-\theta^{f,z}}{\theta^{f,z}}\right)\left(\frac{1+\partial\mathcal{T}_{t,j}^{f,z}/\partial c_j^M}{1+\partial\mathcal{T}_{t,j}^{f,z}/\partial c_j^g}\right) \tag{A.14}$$

Note that this nesting structure does not impose additional restrictions on the household's problem described in Section 2.1, as the original budget constraint (2.6) can be recovered by substituting the optimal choices (A.7)-(A.10) and the expression (A.11) for the implicit price p_t^x into the dissaggregated budget constraint (A.5).

The optimal sequence of choices for a given household of demographic (f, z), which is the solution to the household problem described in Section 2.1 with the nesting structure described in this section, is obtained by backwards induction. Iterating backwards from the terminal age J, candidates for interior solutions of all endogenous variables across each set of adjacent periods $(j, j+1)$ are obtained using the modified endogenous grid method of Iskhakov et al. (2017) over the reduced state space (y_j, y_{j+1}), and for all possible combinations of $n_j \in \mathbb{N}$ and the binary residential status. Candidates for corner solutions are obtained using brute force over the same dimensions. The set of optimal choices, which maximize value function $V_{t,j}^{f,z}(y_j)$, are obtained from the candidate solutions at each grid point over a common current net worth grid.

B Calibration

In this section, we describe our calibration strategy for non-tax parameters in the initial steady state baseline. Select exogenous parameter values and target moments 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 $J = 76$ (actual age 100). 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 65), 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 model ages 41 through 75 are computed from the Social Security Administration's *2013 Actuarial Life Table* as a weighted average of males and females aged 65 through 99.

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 $\Omega_{t,j}^f$ 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 Joint Committee on Taxation's Individual Tax Model (JCT-ITM)[2]. Letting $\Omega_{t,j}^z$ be the

[2] See Joint Committee on Taxation (2015) for more detail.

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 Preferences For Nested Consumption Detail

As described in Appendix A, the consumption composite good x_j nests housing services consumption hs_j and non-housing consumption c_j in a CES fashion:

$$\left(\sigma c_j^{\eta} + (1-\sigma) hs_j^{\eta}\right)^{1/\eta}$$

We exogenously set $\eta = -1.0534$ to imply 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 non-residential capital to total private capital (including durables) of 0.483 as calculated from the NIPA for 2016. Non-housing consumption is itself a Cobb-Douglas composite of charitable giving, c^g_j, and self-consumption, c^i_j (the sum of market-produced consumption c^M_j and home-produced consumption services $c^{f,H}_j$):

$$c_j \equiv (c^i_j)^{\theta^{f,z}} (c^g_j)^{(1-\theta^{f,z})}$$

We calibrate the share parameter for the non-housing consumption composite, $\theta^{f,z}$, by making use of the optimality condition for the consumption ratio c^g_j/c^i_j:

$$\frac{c^g_j}{c^i_j} = \left(\frac{1-\theta^{z,f}}{\theta^{z,f}}\right)$$

which holds under the assumption that the marginal tax rates on consumption is zero. Let $\left(\sum_{j=1}^{R-1} c_j^{\bar{g;f,z}} / \sum_{j=1}^{R-1} \bar{i}_j^{f,z}\right)$ denote an exogenous average charitable giving to labor income ratio in 2017 for working-age households computed using the JCT-ITM. Re-arranging the above optimality condition for $\theta^{f,z}$ and averaging over ages $j = 1, .., R$ yields:

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

where the target ratio is substituted in place of the model-produced ratio. Internally calibrating the share parameter in this fashion allows the model to reproduce the target charitable giving to labor income ratio, and an implied non-charitable consumption to labor income ratio.

B.1.3 Labor Characteristics

We define economic labor income in the model to be a NIPA-comparable wage income concept plus self-employment income.[3] 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 JCT-ITM to distribute the cross-sectional labor income of non-dependent tax filers with age of primary between 25-64.[4] Each for non-joint and

[3] 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.

[4] The BEA does not report distributional characteristics of NIPA wage income the same income classes levels used in our model.

joint tax filers, the $nz = 8$ productivity types represent the following percentile classes: $\{0-20; 21-40; 41-60; 61-80; 81-90; 91-99; 99-99.9; 99.9-100\}$.

Labor productivity for each (z, f, j) demographic, $\mathrm{z}_j^{z,f}$, is the product of a demographic-independent age-varying component, z_j, and a demographic-dependent 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, $\bar{i}^{f,z}$, computed for their respective percentile class from the JCT-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.[5]

The individual labor supply choice set has three discrete employment options — unemployment, part-time, and full-time — with each option corresponding inversely to time spent on home production. Using the 2017 American Time Use Survey from the US 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, $\kappa_j^{z,f}$, are included in our model because they may qualify a household for a federal tax credit. We specify that they depend on a household's number of dependents under age 6, $dep_j^{f,z}$, and the market work hours of the single or married secondary adult so that:

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

where $cc^{z,f}$ is a scale parameter. 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 JCT-ITM for 2017 when labor supply is evaluated as the employment targets in Table 2.

To impute the quantity of home-produced consumption services generated by a given amount of home-production labor hours, we follow (Bridgman, 2016) and assume a consumption value equal to the wages that would be paid to a low-income worker for those hours. In terms of our model, we specify:

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

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

[5] While the Medical Expenditures Panel Survey may seem like an odd choice, it is a large-scale survey that contains direct responses for hourly earnings of both individuals in a married couple.

B.1.4 Estates

The estate of a household who dies at the end of age j is assumed to be apportioned among exogenous and age-varying end-of-life expenditures, c_j^E, estate tax liabilities, $\mathcal{T}_t^{\boldsymbol{est}}(y_{j+1})$,[6] and bequests, beq_j, to descendants prior to the start of the next period. For a decedent household, this can be expressed as:

$$c_j^E + \mathcal{T}_t^{\boldsymbol{est}}(y_{j+1}) + beq_j = y_{j+1} \tag{B.2}$$

End-of-life expenditures in the period of death are assumed to consist of two components — health expenditures and charitable giving —both of which are modeled in a reduced-form fashion. For end-of-life health expenditures, we make use of the age - permanent income profiles for out-of-pocket medical expenditures in the year of death estimated by De Nardi et al. (2021).[7] We double these year-of-death figures to better capture the decummulation of wealth that occurs due to out-of-pocket medical expenditures near the end of life.[8] For end-of-life charitable giving, we assume that the size of gifts made to agents outside of the model are a piecewise linear function of estate size. This function is exogenously calibrated to SOI data for 2001 as a mapping from gross estate size in millions of 2018 dollars to charitable contributions as a share of gross estate:

$$\{1.139, 2.380, 5.100, 10.200, 20.401\} \rightarrow \{0.025, 0.047, 0.059, 0.078, 0.100\}$$

The residual amount of a decedent's estate after estate-tax liabilities (if any) is left to working-age households as bequests. Bequests are assumed to consist of two components: endowments to households in their first year of life $j = 1$ and inheritances to working-age households. Endowments are distributed in an exogenous, time-invariant fashion to target the distribution of wealth for young households as detailed in Appendix B.1.5. Inheritances are distributed to working-age households of a given productivity group based on the quantity of bequests made available by decedents *within* that same productivity group so to mimic the concentrated nature of inheritances. The total quantity of bequests available to be distributed across a given productivity z is computed as:

$$beq_t^z = \int_{\mathbb{J}} (1 - \pi_j) \sum_{f=s,m} \left(y_{t,j+1} - c_j^E - \mathcal{T}_t^{\boldsymbol{est}}(y_{j+1}) \right) \Omega_{t,j}^{f,z} \, dj - \bar{a}_1^{f,z} \Omega_{t,1}^{f,z}$$

where $\bar{a}_1^{f,z}$ is the initial wealth endowment for demographic (f, z). Because we do not explicitly model intergenerational linkages across households, we specify family composition and age variation for inheritances $inh_{t,j}^{f,z}$ in a reduced-form fashion. First, we assume that bequests are distributed based on a square root equivalence scale[9] in the number of adults within each working-age household, which implies that married households receive average inheritances that are $\sqrt{2}$ times as large as those received by single households. Second, the aggregate amount of inheritances for each (f, z) demographic group is then

[6] The specification of estate tax liabilities is discussed in Section 3.2.1.

[7] Figure 6a of De Nardi et al. (2021) shows mean out-of-pocket medical expenditures age - permanent income profiles for single households. An alternate specification of these profiles for *year-of-death* expenditures of single households were obtained from the authors via private correspondence. Because both adult members of married households in our model die contemporaneously, their profiles obtained from doubling the expenditures of the single households at each each and permanent income group.

[8] Jones et al. (2021) show that for the final six years of life, nearly all out-of-pocket medical expenditures occur in the final two years.

[9] This specification reflects the OECD equivalence scale.

apportioned across working ages based on the lifecycle profile for inheritance receipts estimated by Penn-Wharton Budget Model (2021).[10] Formally:

$$inh_{t,j}^{f,z} = \begin{cases} beqshr_j \left(\frac{beq_t^z}{1+\sqrt{2}} \right) \left(\frac{1}{\int_J \pi_j beqshr_j \Omega_{t,j}^{s,z} \ dj} \right) & \text{if } f = s \\ beqshr_j \left(\frac{beq_t^z \sqrt{2}}{1+\sqrt{2}} \right) \left(\frac{1}{\int_J \pi_j beqshr_j \Omega_{t,j}^{m,z} \ dj} \right) & \text{if } f = m \end{cases}$$

for ages 1 through R, and $inh_{t,j}^{f,z} = 0$ for ages $R+1$ through J.

B.1.5 Endowments

Households enter the economy at age $j = 1$ with endowments of initial financial assets $\bar{a}_1^e$, 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[11] 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*.[12] 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 $ne = 10$ pseudorandom numbers from a normal distribution with the associated mean and standard deviations for each class-status combination. These draws are then transformed to follow an inverse hyperbolic sine distribution.

[10] Penn-Wharton Budget Model (2021) estimates the probability of receiving an inheritance by age and income group (Table 3). We marginalize their income dimension and normalize the probabilities to unity to construct a piecewise linear lifecycle profile for working-age households in our model.

[11] The financial component of net worth is 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 misc. loans).

[12] 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.

B.1.6 Borrowing Constraints

Both homeowners and renters can borrow and accumulate debt in excess of assets subject to the borrowing constraint in Equation (2.8). While homeowners can use their property as collateral so long as they maintain their minimum housing equity share of γ, renters cannot have negative net worth in excess of $\underline{y}^{f,z}$. We link this lower-bound of the wealth support 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 Government

B.2.1 Adjustments to Economic Income

To account for differences between a household's economic income and adjusted gross income (Ledbetter, 2007), we use time- and policy-invariant 'calibration ratios' to adjust each particular flow of economic income to its appropriate tax base.[13] For labor income, we specify a calibration ratio $\chi_j^{\boldsymbol{i};f,z}$ that depends on a household's family composition, productivity type, and age group (working or retired). A household's adjusted gross labor income $\hat{i}_{t,j}^{f,z}$ is then:

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

where the tilde accent is used to denote a variable that has been adjusted by a calibration ratio. For capital income, we specify a calibration ratio $\chi_j^{\boldsymbol{a};f}$ that similarly depends on family composition and age group, but is independent of productivity type because of imperfect correlation between household labor and capital income. Instead, we assume that a household's capital income calibration ratio depends on their relative location in the conditional financial wealth distribution $\boldsymbol{f}(a|f, j)$ so that:

$$\chi_j^{\boldsymbol{a};f} = \boldsymbol{\chi}^{\boldsymbol{a}}(\boldsymbol{f}(a|f, j))$$

A household's adjusted gross capital income is then:

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

The labor income calibration ratio is exogenously computed as the portion of total economic labor income[14] included in AGI for each (f, z, j) demographic group using the JCT-ITM. The capital income calibration ratio is assumed to be piecewise-linear over financial wealth, and internally calibrated so that within each (f, j) demographic group the average amount of capital income included in AGI for each $\{0 - 20;\ 21 - 40;\ 41 - 60;\ 61 - 80;\ 81 - 90;\ 91 - 99;\ 99 - 99.9;\ 99.9 - 100\}$ percentile class of capital income in the model matches those values estimated by the JCT-ITM for calendar year 2017. The close fit of our model's adjusted gross labor income and adjusted gross capital income to the data is shown in Tables 3 and 4.

[13] A calibration ratio represents the portion of that income source included in adjusted gross income.

[14] See Section B.1.3 for a definition of economic labor income

While ordinary capital income is taxed jointly with labor income as a single base, preferential capital income is taxed separately at lower rates.[15] We decompose adjusted gross capital income to account for this differential taxation as follows: Let $s^{\boldsymbol{o}}_{t,k}$ denote the endogenous share of a household's ordinary capital income of type k at time t, which is uniform across households because the portfolio composition of financial assets are homogeneous within the model.[16] A household's ordinary and preferential capital income can be expressed as:

$$r^p_t \hat{a}^{\boldsymbol{o},f,z}_{t,j} \equiv r^p_t \left(\sum_k \chi^{\boldsymbol{o}}_k s^{\boldsymbol{o}}_{t,k} \right) \hat{a}^{f,z}_{t,j}$$

$$r^p_t \hat{a}^{\boldsymbol{p},f,z}_{t,j} \equiv r^p_t \left(\sum_k \chi^{\boldsymbol{p}}_k (1 - s^{\boldsymbol{o}}_{t,k}) \right) \hat{a}^{f,z}_{t,j}$$

where the time- and policy-invariant calibration ratios $\chi^{\boldsymbol{o}}_k$ and $\chi^{\boldsymbol{p}}_k$ are internally calibrated in the initial steady state to match the aggregate tax revenue to output ratio for each ordinary and preferential capital income type k as computed using the JCT-ITM. Table 5 shows the model fit for ordinary and preferential capital income tax liabilities.

B.2.2 Federal Transfer Payments

A household's 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 federal tax credits) less federal excise and miscellaneous taxes.

B.2.3 State-local Taxes

Households: A household's state-local tax liabilities are assumed to depend linearly each on their adjusted gross wage income, owner-occupied housing property, and market consumption:

$$slt^{f,z}_{t,j} \equiv \tau^{sli} \hat{i}^{f,z}_{t,j} + \tau^{slp} h^o_j + \tau^{slx} c^M_j$$

The linear state-local tax income rate τ^{sli}, property tax rate τ^{slp}, and sales tax rate τ^{slx} are each calibrated internally so that total tax revenues from each source are equal to 2.08%, 2.95%, and 2.03% of GDP as estimated by the Census Bureau for 2017.

Corporations: Tax liabilities owed by corporations at the state-local level are assumed to be proportional to aggregate corporate earnings:

$$slt^c_t = \tau^{slc} ern^c_t$$

[15] Ordinary capital income includes noncorporate business income, interest income, short-term capital gains, and nonqualified dividends. Preferential capital income includes long-term capital gains and qualified dividends. In 2017, approximately 58.6% capital income included in AGI was considered preferential income. In 2017, there were seven tax brackets on the ordinary income statutory tax schedule - with rates of 10, 15, 25, 28, 33, 35, and 39.6 percent - and three brackets on the preferential income schedule - with rates of 0, 15, and 20 percent. In both cases, the applicable rates depend on income ranges that vary with filing status.

[16] The variable $s^{\boldsymbol{o}}_{t,k}$ is endogenous and time-variant because it depends on the portfolio allocation chosen by the financial intermediary in each period.

The linear state-local tax rate on corporate income τ^{slc} is internally calibrated so that state-local corporate income tax receipts are about 0.28% of aggregate output as estimated by the Census Bureau for 2017.

B.2.4 Social Security Benefits

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 federal payroll tax 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.[17] Moreover, since we explicitly model married households, we account for 'spousal benefits'.[18]

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.2.5 Public Debt and Interest Rate

The government budget constraint in equation (2.30) represents the consolidated budget constraint of the federal and state-local governments. Imposing the condition that state-local governments do not issue debt, we internally calibrate public debt as a percent of aggregate 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.[19] We then assume that 61.2% of this debt is held by foreign entities outside of the model,[20] and follow Penn-Wharton Budget Model (2016) by setting $\kappa^{dom} = 0.60$ so that 40% of new debt issues are assumed to be purchased by exogenous foreign-entities. Because the initial stock of public debt is assumed to be exogenous, the flow budget constraint (2.30) holds in the initial steady state by allowing consumption expenditures to take on the residual value.

The real rate of interest on public debt as in equation (2.24) is assumed be linear in the real interest rate on private debt and nonlinear in the 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

[17] 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.

[18] '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.

[19] 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.

[20] See the Department of Treasury / Federal Reserve Board report on major foreign holders of treasury securities: https://ticdata.treasury.gov/Publish/mfh.txt.

interest rate, ϖ, internally to target a percent of government net interest payments to output of 2.1%, which is the average projected value for federal net interest payments over 2017-2027 in *The Budget and Economic Outlook: 2017 to 2027*.

B.2.6 Public Capital

The rate of economic depreciation on public capital, δ^G is computed to satisfy the steady state expression for the aggregate public investment to capital ratio (exclusive of the time to build structure of public investment), $\iota^G = (\Upsilon_A \Upsilon_P - 1 + \delta^G)$. Using the average annual investment flows and stocks of public non-residential fixed assets as reported by NIPA for years 2007-2016 yields $\delta^G = 0.0317$.

For purposes of accounting, we internally split the stock of productive public capital between the federal and state-local governments. We include only non-defense, non-residential 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 the state-local government. We follow Congressional Budget Office (2016) and set the time-to-build parameters for federal investment to $S = 20$ and:

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

This timing of productivity effects incorporates physical infrastructure, education, and research and development, the latter two of which take longer to become fully productive. Unless specified otherwise, all public capital is assumed to remain constant as a share of aggregate output in our simulations.

Because one of our simulations in this paper involves an increase in federal government investment, we must account for how state-local governments respond to changes in federal spending on capital. Congressional Budget Office (2021) estimates that increases in federal government investment in public capital are partially offset by decreases in state-local government investment in public capital at a rate of about 15%. To account for this, we assume that any implied change in public capital investment at the federal level increases total public capital by only 85% of the change. Since public consumption takes on the residual value of the consolidated government budget constraint, the remaining 15% shows up as a change to non-valued public consumption.

Table A1: Additional Steady State Aggregate Moments

Ratio	**Data**	**Model**
Private Non-Residential Capital - Total Private Capital (including durables)	0.483	0.439
Private Non-Residential Investment - Output	0.130	0.147
Pubic Investment - Public Capital	0.042	0.055
Pubic Capital - Output	0.639	0.639
Net Federal Debt - Output	0.542	0.542

C Trend-Stationary Equilibrium

We formally define an equilibrium in terms of a trend-stationary transformation of the model. Variables with the tilde accent denote those that have been de-trended for technological and/or population growth. Following Moore and Pecoraro (2020, 2021), 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 $\tilde{y} \equiv \tilde{a} + \tilde{h}^o$.

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.

Corporate and noncorporate 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 $\tilde{B}$, domestically-held public bonds $\tilde{B}^G$, and government 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 $\tilde{\Omega}^{f,z}_{t,j}$, a household value function $V^{f,z}_{t,j}(\tilde{y})$, a collection of household decision rules $\{\tilde{c}^{M;f,z}_{t,j}(\tilde{y})$, $\tilde{c}^{g;f,z}_{t,j}(\tilde{y})$, $n^{z,s}_{t,j}(\tilde{y})$, $n^{z,m,1}_{t,j}(\tilde{y})$, $n^{z,m,2}_{t,j}(\tilde{y})$, $\tilde{h}^{o;f,z}_{t,j}(\tilde{y})$, $\tilde{h}^{r;f,z}_{t,j}(\tilde{y})$, $\tilde{a}^{f,z}_{t,j}(\tilde{y})$; $\tilde{y}^{f,z}_{t+1,j+1}(\tilde{y})\}$, a set of firm values $\{\tilde{V}^c_t(\tilde{K}_t^{\ c}), \tilde{V}^n_t(\tilde{K}^n_t)\}$, a collection of firm decision rules $\{\tilde{N}^c_t(\tilde{K}_t^{\ c}), \tilde{N}^n_t(\tilde{K}_t^{\ n}); \tilde{K}^c_{t+1}(\tilde{K}_t^{\ c}), \tilde{K}^n_{t+1}(\tilde{K}_t^{\ n})\}$, prices $\{\tilde{w}_t, p^r_t, R^c_t, R^n_t, i_t, \rho_t, r^p_t\}$, aggregates $\{\tilde{N}_t, \tilde{H}^o_t, \tilde{H}^r_t, \tilde{D}_t, \tilde{C}_t, \tilde{Inc}_t, \tilde{K}_t, \tilde{G}_t, \tilde{B}_t, \tilde{B}^G_t\}$, 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:*

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

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

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

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

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

3. *Firms' decision rules are solutions to their constrained optimization problem.*
4. *Macroeconomic aggregates are consistent with firm behavior such that:*

$$\tilde{N}_t = \sum_{q=c,n} \tilde{N}_t^q(\tilde{K}_t{}^q)$$
$$\tilde{K}_{t+1} = \sum_{q=c,n} \tilde{K}_{t+1}^q(\tilde{K}_t{}^q)$$
$$\tilde{B}_t = \sum_{q=c,n} B_t^q = \sum_{q=c,n} \varkappa^{b,q}\tilde{K}_t{}^q$$

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

$$\tilde{w}_t = (1-\alpha-g)\tilde{G}_t^g(\tilde{K}_t^c)^\alpha(\tilde{N}_t^c)^{-\alpha-g} = (1-\alpha-g)\tilde{G}_t^g(\tilde{K}_t^n)^\alpha(\tilde{N}_t^n)^{-\alpha-g}$$

6. *The asset market clears such that:*

$$\tilde{D}_t = \tilde{V}_t^c + \tilde{V}_t^n + \tilde{B}_t^c + \tilde{B}_t^n + \tilde{B}_t^G + H_t^r$$

where assets are priced to eliminate any arbitrage opportunities:

$$R_t^c - \tau_t^{cw} = R_t^n - \tau_t^{ncw} = (1-\tau_t^i)i_t - \tau_t^{bw} = (1-\tau_t^r)(p_t^r - \delta^r) - \tau_t^{rw}$$

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

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

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:*

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

where private aggregate investment is defined as:

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

with:

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

where aggregate government expenditures is defined as:

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

with:

$$\tilde{I}_t^G = (1/\kappa_1^{TTB}) \left(\tilde{G}_{t+1}(\Upsilon_P \Upsilon_A) - (1-\delta^g)\tilde{G}_t - \sum_{s=2}^{S} \kappa_s^{TTB} \tilde{I}_{t-s+1}^G (\Upsilon_P \Upsilon_A)^{-s+1} \right)$$

and where the implied trade balance is:

$$\tilde{\mathcal{TB}}_t \equiv (1-\kappa^{dom}) \left(\tilde{B}_t^{G,tot}(1+\rho_t) - \tilde{B}_{t+1}^{G,tot}(\Upsilon_P \Upsilon_A) \right)$$

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

$$\tilde{B}_{t+1}^{G,tot}(\Upsilon_P \Upsilon_A) = \tilde{C}_t^G + \tilde{I}_t^G + \tilde{TR}_t - \tilde{T}_t + (1+\rho_t)\tilde{B}_t^{G,tot}$$

and maintains a fiscally sustainable path so that:

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

where tax receipts are collected from households, estates, and corporations:

$$\tilde{T}_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} \sum_{f=s,m} \left(\mathcal{T}_t^{\boldsymbol{i}}(\tilde{i}_{t,j}^{f,z}, r_t^p \tilde{a}_j, \tilde{h}_j^{\boldsymbol{o}}) + \mathcal{T}_t^{\boldsymbol{w}}(\tilde{h}_j^o, \tilde{a}_j) + (1-\pi_j)\mathcal{T}_t^{\boldsymbol{e}}(\tilde{y}_{j+1}) \right) \Omega_{t,j}^{f,z} \ dj \ dz + \tilde{tx} l_t^c$$

and transfers are:

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

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

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

10. *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:*

$$\tilde{Beq}_t = \int_{\mathbb{Z}} \int_{\mathbb{J}} (1-\pi_j) \sum_{f=s,m} \left(\tilde{y}_{t,j+1}\Upsilon_A - \tilde{c}_j^E - \mathcal{T}_t^{\boldsymbol{est}}(\tilde{y}_{j+1}) \right) \Omega_{t,j}^{f,z} \ dj - \tilde{\tilde{a}}_1^{f,z} \Omega_{t,1}^{f,z} \ dz$$

and the aggregate amount of inheritances received by2 living households is consistent with the aggregate amount of bequests left by decedent households:

$$\int_{\mathbb{Z}} \int_{\mathbb{J}} \tilde{inh}_{t,j}^{f,z} \tilde{\Omega}_{t,j}^{f,z} \ dj \ dz = \tilde{Beq}_t$$

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.*

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