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A Tale of Two Bases: Progressive Taxation of Capital and Labor Income

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Abstract

Macroeconomic models routinely abstract simultaneously from two features of the US federal tax code: the joint taxation of ordinary capital and labor income and the special taxation of preferential capital income. In this article, we argue that this abstraction omits a "portfolio-effect" mechanism where endogenous changes to the ordinary-preferential composition of households' capital income influence individuals' optimal labor and saving decisions through its impact on their effective marginal tax rates. We demonstrate the quantitative importance of this tax detail by simulating provisions from the recently enacted "Tax Cuts and Jobs Act" using a heterogeneous-agent overlapping generations framework calibrated to the US economy. Our findings imply that accounting for the detailed taxation of labor and capital income should be considered an important modeling feature for tax policy analysis.

Keywords

dynamic scoring, progressive income taxation, modeling tax reform, heterogeneous agents, tax calculator

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Quantitative heterogeneous-agent general equilibrium models have become common tools for tax policy analysis. Despite the rich economic environment in these models, it is routine to specify a progressive tax system for household income that treats all capital and labor income as a single base or as two distinct bases. This is an abstraction; the US federal government taxes labor income jointly with *ordinary* capital income as a single base at ordinary rates,[1] while *preferential* capital income is taxed as a separate base at special lower rates.[2] Since in 2017 approximately 58.6 percent of nonwage income reported by taxpayers was preferential income,[3] the abstraction is not necessarily innocuous. This begs the question: Does the differential in applicable tax rates have implications for household behavior that matter at the aggregate level? Changes to the ordinary-preferential capital income composition of a household's asset portfolio affect the size of their ordinary income tax base, and under a progressive tax schedule, could result in a change to the effective marginal tax rate (EMTR) applied to their ordinary capital and labor income. By altering after-tax returns, this "portfolio effect" feeds into households' labor and savings decision-making processes.

This article demonstrates the quantitative importance of accounting for this tax detail using a large-scale overlapping generations (OLG) model with a two-entity production sector for distinct corporate and noncorporate firms. This feature allows for an endogenous composition of household portfolios which can change in response to changes in the pattern of investment across sectors. Crucially, capital income from these portfolios can be decomposed into corporate dividends, noncorporate distributions, interest, and capital gains. So that we can explicitly model the taxation of household capital and labor income as specified in the US Internal Revenue Code (IRC) and capture the tax detail underlying the portfolio effect, we expand upon the internal calculator framework introduced in Moore and Pecoraro (2020b). This novel feature allows for us to compute the portion of this income that is treated as ordinary capital income and combine it with labor income to obtain the ordinary income base, with the residual flow of portfolio income determining the preferential income base. Each base is subsequently taxed according to their respective statutory rate schedules while taking into account other underlying major tax provisions so that households' EMTRs are endogenous. Descriptions of the model structure and the calibration of tax variables appear in "Model" and "Calibration".

Existing approaches to modeling progressive household income taxation in the United States have generally taken one of the two forms. The first approach, which ignores the distinction between ordinary and preferential capital income, is to simply add all capital income to labor income and tax both as a single base according to a smooth or piecewise function (Altig and Carlstrom 1999; Ventura 1999; Daz-Giménez and Pijoan-Mas 2006; Conesa, Kitao, and Krueger 2009; Kitao 2010; Guner, Kaygusuz, and Ventura 2011; Nishiyama 2015; Lopez-Daneri 2016; Daz-Giménez and Pijoan-Mas 2019; Raei 2020a). The second approach, which acknowledges that the tax treatment of capital and labor income differ, is to maintain independent bases for all capital and labor income by taxing only labor income according to a smooth or piecewise function and taxing capital income at a flat rate(s) (Altig et al. 2001; Conesa, Kitao, and Krueger 2009; Krueger and Ludwig 2013; Zodrow and Diamond 2013; Krueger and Ludwig 2016; Guvenen et al. 2019; Holter, Krueger, and Stepanchuk 2019; Kindermann and Krueger 2020). In a similar vein to the latter approach, Gourio and Miao (2011) treat labor and interest income as a single tax base, while using flat tax rates on other capital income types, and DeBacker, Evans, and Phillips (2019) use separate tax functions for capital and labor income that condition on the size of the other respective tax base. Despite this large literature, we are not aware of any previous work that allows for the joint taxation of ordinary capital and labor income while simultaneously accounting for the special tax treatment of preferential capital income,[4] leaving the "portfolio-effect" mechanism we describe in this article unexplored.

We begin our analysis in "The Portfolio-Effect: An Illustrative Example" by illustrating the portfolio-effect mechanism in terms of a partial equilibrium impulse response of households' labor and saving decisions to a one-time capital income recharacterization shock. In "Policy Experiments", we then use our complete OLG model to show the quantitative importance of the portfolio effect in general equilibrium. Using the internal tax calculator (ITC) and the conventional tax specification (CTS) with independent capital and labor income bases each in turn to determine the tax treatment of household income, we simulate transition paths following the implementation of two different subsets of the recently enacted "Tax Cuts and Jobs Act" (TCJA):[5] (i) the corporate tax rate reduction[6] and (ii) the individual tax provisions.[7] We find that policy-induced changes to the ordinary-preferential composition of households' capital income generate quantitatively significant effects on aggregate labor supply and savings behavior from the portfolio effect. On average over the first decade following the corporate rate cut, the increases in aggregate labor supply and the stock of savings are about 6.9 and 1.6 times larger when using the tax calculator because this environment captures the household labor supply and saving incentives that result from a long-run shift toward preferential capital income associated with an expansion of the corporate sector. For the decade following the changes to individual tax provisions, aggregate labor supply and savings increase by an average of about 1.9 and 1.6 times more when using the tax calculator. This results from an immediate and temporary shift toward preferential capital income that occurs due to an increase in equity values, which gives households the incentive to intertemporally shift labor supply forward and increase savings while the relevant EMTRs are lower.

Our findings imply that while the CTS may describe income tax liabilities over the income distribution relatively well for the United States (Guner, Kaygusuz, and Ventura 2014), the simplified specification of household capital income taxation fails to capture the portfolio effect. As this mechanism can generate quantitatively significant behavior that affects the projections of macroeconomic aggregates following a tax reform, accounting for the detailed taxation of labor and capital income should be considered when performing tax policy analysis.

Model

In this section, we describe the large-scale OLG framework used in this article: The basic market structure captures the interaction of households, two representative firms, financial intermediaries, and government. Households make savings, consumption, labor, leisure, and residential decisions. Corporate and noncorporate firms hire labor directly from households and finance their capital investments and productive operations through a combination of debt and equity. Financial intermediaries pool deposits of financial assets from households and allocate their portfolio across business debt and equity, consumer debt, mortgage debt, public debt, and rental housing, passing the return on these investments back to deposit-holding households. Federal, state, and local governments collect taxes from households and firms, using the revenue to make consumption expenditures, public capital investment, and transfer payments. With the exception of mortality risk, all agents have perfect foresight. Population and technological growth in the model economy is assumed to be exogenous, so that the model exhibits a balanced growth path in trend-stationary form.

We build upon the household sector and ITC framework developed in Moore and Pecoraro (2020b), which was used to study the effects of nonconvexities and conditional dependence of tax provisions present in IRC provisions applicable to labor income.[8] The model developed in this article has two main innovations over the previous work. First, we introduce a two-entity production sector allowing for distinct corporate and noncorporate businesses. Unlike the consolidated business sector used in previous work—where capital income is an implicit composite of business distributions, interest, and capital gains—the two-entity framework allows for the decomposition of capital income. Second, we expand the ITC to allow for the explicit accounting of the special tax treatment of preferential capital income while simultaneously capturing the joint tax treatment of labor and ordinary capital income as specified in the IRC. Together, these two innovations allow us to explore the portfolio-effect mechanism in this article.

In addition to the novel modeling of interaction between ordinary and preferential tax bases, the ITC maintains the explicit modeling of other major provisions in the tax code.[9] This is crucial for our analysis because households' EMTRs on a given source of income often differ from their statutory marginal tax rates because of the phasing-in and -out of underlying provisions.[10] Explicitly modeling the major IRC provisions in the ITC generates the endogenous wedges between statutory and EMTRs. Most importantly, modeling the underlying tax provisions means that we can remain agnostic about how endogenous changes to households' portfolio composition affect their EMTRs.

Firms

Goods production occurs in two perfectly competitive sectors, corporate and noncorporate, which differ in terms of tax treatment and the distribution of profits.[11] 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 produce output at profit maximizing levels. Output produced within each sector is assumed to be an identical numéraire good. As in Gervais (2002), Fernánez-Villaverde and Krueger (2010), and Cho and Francis (2011), the output good can costlessly be transformed by households into a consumption good, owner-occupied housing services, or a liquid financial asset.

Growth in technological efficiency, A_t, is assumed to be labor-augmenting to be consistent with a balanced growth path. It evolves identically within each sector according to $A_{t+1} = \Upsilon_A A_t$, where $\Upsilon_A = (1 + \upsilon_A)$ is the exogenous annual gross rate of technological growth. Production in both sectors is assumed to use constant returns to scale Cobb–Douglas technology, with the following aggregate production function:

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

where $G_t = G_t^{\text{fed}} + G_t^{sl}$ is the sum of beginning-of-period public capital owned by the federal, state, and local governments; K_t^q and N_t^q are the beginning-of-period productive private capital and effective labor employed in each sector $q = c, n$; and Z^q is a scale parameter. We include public capital as a complement to private inputs in an aggregate production function with constant returns to scale. The implied decreasing returns to scale for private factors of production is critical for our analysis, as it allows us to obtain an interior solution with our two entity, single output good framework. Moreover, the presence of a public factor input along with our assumption of perfect financial and labor markets leads to economic rents which are fully captured by firms.

An endogenous share $\Lambda_t^c < 1$ of aggregate effective labor, determined by the equalization of cross-sector marginal products of labor under perfect labor markets, is employed in the corporate sector with the residual share $\Lambda_t^n = 1 - \Lambda_t^c$ employed in the noncorporate sector. Corporate and noncorporate labor inputs are then $N_t^c = \Lambda_t^c N_t$ and $N_t^n = (1 - \Lambda_t^c)N_t$, respectively.

We assume a one-period time-to-build structure for investment in productive private capital, so that the capital used for production in the current period is predetermined by investment decisions from the previous period. Investment decisions that cause deviations from the steady-state rate of capital accumulation generate adjustment costs subject to the convex cost function Ξ_t:

$$K_{t+1}^q = (1 - \delta^K)K_t^q + I_t^q - \Xi_t^q \quad \text{for } q = c, n, \tag{2}$$

$$\Xi_t^q = \frac{\xi^K}{2}\left(\frac{I_t^q}{K_t^q} - \Upsilon_P \Upsilon_A + 1 - \delta^K\right)^2 K_t^q \quad \text{for } q = c, n. \tag{3}$$

Finally, we assume that the debt portion of total resources used to finance investment in each sector is an exogenous, time-invariant ratio of the private capital stock, $\varkappa^{b,q}$:

$$B_t^q = \varkappa^{b,q} K_t^q \quad \text{for } q = c, n, \tag{4}$$

where B_t^q is the beginning-of-period net stock of debt held by the representative firm in sector q.

Corporate sector. The corporate firm finances expenditures with debt (bonds) and equity (stock shares). Profit is remitted back to shareholders through dividends. Gains are realized when the value of corporate shares increase. As in Poterba and Summers (1984) and Hubbard, Kashyap, and Whited

(1995), the after-tax rate of return to the marginal investor-household R_t^c depends on both capital gains gns_t^c and dividend payouts div_t occurring in period t:

$$R_t^c = \frac{(1-\tau_t^g)gns_t^c + (1-\tau_t^d)div_t}{V_t^c}, \tag{5}$$

where τ_t^g is the aggregate accrual-equivalent tax rate on capital gains, τ_t^d is an aggregate tax rate on dividends, and V_t^c is the value of the representative corporate firm. Capital gains are equal to the change in firm value less the value of new share issues, shr_t:

$$gns_t^c = V_{t+1}^c - V_t^c - shr_t. \tag{6}$$

The firm's objective is to choose the time path of private capital K_t^c and hire the quantity of effective labor input N_t^c that maximize the firm's value at time t. Rearranging equation (5) for V_t^c and solving forward gives the firm's objective function below. Letting $\beta_t^c \equiv \frac{1-\tau_t^g}{R_t^c+1-\tau_t^g}$, the corporate firm will maximize:

$$V_t^c(K_t^c) = \max_{N_t^c, K_{t+1}^c} \frac{(1-\tau_t^d)div_t - (1-\tau_t^g)shr_t}{R_t^c + 1 - \tau_t^g} + \beta_t^c V_{t+1}^c(K_{t+1}^c), \tag{7}$$

subject to:

1. a cash flow restriction:

$$ern_t^c + B_{t+1}^c - B_t^c + shr_t = div_t + I_t^c + txl_t^c + slt_t^c, \tag{8}$$

2. the law of motion for capital in equation (2),
3. the debt issues rule in equation (4), and
4. the dividend payout rule in equation (9) defined below.

where the cash flow restriction in equation (8) states that the corporate firm's intraperiod 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, federal tax liabilities txl_t^c, and state and local tax liabilities slt_t^c.

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

$$div_t = \chi^d (ern_t^c - txl_t^c). \tag{9}$$

Corporate earnings are equal to revenue from production, less wage, and net interest expense:

$$ern_t^c = Y_t^c - w_t N_t^c - i_t B_t^c, \tag{10}$$

where i_t is the real interest rate on private bonds. Corporate tax liabilities at the federal level are equal to the federal corporate aggregate EMTR, τ_t^c, times the taxable earnings base (which allows for wage expensing and other deductions), less credits:

$$txl_t^c = \tau_t^c \left(Y_t^c - w_t N_t^c - ded_t^c \right) - crd_t^c, \tag{11}$$

where ded_t^c and crd_t^c are the corporate firm's nonwage tax deductions credits, respectively.

Lastly, corporate tax liabilities at the state and local level are assumed to be proportional to corporate earnings for simplicity:

$$slt_t^c = \tau_t^{\text{slc}} ern_t^c. \tag{12}$$

Noncorporate sector. While the noncorporate firm explicitly issues debt in a similar fashion to the corporate firm, shares are not explicitly sold or bought back. Net distributions dst_t incorporate the portion of earnings that are passed through to investors and taxed at the household level. We therefore specify that from the view of the marginal investor-household, the after-tax rate of return to noncorporate firm equity, R_t^n, depends both on capital gains, gns_t^n, and aggregate pass-through distributions net of tax liabilities $dst_t - txl_t^n$:

$$R_t^n = \frac{(1 - \tau_t^g) gns_t^n + dst_t - txl_t^n}{V_t^n}, \tag{13}$$

where capital gains are the change in the value of the noncorporate firm:

$$gns_t^n = V_{t+1}^n - V_t^n. \tag{14}$$

Similar to the corporate firm, the objective function of the noncorporate firm is derived by solving equation (13) forward. Letting $\beta_t^n \equiv \frac{(1-\tau_t^g)}{R_t^n + 1 - \tau_t^g}$, the objective of the noncorporate firm is to choose labor and private capital inputs to maximize:

$$V_t^n(K_t^n) = \max_{N_t^n, K_{t+1}^n} \left(\frac{dst_t - txl_t^n}{R_t^n + 1 - \tau_t^g} \right) + \beta_t^n V_{t+1}^n(K_{t+1}^n), \tag{15}$$

subject to:

1. the cash flow restriction

$$ern_t^n + B_{t+1}^n - B_t^n = dst_t + I_t^n, \tag{16}$$

2. the law of motion for capital in equation (2), and
3. the debt issues rule in equation (4).

As with the corporate firm, earnings are equal to revenue less wages and interest payments on outstanding debt:

$$ern_t^n = Y_t^n - w_t N_t^n - i_t B_t^n. \tag{17}$$

The aggregate tax liability for noncorporate income txl_t^n is equal to the noncorporate aggregate EMTR, τ_t^n, times the taxable earnings base (which allows for wage expensing and other deductions), less credits:

$$txl_t^n = \tau_t^n \left(Y_t^n - w_t N_t^n - ded_t^n \right) - crd_t^n. \tag{18}$$

Unlike the corporate firm, the noncorporate firm is not liable for taxes at the business-entity level and txl_t^n therefore does not enter the government's budget constraint directly. Rather, noncorporate distributions are passed through to the household level where they are taxed jointly with households' other income and remitted by the government. A description of our method for incorporating these tax liabilities at the household level is discussed in "Government".

Households

The economy is populated with OLG of finitely-lived households who are ex ante heterogeneous with respect to family type, single $f = s$ or married $f = m$, age, $j = 1, \ldots, J$, labor productivity types, $z = 1, \ldots, Z$, and endowment type, $e = 1, \ldots, E$. Survival is certain until retirement age $j = R$ such that $\pi_j = 1$ for $j = 1, \ldots, R$, and thereafter is uncertain, $\pi_j < 1$ for $j = R + 1, \ldots, J - 1$, until the maximum age J where $\pi_J = 0$. There is no other form of uncertainty. The population is assumed to grow exogenously at the gross rate of Υ_P.

The value function for a household of age j, with permanent labor productivity type z, and family composition f is $V_{t,j}^{f,z}(a_j, h_j^o)$, which is increasing in the two household-level state variables:[12] beginning-of-period financial wealth a_j and owner-occupied housing stock, h_j^o. Each household chooses optimal future values a_{j+1} and h_{j+1}^o while simultaneously making optimal intratemporal choices to maximize instantaneous utility $U_{t,j}^{f,z}$, which itself is increasing in composite good x_j and decreasing market labor supply n_j. The composite good includes housing services hs_j and consumption good c_j, the latter of which is itself a composite of ordinary market consumption, a home production good, and charitable contributions.[13]

To avoid problems associated with the curse of dimensionality, which are amplified by usage of the ITC, we follow Chang et al. (2011) and specify indivisible market labor supply $n_j \in \mathbb{N} \equiv \{0, n^{PT}, n^{FT}\}$, such that individuals may choose between no work, part-time work, or full-time work.[14,15] Costs to market work include a utility cost and a monetary cost. To allow for an operative extensive margin, we follow Holter, Krueger, and Stepanchuk (2019) and specify that single households face a fixed utility loss of F^s if the individual enters the labor force, while married households face a fixed utility loss of F^m if the secondary earner works. In addition, we follow Guner, Kaygusuz, and Ventura (2011) and specify that (i) the monetary child-care cost, $\kappa_j^{f,z}$, that is an increasing function of the number of qualifying dependents within that household, $\nu_j^{f,z}$, and the market work hours of the single and secondary worker; and (ii) the disutility of market labor function for single and secondary worker contains a separable term $\phi\nu_j^{f,z}$, which captures the interaction between lifecycle disutility of work and the presence of children.

The objective of this household's optimization problem for a known policy regime is:[16]

$$V_{t,j}^{f,z}(a_j, h_j^o) = \begin{cases} \max\limits_{\substack{a_{j+1}, h_{j+1}^o, \\ x_j, n_j \in \mathbb{N}}} U_{t,j}^{s,z}(x_j, n_j) + \beta\pi_j V_{t+1,j+1}^{s,z}(a_{j+1}, h_{j+1}^o) & \text{if} \quad f = s \\ \max\limits_{\substack{a_{j+1}, h_{j+1}^o, \\ x_j, n_j^1, n_j^2 \in \mathbb{N}}} U_{t,j}^{m,z}(x_j, n_j^1, n_j^2) + \beta\pi_j V_{t+1,j+1}^{m,z}(a_{j+1}, h_{j+1}^o) & \text{if} \quad f = m, \end{cases} \tag{19}$$

$$U_{t,j}^{f,z}(x_j, n_j) \equiv \begin{cases} \max\limits_{c_j, h_j^r} \log(x_j) - \psi^s \dfrac{(n_j + \phi\nu_j^{s,z})^{1+\zeta^s}}{1+\zeta^s} - F^s(n_j) & \text{if} \quad f = s \\ \max\limits_{c_j, h_j^r} \log(x_j) - \psi^{m,1} \dfrac{(n_j^1)^{1+\zeta^{m,1}}}{1+\zeta^{m,1}} - \psi^{m,2} \dfrac{(n_j^2 + \phi\nu_j^{m,z})^{1+\zeta^{m,2}}}{1+\zeta^{m,2}} - F^m(n_j^2) & \text{if} \quad f = m, \end{cases} \tag{20}$$

where

$$y_j \equiv h_j^o + a_j, \tag{21}$$

$$x_j \equiv \left(\sigma c_j^\eta + (1-\sigma) hs_j^\eta\right)^{1/\eta}, \tag{22}$$

$$hs_j \equiv \max\{h_j^o, h_j^r\}. \tag{23}$$

Households choices are restricted by the following budget constraint:

$$p_t^c c_j + p_t^r h_j^r + a_{j+1} + h_{j+1}^o \leq (1 + r_t^p) a_j + (1 - \delta^o) h_j^o + i_{t,j}^{f,z} - T_{t,j}^{f,z} - \kappa_j^{f,z} - \xi_j^H, \tag{24}$$

where expenditures on the left-hand side are the composite consumption good c_j which is valued at the implicit price p_t^c, rental housing $p_t^r h_j^r$, end-of-period stock of financial wealth a_{j+1}, and end-of-period owner-occupied housing h_{j+1}^o. Available resources on the right-hand side are the sum of the gross return to beginning-of-period financial wealth $(1 + r_t^p)a_j$ deposited at a financial intermediary, beginning-of-period owner-occupied housing stock less economic depreciation $(1 - \delta^o)h_j^o$, and noncapital income $i_{t,j}^{f,z}$ less net tax liabilities $T_{t,j}^{f,z}$, childcare costs $\kappa_j^{f,z}$, and housing transaction costs ξ_j^H that are nonzero only when a household changes residential status.

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

$$i_{t,j}^{f,z} \equiv \begin{cases} n_j w_t z_j^{s,z} + ss_j^{s,z} & \text{if} \quad f = s \\ (n_j^1 + \mu^z n_j^2) w_t z_j^{m,z} + ss_j^{m,z} & \text{if} \quad f = m, \end{cases} \tag{25}$$

where w_t is the market real wage rate, $z_j^{f,z}$ 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.

Following Gervais (2002) and Cho and Francis (2011), households are permitted to borrow and accumulate debt in excess of savings subject to the following restrictions:

$$y_j \geq \begin{cases} \underline{y}^{f,z} & \text{if} \quad h_j^o = 0 \\ \gamma h_j^o & \text{if} \quad h_j^o > 0, \end{cases} \tag{26}$$

where $\underline{y}^{f,z} < 0$ is the lower bound of the real wealth support for renters and the parameter $0 \leq \gamma \leq 1$ can be interpreted as the down-payment ratio or the minimum equity which a homeowner may hold in their home. Both rental housing and owner-occupied housing are subject to minimum sizes, where $\underline{h}^r < \underline{h}^o$ making rentals relatively more affordable.

$$hs_j \geq \underline{h}^r, \tag{27}$$

$$h_j^o \geq \underline{h}^o \quad \text{if} \quad h_j^o > 0. \tag{28}$$

It is assumed that households enter the economy with initial financial wealth of an exogenous a_1 and zero owner-occupied housing, so that $y_1 = a_1$ and $h_1^o = y_{J+1} = 0$. Should a household live to the maximum age J, they are assumed to die with zero net worth, so that $V_{t,J+1}^{f,z} = 0$. Should a household instead die before reaching the maximum age J, they are assumed to incur end-of-life expenditures, c_t^{eol}, with their estates costlessly liquidated and collected by the government, taxed, and redistributed in an exogenous fashion to agents aged $j = 1$.[17] Given an exogenous linear tax rate on estates of τ_t^{beq} and an exogenous distribution of bequests which aggregates to $\bar{\Lambda}$, end-of-life expenditures are computed as a residual so that:

$$c_t^{\text{eol}} = (1 - \tau_t^{\text{beq}}) \int_{\mathbb{Z}} \int_J (1 - \pi_j) \sum_{f=s,m} y_{t+1,j+1} \Omega_{t,j}^{f,z} \, dj \, dz \; - \bar{\Lambda}. \tag{29}$$

Financial Intermediaries

The financial sector is perfectly competitive, consisting of overlapping cohorts of identical, two-period lived financial intermediaries with the technology to pool savings from households and invest in financial assets and rental property.[18] Each period the representative intermediary of a given cohort will make the portfolio decision on behalf of households by collecting end-of-period deposits D_{t+1} and deciding upon an investment allocation. These deposits may be allocated across corporate and noncorporate equity V_{t+1}^c and V_{t+1}^n, corporate and noncorporate bonds B_{t+1}^c and B_{t+1}^n, federal government bonds B_{t+1}^g, and rental housing property H_{t+1}^r so that:

$$D_{t+1} = V_{t+1}^c + V_{t+1}^n + B_{t+1}^g + B_{t+1}^c + B_{t+1}^n + H_{t+1}^r \quad \forall t. \tag{30}$$

The assets remaining at the end-of-life for each cohort are costlessly transferred to the subsequent cohort.

Corporate and noncorporate equity yield dividends or distributions and capital gains. While corporate and noncorporate bonds yield a pretax rate of return of i_{t+1}, we assume that investment in government bonds yields a low, "safe" pretax rate of return ρ_{t+1}, which depends positively on both the private bond rate and the public debt-output ratio:

$$\rho_{t+1} = \varpi i_{t+1} + \varsigma \exp\left(\frac{B^g_{t+1}}{Y_{t+1}}\right) \quad \forall t. \tag{31}$$

The intermediary rents out housing services at a price of p^r_{t+1} and incurs expenses from the economic depreciation at rate δ^r. For convenience, we denote a given representative intermediary's income as:

$$\begin{aligned} Inc_{t+1} \equiv\ & div_{t+1} + dst_{t+1} + gns^c_{t+1} + gns^n_{t+1} + (p^r_{t+1} - \delta^r)H^r_{t+1} + \rho_{t+1}B^g_{t+1} \\ & + i_{t+1}(B^c_{t+1} + B^c_{t+1}) \quad \forall t, \end{aligned} \tag{32}$$

which is remitted back to households in the form of a portfolio return r^p_{t+1} on their deposits.

Formally, the maximization problem for a given cohort's representative financial intermediary is as follows:

$$\max_{\substack{V^c_{t+1}, V^n_{t+1}, \\ B^c_{t+1}, B^n_{t+1}, H^r_{t+1}}} \quad Inc_{t+1} - r^p_{t+1}D_{t+1}, \tag{33}$$

where it is assumed that the financial intermediary has perfectly elastic demand for government bonds. A characteristic of the optimal allocation is that no arbitrage opportunities exist in equilibrium. This no-arbitrage condition implies that the after-tax marginal rate of return from across all investment vehicles will be equalized. Recalling the expressions for the after-tax rates of return of corporate and noncorporate equity in equations (5) and (13), we can express this condition as:

$$R^c_{t+1} = R^n_{t+1} = (1 - \tau^i_{t+1})i_{t+1} = p^r_{t+1} - \delta^r \quad \forall t, \tag{34}$$

where τ^i_{t+1} is the aggregate EMTR on interest income. Because this expression reflects the aggregate effective marginal after-tax rates of return on each asset in the financial market, this portfolio allocation is optimal for households on average.

Finally, perfect competition in the financial market implies a zero-profit condition each period for a given cohort's representative intermediary. Households therefore receive a pretax portfolio return on their deposits equal to:

$$r^p_{t+1} = \frac{Inc_{t+1}}{D_{t+1}} \quad \forall t, \tag{35}$$

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

Government

Household income taxation. In this section, we detail the tax treatment of household income, which involves the specification of federal labor income taxes, capital income taxes, payroll taxes, state and local taxes, and the special tax treatment of social security benefits. We describe the general framework of household income taxation under our ITC and the CTS, each in turn.

We introduce the "hat-notation" to denote income variables that have been adjusted for inclusion in adjusted gross income (AGI).[19] Adjusted gross labor income, $\hat{i}^{f,z}_{t,j}$, includes a portion of wage income for a given working-age household or a portion of social security income for a given retired households. Adjusted gross capital income, $r^p_t \hat{a}^{f,z}_{t,j}$ includes a portion of capital income received by a given household from the financial intermediary. Adjusted gross capital income can be decomposed into ordinary and preferential components, $r^p_t \hat{a}^{\mathbf{o},f,z}_{t,j}$ and $r^p_t \hat{a}^{\mathbf{p},f,z}_{t,j}$, respectively.[20] We define a given household's total adjusted gross ordinary income and total adjusted preferential capital income as:

$$ord^{f,z}_{t,j} \equiv \hat{i}^{,z}_{t,j} + r^p_t \hat{a}^{\mathbf{o},f,z}_{t,j}, \tag{36}$$

$$pci^{f,z}_{t,j} \equiv r^p_t \hat{a}^{\mathbf{p},f,z}_{t,j}, \tag{37}$$

where the sum of both makes up total AGI.

ITC. Under the ITC, a given household's net tax income liability $T^{f,z}_{t,j}$ is equal to tax liabilities on ordinary income, $oit^{f,z}_{t,j}$, plus tax liability on preferential capital income, $cit^{f,z}_{t,j}$, plus payroll tax liabilities associated with the social security system, $\tau^{pr}_{t,j}\hat{i}^{f,z}_{t,j}$, less federal transfer payments, $trs^{f,z}_{t,j}$, plus state and local tax liabilities, $slt^{f,z}_{t,j}$:

$$T^{f,z}_{t,j} = oit^{f,z}_{t,j} + cit^{f,z}_{t,j} + \tau^{pr}_{t,j}\hat{i}^{f,z}_{t,j} - trs^{f,z}_{t,j} + slt^{f,z}_{t,j}. \tag{38}$$

Household tax liability on ordinary income, $oit^{f,z}_{t,j}$, is determined by the application of a statutory marginal tax rate schedule, deductions, and credits. This mapping from choice variables, state variables, and demographic characteristics to a tax liability is developed to be as close to the actual IRC as possible for the provisions modeled: the average tax rate on ordinary income before tax credits, τ_t^o, is determined by the statutory tax rate schedule in the tax calculator, ordinary income $ord_{t,j}^{f,z}$, and deductions $ded_{t,j}^{f,z}$. The structure of deductions varies as some are a function of labor income only, some are a function of broader income sources, and some are a function of tax-preferred consumption components—owner-occupied housing and charitable giving in our case—where charitable giving is a component of the consumption composite $c_{t,j}$.

$$oit_{t,j}^{f,z} = \max\left\{\tau_t^o ord_{t,j}^{f,z}, 0\right\} - crd_{t,j}^{f,z} - tra_t^{f,z}, \tag{39}$$

$$\tau_t^o = \boldsymbol{\tau}(ord_{t,j}^{f,z} - ded_{t,j}^{f,z}), \tag{40}$$

$$ded_{t,j}^{f,z} = \boldsymbol{d}(\hat{i}_{t,j}^{f,z}, ord_{t,j}^{f,z}, pci_{t,j}^{f,z}, h_{t,j}^o, c_{t,j}), \tag{41}$$

$$crd_{t,j}^{f,z} = \boldsymbol{c}(\hat{i}_{t,j}^{f,z}, ord_{t,j}^{f,z}, ded_{t,j}^{f,z}, pci_{t,j}^{f,z}, \kappa_{t,j}^{f,z}), \tag{42}$$

where bold emphasis denotes a generalized function. The last term in equation (39) is a productivity type-family composition specific transfer payment $tra_t^{f,z}$, which is used as a nondistortionary method of ensuring that households within a given (f, z) demographic group on average face a target average tax rate on labor income. This transfer may be positive or negative for different household groups and is zero when the household supplies no labor.

A households' tax liability on preferential capital income depends on their total AGI and a statutory tax rate schedule. We define this relationship with the following function:

$$cit_{t,j}^{f,z} = \boldsymbol{q}(ord_{t,j}^{f,z}, pci_{t,j}^{f,z}). \tag{43}$$

This mapping, like that for ordinary income tax liabilities, is developed to be as close to the actual IRC as possible. Preferential capital income sources are taxed at relatively lower rates according to a progressive statutory tax rate schedule.

Working households pay into the social security program at proportional payroll tax rate on labor income each period, which applies to adjusted gross labor income up to a specified threshold. Formally:

$$\tau^{pr}_{t,j} = \boldsymbol{p}\left(\hat{i}^{f,z}_{t,j}\right) \text{if } j \leq R. \tag{44}$$

The payroll tax rate functions are independent of demographic characteristics other than age.

CTS. Under the CTS, a given households' tax liabilities, $T^{f,z}_{t,j}$, is equal to tax liabilities on wage income, $wit^{f,z}_{t,j}$, plus tax liability on capital income, $\bar{\tau}^{k,f}_{t,j}\hat{a}^{f,z}_{t,j}r^{p}_{t}$, plus tax liabilities associated with the social security system for retirees, $\tau^{pr}_{t,j}\hat{i}^{f,z}_{t,j}$, less federal transfer payments, $trs^{f,z}_{t,j}$, plus state and local tax liabilities, $slt^{f,z}_{t,j}$:

$$T^{f,z}_{t,j} = wit^{f,z}_{t,j} + \bar{\tau}^{k,f}_{t,j}\hat{a}^{f,z}_{t,j}r^{p}_{t} + \tau^{pr}_{t,j}\hat{i}^{f,z}_{t,j} - trs^{f,z}_{t,j} + slt^{f,z}_{t,j}, \tag{45}$$

where labor and capital income are modeled as separate bases to account for their differential tax treatment without interaction.

For the taxation of labor income for working-age households, we specify the Bénabou (2002) tax function, a commonly used tax function for wage income that generates smooth average tax rates and EMTRs over income (Guner, Kaygusuz, and Ventura 2014; Heathcote, Storesletten, and Violante 2017; Holter, Krueger, and Stepanchuk 2019). This function is continuously differentiable, allows for negative average tax rates to capture the effect of refundable tax credits, and is easily parameterized with the exogenous specification of an EMTR and average tax rate at the desired level of aggregation. It takes the following form over adjusted gross labor income:

$$wit^{f,z}_{t,j} = \hat{i}^{f,z}_{t,j} - \lambda^{f}_{1}(\hat{i}^{f,z}_{t,j})^{1-\lambda^{f}_{2}} - tra^{f,z}_{t} \text{ if } j \leq R, \tag{46}$$

where λ^{f}_{1} and λ^{f}_{2} are parameters which together determine the income-weighted average tax rate and EMTR applied to adjusted gross labor income at the family composition level of aggregation. As with the ITC, the transfers $tra^{f,z}_{t}$ are used as a nondistortionary method of targeting changes to the average tax rate on labor income for (f, z) demographic group following a policy change but set to zero in the initial steady state under the CTS.

Average tax rates on adjusted gross capital income are determined by age group-family composition specific flat tax rates, one each for working single, working married, retired single, and retired married households. These tax rates are denoted by $\bar{\tau}^{k,f}_{t,j}$.

While payroll taxes are levied in the same manner as specified under the ITC, the special tax treatment of the security income received by retired households is captured using (f, z) demographic-specific exogenous average tax rate applied to that income, $\bar{\tau}_t^{SS,f,z}$:

$$\tau_{t,j}^{pr} = \begin{cases} \boldsymbol{p}\left(\hat{i}_{t,j}^{f,z}\right) & \text{if } j \leq R \\ \bar{\tau}_t^{SS,f,z} & \text{if } j > R \end{cases}. \tag{47}$$

Federal government. Total taxes collected by the federal government, $T_t^{\text{fed}} \equiv txl_t^{hh} + txl_t^c + txl_t^{\text{beq}}$, are the sum of tax receipts collected from households, corporations, and on estates left by the dead. These receipts, along with bond issues, are used to finance nonvalued public consumption, C_t^{fed}, capital expenditures, I_t^{fed}, and transfer payments to households TR_t^{fed}. The recursive budget constraint of the federal government is written as:

$$I_t^{\text{fed}} + C_t^{\text{fed}} + TR_t^{\text{fed}} \leq T_t^{\text{fed}} + B_{t+1}^g - (1 + \rho_t)B_t^g, \tag{48}$$

where the law of motion for federal public capital follows:

$$G_{t+1}^{\text{fed}} = (1 - \delta^g)G_t^{\text{fed}} + I_t^{\text{fed}}. \tag{49}$$

Equation (48) states that federal public expenditures on nonvalued consumption and capital can be no larger than total tax revenue net of transfer payments plus new debt issues, $B_{t+1}^g - B_t^g$, less interest paid on old debt $\rho_t B_t^g$. To rule out explosive debt paths, we maintain the no-Ponzi condition:

$$\lim_{k \to \infty} \frac{B_{t+k}^g}{\prod_{s=0}^{k-1}(1 + \rho_{t+s})} = 0, \tag{50}$$

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

Total income taxes collected by the federal government from households, txl_t^{hh} consist of tax liabilities from both labor and capital income, as well as payroll taxes and tax liabilities on social security income. Rearranging either equation (38) or (45), this is obtained as follows:

$$txl_t^{hh} = \int_{\mathbb{Z}} \int_J \sum_{f=s,m} (T_{t,j}^{f,z} + trs_{t,j}^{f,z} - slt_{t,j}^{f,z})\Omega_{t,j}^{f,z} \, dj \, dz. \tag{51}$$

Total income taxes collected by the federal government from corporations, txl_t^c, are defined in equation (11) and repeated here for convenience:

$$txl_t^c = \tau_t^c\left(Y_t^c - w_t N_t^c - ded_t^c\right) - crd_t^c.$$

Taxes collected on estates left by deceased households are txl_t^{beq}.

In addition to social security payments to retirees, $ss_{t,j}^{f,z}$, households receive lump-sum net transfer payments from the federal government, trs_t. These two terms aggregate to total federal government transfers TR_t^{fed}.

State and local government. The structure of the state and local government's budget is described in Appendix B.

Equilibrium

Equilibrium is formally defined in Appendix D in terms of a trend-stationary transformation of the model. Here, we informally define an equilibrium as a collection of household decision rules that maximize households' utility subject to household budget constraints; a collection of economic aggregates that are consistent with household behavior and the associated measure of households; profit-maximizing behavior by the corporate and noncorporate firms; a set of prices that facilitate cross-sector price-equalization and clearing in factor, asset, and goods markets; and an associated set of policy aggregates that are consistent with budget constraints of the federal, state, and local governments. When in trend-stationary form, our model exhibits an equilibrium balanced growth path.

Calibration

The set of parameters to be calibrated include nontax and tax policy parameters, both of which rely heavily on use of the Joint Committee on Taxation's Individual Tax Model (JCT-ITM) for specification, which makes use of data from individual tax returns filed with the Internal Revenue Service and compiled by the Statistics of Income (SOI) division.[21] In calibrating the model, we vary the use of long-run historical data, recent observations, and projections to construct parameter values in targeting the 2017 US economic environment and tax law as closely as possible for the initial steady-state baseline equilibrium.

Nontax Policy Parameters and Targets

The calibration strategy for household demographics, characteristics, and preferences generally follows that described in Moore and Pecoraro

(2020b), with deviations from that strategy described in the "Household Demographics, Preferences, and Characteristics" subsection in Appendix C. The calibration strategy for the production sector and nontax portion of government in our economy is described in the "Firm Production Technology, Financing, and Housing" and "Government: Public Capital and Debt" subsections in Appendix C. Select exogenous parameters used are summarized in table C1 in Appendix C, with key aggregate targets for labor supply, housing and business capital accumulation, and capital income summarized in tables C2 and C3 in Appendix C.

Tax Policy Parameters and Targets

Adjustments to gross income. AGI is a concept used by the Internal Revenue Service to measure income for tax purposes, which differs from the measures of economic income produced by the Bureau of Economic Analysis (Ledbetter 2007). Since gross income variables within the model are calibrated in terms of economic income, adjustments to gross income must be made when using either the ITC or the conventional tax system to arrive at the appropriate base. This adjustment process, which makes use of "calibration ratios," is described in the "Adjustments to Economic Income" subsection in Appendix C.

Capital income decomposition. The share of each gross capital income type k to be treated as ordinary, $s^o_{t,k}$, or preferential, $s^p_{t,k}$, is computed as the product of two terms. Let $\mu_{t,k}$ denote the endogenous share of total portfolio income for a given capital income type k, so that $\sum \mu_k = 1$. Next, let $\bar{\mu}^o_{t,k}$ denote the exogenous share of a given capital income type k that is treated as ordinary for tax purposes, which is estimated by the JCT-ITM for 2017.[22] The portfolio shares for each k can then be obtained as follows:

$$s^o_{t,k} = \bar{\mu}^o_{t,k}\mu_{t,k},$$

$$s^p_{t,k} = (1 - \bar{\mu}^o_{t,k})\mu_{t,k},$$

where by construction, the aggregate consistency condition $\Sigma_k \left(s^o_{t,k} + s^p_{t,k} \right) = 1$ holds. These shares are free to vary with policy through endogenous changes to μ_k. Multiplying a households' financial income by either $s^o_{t,k}$ or $s^p_{t,k}$ yields the ordinary or preferred quantity of capital income

Table 1. Capital Income Decomposition.

Model Tax Treatment	Corporate Dividends (Percent)	Noncorporate Distributions (Percent)	Interest Income (Percent)	Capital Gains (Percent)	Rental Income (Percent)
Ordinary					
ITC	2.8	20.9	10.7	4.5	2.4
CTS	2.5	20.5	10.2	4.7	2.1
Preferential					
ITC	8.4	0	7.1	43.2	0
CTS	8.4	0	6.8	44.5	0

Note: ITC = internal tax calculator; CTS = conventional tax specification.

of type k. Table 1 shows the decomposition of aggregate household capital income that results from this process for the initial steady-state equilibrium.

Household taxation with the ITC. The ITC explicitly models the following individual tax provisions in the IRC 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 and Medicare surtaxes; and the dependent care credit.

To ensure that the average federal tax rates on adjusted gross labor income for the average household in each (f, z) demographic in the model match those computed by the JCT-ITM, we set $tra^{f,z}$ endogenously in the initial steady state as described in Moore and Pecoraro (2020b).[23] The fit of these average tax rates to the targets is shown in tables 2 and 3, which display average adjusted gross labor income and average labor income tax liability, both for each (f, z) demographic.[24]

The Old-Age, Survivors, and Disability Insurance (OASDI) portion of the payroll tax rate of 12.4 percent is applied to adjusted gross labor income up to the 2017 tax-law threshold of US$127,200 for each individual worker. In particular, we allow for different OASDI bases for each potential worker in married households. So that payroll tax receipts relative to output are about 4.4 percent as estimated by Congressional Budget Office (CBO) for 2017, OASDI bases are scaled uniformly across individuals.

Finally, to ensure that the ITC produces household capital income tax liabilities to output ratios that are consistent with those estimated by the

Table 2. Average Adjusted Gross Labor Income in Baseline ('000s of 2018$).

Productivity Type	Target	ITC	CTS	Target	ITC	CTS
	Single Households			Married Households		
1	0.6	0.6	0.6	16.2	16.4	16.3
2	11.9	11.9	12.1	51.2	51.4	51.6
3	25.8	25.6	26.1	82.8	82.7	83.3
4	44.6	44.8	44.8	119.4	119.1	120.3
5	97.4	97.4	98.4	279.6	279.7	282.0

Note: ITC = internal tax calculator; CTS = conventional tax specification.

Table 3. Average Labor Income Tax Liability in Baseline ('000s of 2018$).

Productivity Type	Target	ITC	CTS	Target	ITC	CTS
	Single Households			Married Households		
1	−0.1	−0.1	−0.5	−2.0	−2.0	−3.2
2	−2.0	−2.1	−1.9	0.7	0.8	0.5
3	−1.3	−1.3	−1.7	5.6	5.5	4.9
4	2.8	2.8	2.3	11.9	11.9	13.1
5	14.7	14.6	16.1	57.1	57.0	60.0

Note: ITC = internal tax calculator; CTS = conventional tax specification.

JCT-ITM for each capital income type k, we make use of the base adjustments for each income type as described in the "Adjustments to Economic Income" subsection in Appendix C. Table 4 shows the targets and actual outcome of this process in the initial steady state.[25]

Household taxation with the CTS. For the labor income tax function in equation (46), the parameters $\{\lambda_1^f, \lambda_2^f\}$ are set in the initial steady state to target an aggregate average tax rate, $\overline{\text{ATR}}^f$, and an EMTR, $\overline{\text{EMTR}}^f$, both at the family-composition level of aggregation computed from the JCT-ITM. The parameters are computed as follows:[26]

$$\lambda_1^f = (1 - \overline{\text{ATR}}^f)\left(\frac{\int_{\mathbb{Z}}\int_J (\hat{i}_j^{f,z})\hat{\Omega}_j^{f,z}\ dj\ dz}{\int_{\mathbb{Z}}\int_J (\hat{i}_j^{f,z})^{1-\lambda_2^f}\hat{\Omega}_j^{f,z}\ dj\ dz}\right),$$

Table 4. Aggregate Capital Income Tax Ratios in Steady-state Baseline.

Target Ratio	Target	ITC
Noncorporate distribution taxes to aggregate output ratio	.0136	.0136
Corporate dividend taxes to aggregate output ratio	.0021	.0021
Interest income taxes to aggregate output ratio	.0008	.0005
Capital gains taxes to aggregate output ratio	.0067	.0067
Target Ratio	**Target**	**CTS**
Total capital income taxes to aggregate output ratio	.0221	.0229

Note: ITC = internal tax calculator; CTS = conventional tax specification.

$$\lambda_2^f = \frac{\overline{\text{EMTR}}^f - \overline{\text{ATR}}^f}{1 - \overline{\text{ATR}}^f},$$

where λ_1^f must be endogenously calibrated given its dependence on household adjusted gross labor income, and the transfers $tra^{f,z}$ are set to zero in the initial steady state. Table 3 shows the labor income tax liabilities generated by this function on average over (f, z) demographics in the initial steady state, with the associated average adjusted gross labor income levels shown in table 2.

The age-group and marital status–specific capital income tax rates, $\bar{\tau}_j^{k,f}$, are computed from the JCT-ITM as total capital income tax liabilities relative to total capital income included in AGI for each demographic group. Given these exogenous tax rates, a uniform adjustment to gross capital income for all households is calibrated internally as described in the "Adjustments to Economic Income" subsection in Appendix C, so that aggregate capital income taxes relative to aggregate output within the initial steady state match the target specified in table 4.

While payroll taxes on labor income for working-age households are calibrated under the CTS in the same fashion as is done under the ITC as described in "Household taxation with the ITC", the special tax treatment of social security income under the CTS is modeled via exogenous average tax rates $^{-SS,f,z}$ computed from the JCT-ITM for each (f, z) demographic. The gross social security income base is scaled uniformly for all households, so that social security tax receipts relative to aggregate output matches the target of 0.18 percent in the initial steady state.

Firm taxation and other taxes. While the taxation of household income differs across tax systems, firm-level taxation is identical under both the ITC and CTS. The set of aggregate EMTRs, $\{\tau^{c}, \tau^{nc}, \tau^{d}, \tau^{i}, \tau^{g}\}$, which apply to aggregate corporate income, noncorporate income, dividend income, interest income, and capital gains, are exogenously set to those values computed by the JCT-ITM for year 2017. We allow for both the corporate and noncorporate firms to deduct from income their interest expense, accelerated tax depreciation of capital assets, and state and local tax liabilities in the initial baseline through ded^{c} and ded^{nc}. We endogenously calibrate the lump-sum credits, crd^{c} and crd^{nc}, 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 CBO in the *The Budget and Economic Outlook: 2017 to 2027*, and for the noncorporate firm, we target a ratio of 1.36 percent estimated by the JCT-ITM.[27]

The linear federal tax rate on estates, τ^{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 gross domestic product from the CBO for 2017. Federal transfer payments consist the sum of a uniform lump-sum net transfer, *trs*, which is set to be equal to 0.40 percent of aggregate output to represent federal transfers (less those for Old-Age and Survivors Insurance (OASI), Medicare, Medicaid, and the outlay portion of tax credits) minus federal excise and miscellaneous taxes.

The Portfolio Effect: An Illustrative Example

To motivate our quantitative analysis in “Policy Experiments”, consider the stylized case of a hypothetical, high-income single household without children, earning US$200,000 of adjusted gross labor income in 2017. This household would have a federal EMTR of 26.37 percent on ordinary income as computed by the ITC.[28,29] Should this household receive an additional US$25,000 in qualified dividend income, their EMTR on ordinary income will be unaffected because qualified dividends are preferential capital income and therefore taxed at special low rates as a separate base. If this household instead received an additional US$25,000 in noncorporate distributions, their EMTR on ordinary income would increase to 34.88 percent because the distributions are treated as ordinary income and taxed jointly with wage income on a progressive tax schedule. With a resulting percent reduction in the marginal after-tax return to labor of -11.56 percent in the latter case, this household would decrease labor hours by 3.5 percent assuming a consumption-constant elasticity of 0.30.

In an explicitly intertemporal setting, the household-level behavioral responses also involve timing shifts and a saving decision. To demonstrate how the detailed tax treatment of capital income can affect households' labor and saving choices in this environment, we simulate two examples of one-year shocks to the characterization of capital income. In the first example, all capital income is exogenously recharacterized as ordinary income for 2018 (year 1) and taxed jointly with labor income, while in the second example, all capital income is recharacterized as preferential capital income and taxed as a separate base for one period. In 2019 (year 2), the ordinary-preferential composition of capital income reverts permanently to its baseline composition.[30] Since the pretax value of every household's adjusted gross capital income remains unchanged, this shock has no effect in the CTS.

The impulse responses for the ITC shown in figure 1 are partial equilibrium, allowing households to reoptimize their lifetime choices following the shock while holding market prices constant at the initial steady-state values. The shift to ordinary treatment causes the EMTR on ordinary income to increase, resulting an immediate reduction in effective labor supply. Conversely, the shift to preferential treatment decreases the EMTR on ordinary income, resulting in an immediate increase in effective labor supply. In both cases, the stock of savings changes in the same direction as labor supply to reflect the implied consumption-smoothing behavior of households in response to a change in their after-tax lifetime resources.[31]

While these examples represent extreme swings in the tax treatment of household capital income, they highlight the main point of our article: careful accounting for the complexity of capital income taxation as under the ITC has implications for household labor supply and savings behavior. In this respect, our assumption that portfolio decisions occur at the financial intermediary level is not integral to the mechanism that we seek to highlight. In the following section, we show that policy-induced changes to the ordinary-preferential composition of household capital income generate quantitatively significant effects on the macroeconomic aggregates.

Policy Experiments

We analyze the general equilibrium transition path following the implementation of two different subsets of tax changes contained in the recently enacted "TCJA": (i) the corporate rate reduction and (ii) the individual tax provisions. These experiments are performed using the ITC and the CTS

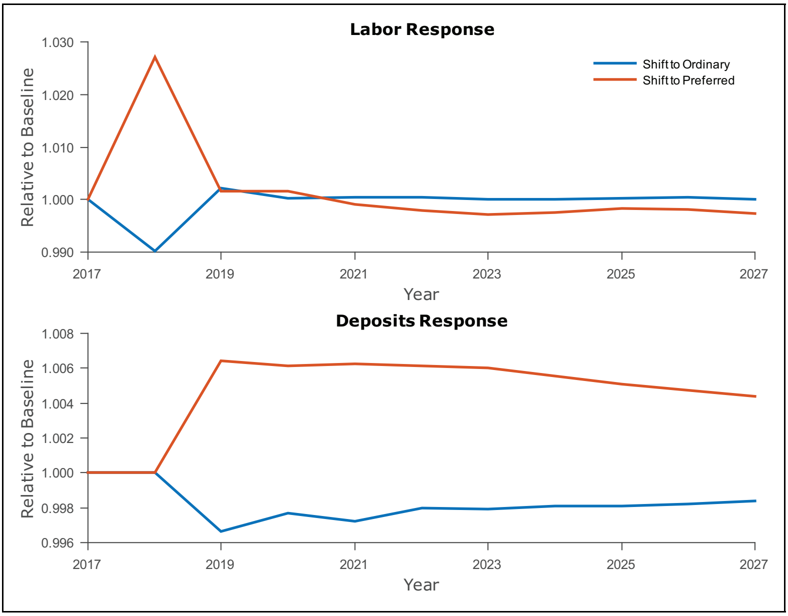

Figure 1. Impulse response of labor and deposits: Illustrative example.

each in turn, beginning from an initial steady state associated with 2017 tax law.[32] We report simulation results for the first ten years following the policy change to coincide with the "budget window" used by the US Congress to inform legislative decision making.

The announcement and implementation of policy changes occur in 2018 and are assumed to be unanticipated in 2017. Following the change, agents have perfect foresight regarding the future time path of policy and the economy. Federal budget deficits or surpluses generated by the new policy are financed by borrowing or used to pay down existing debt for the first thirty years following the policy change. To ensure that Federal debt remains on a long-run sustainable debt path as the economy reaches a final steady state, adjustments to nonvalued government consumption expenditures made in 2048.[33]

Policy Experiment 1: TCJA Corporate Tax Rate Reduction

We simulate enactment of the corporate rate reduction as in Title II of JCT (2017), which eliminated the previous-law statutory tax rate schedule on corporate income in the United States with maximum rate of 35 percent and replaced it with a single 21 percent statutory rate beginning in calendar year 2018. The conventional revenue target, a loss of US$1.349 trillion over fiscal years 2018 to 2027, is matched under both the ITC and CTS tax systems.[34] While involving only a direct tax change at the corporate level, the policy-induced increase in preferential capital income from an expansion of the corporate sector quantitatively matters for aggregate labor supply and savings responses.

The corporate tax rate reduction causes a major shift in economic activity from the noncorporate sector to the corporate sector, with fully mobile capital and labor reallocating to eliminate any arbitrage opportunities. Figure 2 shows that in both tax systems, an expansion of corporate sector output gives rise to higher dividend payouts and capital gains on corporate equity—both of which are largely treated as preferential income—as well as interest payments from increased borrowing to finance operations. Conversely, noncorporate sector output contracts and generates a downward trend in distributions[35]—which are treated as ordinary income—as well as capital losses on noncorporate equity and a reduction in interest payments.

The most important difference arises from corporate equity valuation and the accrual of capital gains. In the first year of the new policy regime, capital gains on corporate equity increase by 3.3 percent under the ITC but increase by only 0.8 percent under the CTS. This outcome is a result of general equilibrium effects associated with a relatively higher effective (productivity-weighted) labor supply response under the ITC, shown in figure 3, which immediately raises the present discounted value of corporate firms. The policy-induced changes to the ordinary-preferential composition of adjusted gross capital income are shown in figure 4, which result from the portfolio rebalancing undertaken by financial intermediary on behalf of households. While ordinary capital income initially increases before a long-run decline under both tax systems because of the behavior of noncorporate distributions, only under the ITC does preferential capital income increase as a result of the different path of corporate capital gains under that tax system.

Key among the projected paths of aggregates and prices in figure 3 is the relatively larger accumulation of deposits and increase in effective labor supply under the ITC. The gradual movement of economic activity into the corporate sector results in an increase in the preferential share of capital income over time that encourages households to accumulate relatively more deposits because more capital income is taxed at lower rates. Similarly, the gradual reduction in ordinary capital income will result in a smaller EMTR

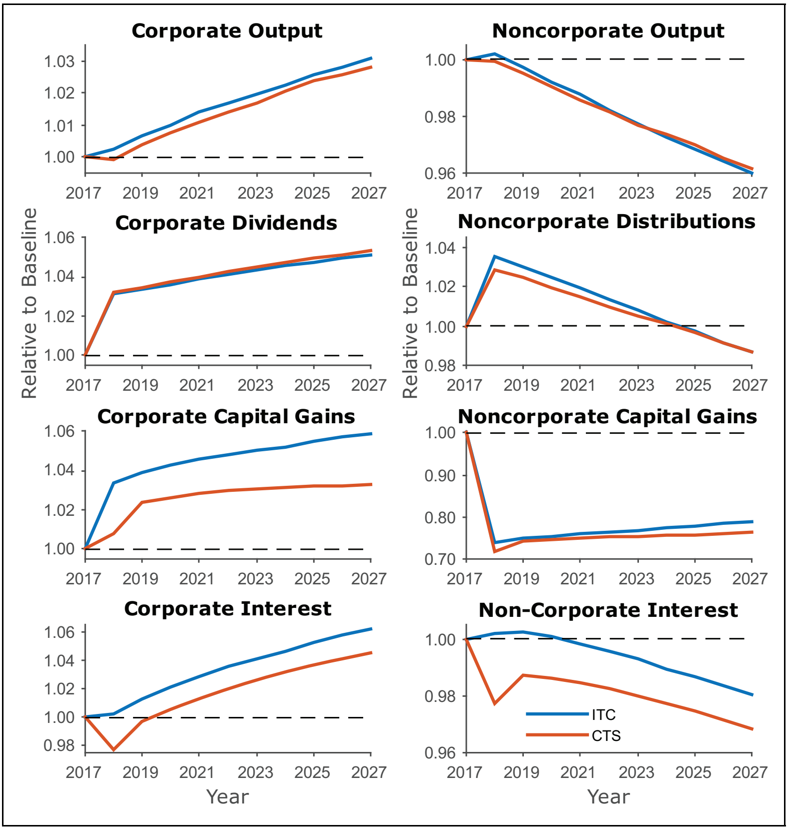

Figure 2. Changes to economic activity by sector: Tax Cuts and Jobs Act corporate rate reduction.

on labor income, especially for wealthier households who tend to have high quantities of capital income and relatively higher labor productivity. This leads to effective labor supply increases that grow over time. Contrast this with the behavior of labor supply under the CTS, which remains largely unchanged until 2023 when capital deepening sufficiently raises the real wage rate.[36]

Policy Experiment 2: Individual Tax Provisions of TCJA

We simulate enactment of the individual tax provisions in Title I of JCT (2017), most of which became effective beginning in 2018 and are

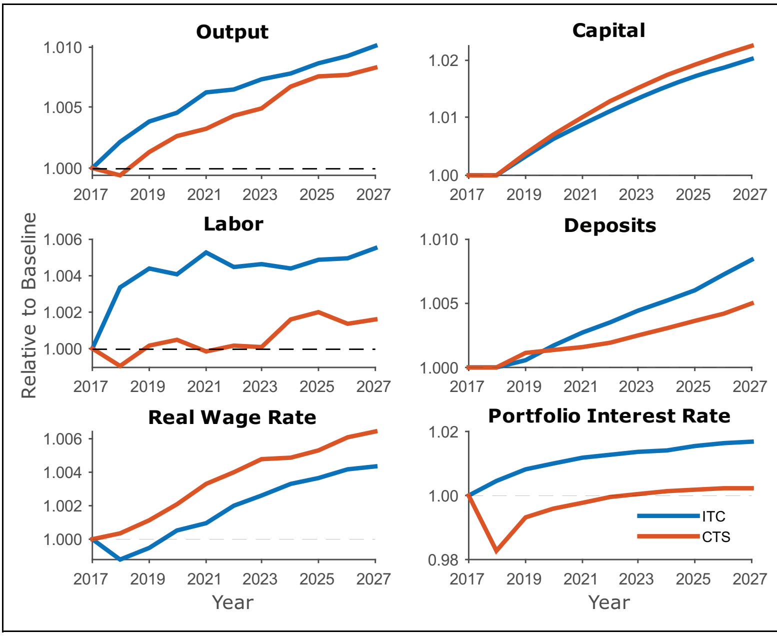

Figure 3. Changes to key aggregates: Tax Cuts and Jobs Act corporate rate reduction.

scheduled to expire in 2025. Key among these provisions, all of which are modeled explicitly within the ITC, are an overall reduction in statutory tax rates on ordinary income, expansion of the standard deduction, modification of itemized deductions, 20 percent deduction of qualified business income for pass-through entities, repeal of personal exemptions, and expansion of the child tax credit. The total conventional revenue loss of these tax changes was estimated to be US$1.126 trillion over fiscal years 2018 to 2027 in JCT (2017), which is matched under both the ITC and CTS tax systems. The main finding here is that the policy-induced increase in households' labor supply endogenously generates a change to the composition of capital income toward preferential in the short run, which itself feeds back into household behavior and leads quantitative differences in the path of economic aggregates.

Figure 5 shows the response of select economic aggregates and prices over the budget window. Although qualitatively similar, there are substantial differences in magnitudes across the ITC and CTS simulations. The

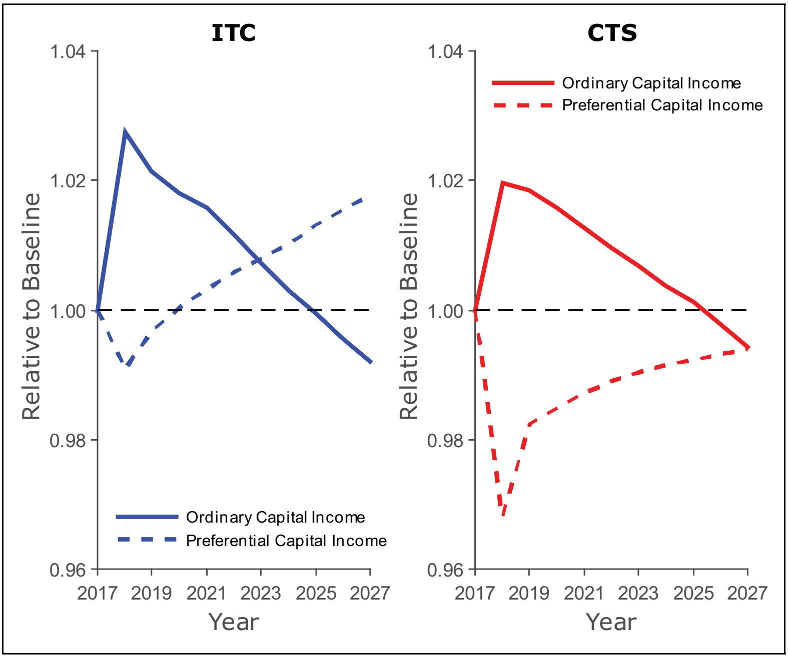

Figure 4. Changes to portfolio composition: Tax Cuts and Jobs Act corporate rate reduction.

relatively larger effective labor supply increase under the ITC tax system drives the relatively larger increase in aggregate output. Increased output leads to more capital income flowing from firms to households; figure 6 shows that the increase in each type capital income is substantially larger under the ITC. Figure 7 shows this result in terms of its impact on the ordinary-preferential composition of household capital income. An immediate increase in preferential capital income, resulting from the substantial increase in capital gains, eventually gives way to a more sustained increase in ordinary capital income as noncorporate distributions grow until the tax provisions expire in 2026.

The relatively larger response of labor supply under the ITC is an outcome of a self-reinforcing relationship between firm equity value and labor supply that is present when accounting for the detailed tax treatment of household capital income: firms that foresee the increase in future output—following from additional labor input—experience an immediate increase in their present discounted value that results in a capital gain for households

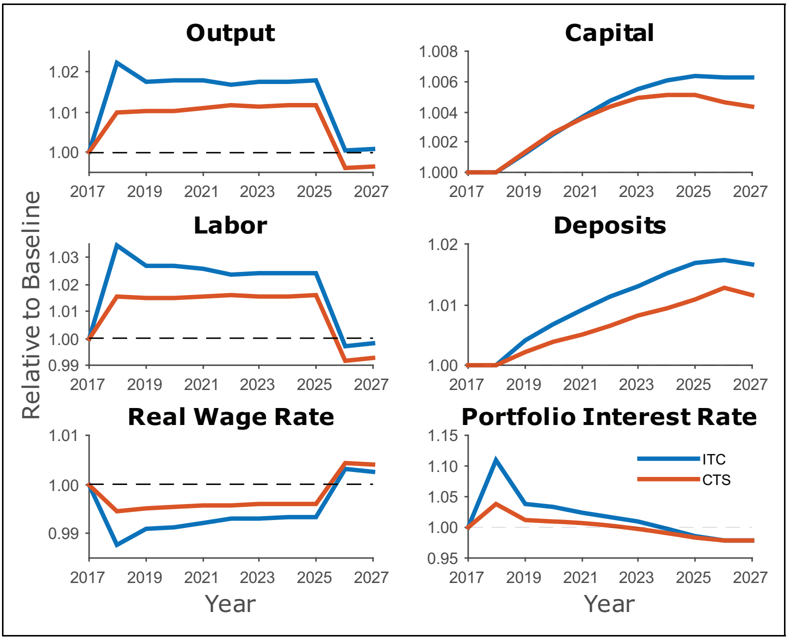

Figure 5. Changes to key aggregates: Individual Tax Cuts and Jobs Act provisions.

who hold equity. Because capital gains are largely treated as preferential capital income, this additional income is taxed separately from labor income at low rates. Households foresee that this increase in preferential capital income is temporary and shift their labor supply toward these years when EMTR on labor income is relatively lower.

As with the corporate rate reduction, households' accumulation of savings deposits is substantially higher in the ITC than in the CTS despite similar levels of productive capital accumulation by firms. While additional incentives to save in financial wealth under the ITC arise from the changing composition of capital income, all flows of new savings are not immediately invested into productive capital in our model with explicit firm financing. In the market-clearing equilibrium, the quantity of savings deposits must be sufficiently large to support the quantity of outstanding equity, bonds, and rental housing. Because the value of private equity immediately increases by substantially more under the ITC as described above, the borrowing rate increases to clear the market, discouraging firms from issuing additional bonds to finance capital investment.

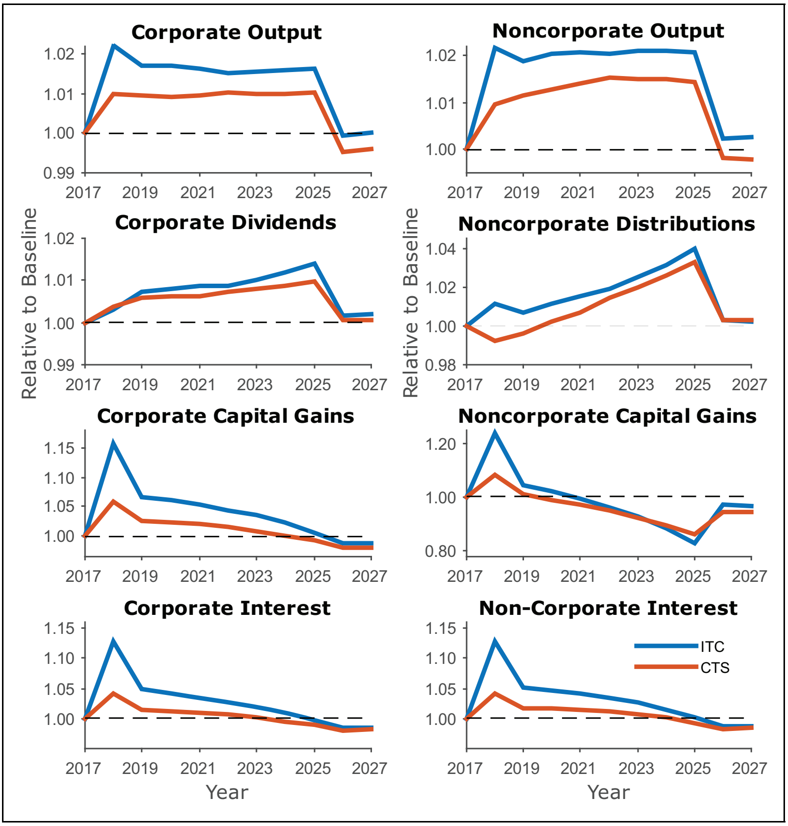

Figure 6. Changes to economic activity by sector: Individual Tax Cuts and Jobs Act provisions.

Limitations

We have shown that when accounting for the detailed taxation of household income, changes to the ordinary-preferential composition of capital income have quantitatively significant implications for household labor and saving behavior. However, our study is not without limitations. First, throughout this article, we have maintained the implicit assumption that households within our model do not vary in the extent to which savings are held in tax-deferred or tax-preferred accounts. Because lifecycle variation in the utilization of these savings vehicles will affect the size of households' income tax bases differently at different ages, their incorporation within the

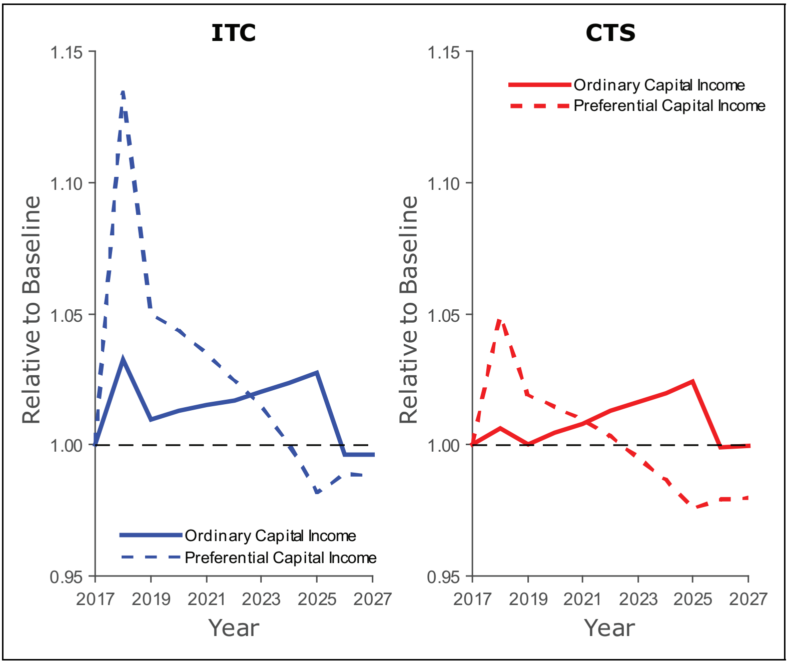

Figure 7. Changes to portfolio composition: Individual Tax Cuts and Jobs Act provisions.

modeling framework has the potential to affect the EMTRs relevant for labor and savings decisions and thus macroeconomic outcomes. Second, since the financial intermediary determines the composition of capital assets held by households within our model, the portfolio is optimal only in the aggregate. While this assumption did not prevent us from exploring households' optimal responses to endogenous changes to the composition of their capital income, households in reality may choose their own portfolios in lieu of investments managed by an intermediary such as mutual fund. Possible directions for future research are to incorporate special savings vehicles and heterogeneous portfolios along with the tax detail introduced in this work.

Conclusion

We have argued that simultaneously accounting for the joint taxation of ordinary income and the special taxation of preferential income as in the United States generates a "portfolio-effect" mechanism, whereby changes to the ordinary-preferential composition of households' capital income can influence individuals' optimal labor and saving decisions through its impact on their effective marginal tax rates. To explore this mechanism, we used a heterogeneous-agent overlapping generations model with a two-entity production sector and an internal tax calculator to simulate two subsets of tax provisions in the "TCJA": (i) the corporate tax rate reduction and (ii) the individual tax provisions. In both cases, changes to the pattern of investment across corporate and noncorporate sectors result in endogenous changes to the composition of households' capital income which affect their labor and saving incentives. This portfolio effect was sufficiently strong to affect the path of aggregate labor supply and savings. Consequentially, failure to account for the complexity of household capital and labor income taxation when modeling a tax reform risks omission of an important mechanism from the analysis.

Appendix A

Household Consumption Detail

We assume that the consumption-composite good, c_j, is a Cobb–Douglas function of different nondurable consumption types. The first subcomponent 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 subcomponent, c_j^i, is the sum of market-produced consumption c_j^M and home-produced consumption services ch_j^f:

$$c_j \equiv (c_j^i)^{\theta^{f,z}} (c_j^g)^{(1-\theta^{f,z})}, \tag{A1}$$

$$c_j^i \equiv \begin{cases} c_j^M + ch_j^s(nh_j^s) & \text{if} \quad f = s \\ c_j^M + ch_j^{m,1}(nh_j^{m,1}) + ch_j^{m,2}(nh_j^{m,2}) & \text{if} \quad f = m, \end{cases} \tag{A2}$$

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 as described in the "Household Demographics, Preferences, and Characteristics" subsection in Appendix C.

To obtain an expression for the implicit price of composite consumption p_t^c, we let the sum of c_j^M and c_j^g enter the households' budget constraint in equation (24) instead of the composite term $p_t^c c_j$. Then using equations (A1) and (A2) to optimize over $\{c_j^M, c_j^g\}$, one can obtain:

$$c_j^i = (\vartheta_{t,j}^{f,z})^{(\theta^{f,z}-1)} c_j,$$

$$c_j^g = (\vartheta_{t,j}^{f,z})^{\theta^{f,z}} c_j,$$

where:

$$\vartheta_{t,j}^{f,z} = \left(\frac{1-\theta^{f,z}}{\theta^{f,z}}\right)\left(\frac{1+\partial T_{t,j}^{f,z}/\partial c_j^M}{1+\partial T_{t,j}^{f,z}/\partial c_j^g}\right),$$

and market consumption, c_j^M, can then be computed as a residual from equation (A2). Using these expressions along with the households' budget constraint, we obtain the following equivalence:

$$p_t^c c_j = \left((\vartheta_{t,j}^{f,z})^{(\theta^{f,z}-1)} + (\vartheta_{t,j}^{f,z})^{\theta^{f,z}}\right) c_j. \quad \text{(A3)}$$

Appendix B

State and Local Government

Total taxes collected by the composite state and local government T_t^{sl} are the sum of tax receipts collected from households and corporations. These receipts are assumed to be spent on nonvalued state and local composite government consumption expenditures C_t^{sl} and investment in productive public capital I_t^{sl}. We specify an intraperiod balanced-budget constraint such that:

$$I_t^{sl} + C_t^{sl} = T_t^{sl}, \quad \text{(B1)}$$

where the law of motion for state and local public capital follows:

$$G_{t+1}^{sl} = (1-\delta^g) G_t^{sl} + I_t^{sl}. \quad \text{(B2)}$$

Tax liabilities owed by a given household at the state and local level are assumed to be proportional to adjusted gross labor income labor income and owner-occupied housing:

$$slt_{t,j}^{f,z} \equiv \tau_t^{sl} \hat{i}_{t,j}^{f,z} + \tau_t^{\text{slp}} h_{t,j}^o, \quad \text{(B3)}$$

where τ_t^{sl} is a linear tax rate taken to represent potentially deductible state and local income and sales tax and τ_t^{slp} is a linear average tax rate on owner-occupied property. Tax liabilities owed by corporations at the state and local level were specified in equation (12) but repeated here for convenience:

$$slt_t^c = \tau_t^{\text{slc}} ern_t^c.$$

Aggregate state and local taxes can therefore be expressed as:

$$T_t^{sl} = \int_{\mathbb{Z}} \int_J \sum_{f=s,m} slt_{t,j}^{f,z} \Omega_{t,j}^{f,z} \, dj \, dz + slt_t^c. \tag{B4}$$

Appendix C

Calibration

Nontax policy parameters values and targets

Household demographics, preferences, and characteristics. As the household sector of our model utilizes the framework developed in Moore and Pecoraro (2020b), the calibration strategy for household demographics, preferences, and characteristics generally follows that described in Appendixes A.1.1, A.1.3, and A.2 of that work. However, since we currently specify an initial year of 2017 instead of 2018,[37] both the exogenously and endogenously calibrated parameter values may vary from Moore and Pecoraro (2020b) despite the same calibration strategy and targets, key of which are reported in tables C2 and C3. For this reason, table C1 contains the currently used values for the same set select exogenous parameters reported in the earlier work. Only the deviations from the prior calibration strategy for the household sector made in this article are described below.

The instantaneous utility function in this article accounts for the effect of children at home on the supply of market labor hours in the spirit of Guner, Kaygusuz, and Ventura (2011) and Borella, De Nardi, and Yang (2019). We specify an additive product along with labor hours in the labor disutility function, $\phi\nu_j^{f,z}$, meant to capture the interaction between lifecycle disutility of work and the presence of children. We let $\nu_j^{f,z}$ be the number of dependents under the age of six for a given (j,f,z) demographic, which are calculated using the JCT-ITM for 2017. 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, Kaygusuz, and Ventura (2011).

The amount of hours spent on home production have a fixed, inverse relationship to the amount of market labor hours. We use the 2017 *American Time Use Survey* to compute the average hours spent working in full-time and part-time jobs for all workers, and the 2013 to 2017 average for hours spent doing "household activities" for full-time, part-time, and unemployed individuals by worker type (single, married primary, and married secondary). Normalizing available (nonsleep) time to unity yields the following mapping from market work hours to home work hours:

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

We assume that households value home production as a function of nonwork hours:

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

where $w_t z^{s,1}$ is the effective wage rate for the lowest productivity type single household. This is a similar approach to that used by (Bridgman 2016) in measuring the empirical value of home production.

We define labor income to be equal to the National Income and Product Accounts (NIPA)-comparable wage concept used Moore and Pecoraro (2020b).[38] That is, we do not include a share of noncorporate income in our labor income definition for purposes of sorting households by labor productivity. Relative to the previously used composite income concept, we can better account for the joint tax treatment of business and wage income because our current framework allows for the explicit decomposition of capital income across different types. Figure 1 shows the initial steady-state labor income targets, $\bar{i}^{f,z}$, and the model fit for both the ITC and CTS. The targets are matched in the model under both tax systems by internal calibration of the permanent component of labor productivity.

Households who die before reaching the maximum age J leave behind estates after end-of-life expenditures, c_t^{eol}, which are computed as a residual from equation (29). Given the endogenous end-of-period net worth of dying households and the exogenous tax rate τ_t^{beq}, the exogenous distribution of bequests that aggregates to $\bar{\Lambda}$ must be specified so that c_t^{eol} can be computed. First, we assume that all bequests are received by households entering the economy at age $j = 1$ as endowments of initial financial wealth a_1 and allow for variation in this dimension over each (f, z) demographic indexed by $e = \{1, \ldots, ne\} \in E$. To derive this distribution, we compute the mean and standard deviation of each net worth[39] quintile for twentyfour- to twenty-six-year old single and married individuals, respectively, from a truncated sample of the 1989 to 2016 waves of the *Survey of Consumer Finances*.[40] We obtain the following mean and standard deviations for single and married household quintiles:

$$\bar{x}^s = \{-2304, 731, 5628, 15185, 51054\},$$

$$\bar{x}^m = \{1845, 7252, 15606, 33219, 83852\},$$

$$s^s = \{1369, 872, 1885, 3738, 15916\},$$

$$s^m = \{1433, 1961, 3131, 7029, 23905\}.$$

For each quintile and marital status combination, we draw $ne = 20$ pseudorandom numbers from standard normal distribution with the associated mean and standard deviations. We then set the distribution for each (f, z) demographic by performing an inverse hyperbolic sine transformation to these draws. It is assumed that this distribution is time-invariant and aggregates to:

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

where $\Omega^e = \frac{1}{ne}$ is the measure of endowment level e. While this variation in endowment level does not change the dynamic optimization problem, endowment heterogeneity does add an additional layer of aggregation such that for any variable x:

$$x_{t,j}^{f,z} = \int_E x_{t,j}^{f,z,e} \Omega^e \, de.$$

Therefore in each year of the simulation, $nf \times nz \times ne$ households enter the model. To reduce notational clutter, we assume this level of aggregation is implicit in our definition of equilibrium in Appendix D.

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

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

Firm production technology, financing, and housing. As our current specification of firm production technology and the housing sector follow from

Moore and Pecoraro (2020b), the calibration strategy for computing parameter values for factor shares, economic depreciation rates, capital adjustment costs, housing transaction costs, and minimums remain the same as that described in the Appendix of that paper. Those parameter values are reported in table C1. The strategy for calibrating the additional parameter values used in our current two-sector framework is described below and summarized in table C3.

While the corporate and noncorporate firms are assumed to finance operations with some combination of debt and equity, each representative firm maintains a constant debt to capital ratio $\varkappa^{b,q}$ for $q = c, n$. These parameter values are set to $\varkappa^{b,c} = 0.435$ and $\varkappa^{b,n} = 0.085$ to target an initial steady-state ratio of interest expense to aggregate output for the corporate and noncorporate sectors of 0.039 and 0.003, which are computed from the SOI and NIPA for 2016.

While distributions of pass-through income to households from the noncorporate firm are computed as a residual from the noncorporate firm's cash flow equation, the corporate firm distributes dividends to households as a $\varkappa^d$ portion of after-tax earnings. This parameter is set to $\varkappa^d = 0.15$, which targets the ratio of net dividends of domestic C-corporations to aggregate output of 0.031 as measured by NIPA for 2016.

So that the model can reproduce the relative sizes of output produced by corporate and noncorporate sectors, we incorporate time-invariant scale parameters Z^q for $q = c, n$ on the firms' production functions. Targeting the ratio of corporate gross receipts to total business gross receipts equal to 0.692 as computed from the SOI for 2016, we set $Z^c = 1.03$ and $Z^n = 1$.

Government: Public capital and debt. The level of productive public capital is set endogenously, so that the initial steady-state ratios of federal and state-local public capital to output are 18.4 and 55.1 percent, which are the average observed values over 2007 to 2016 from NIPA.

The rate of return on public debt is parameterized function of the federal debt-output ratio and the private bond real interest rate. The parameter ς determines the response of this interest rate to changes in the debt-output ratio and is set equal to 0.1910, which implies that the interest rate 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). The parameter ϖ determines the response to changes in the private bond real interest rate and is set so that, given ς and the steady-state debt-output ratio, net interest payments relative to output in the initial steady-state match the average value projected over 2017 to 2027 in *The Budget and Economic Outlook: 2017 to 2027*, which is 2.1 percent.

State and local government. The linear state and local tax rate τ^{sl} is exogenously set to an effective rate of 5.81 percent 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 to 2014, and the average portion of total residential capital that is not consumer durables as reported by NIPA for 2007 to 2016. Finally, 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 to 2016 average computed from NIPA estimates.

Adjustments to economic income. To account for differences between personal economic income and adjusted gross income (Ledbetter, 2007), we use "calibration ratios" to scale each particular flow of economic income which may be subject to taxation.[41] All calibration ratios are assumed to be time-invariant but may exogenously be changed in response to policy.

Under both the ITC and CTS tax systems, adjusted labor income is obtained from labor income in the same fashion. For working-age households, adjusted gross labor income, $\hat{i}_{t,j}^{f,z}$, comes from wage income, for which we apply an (f, z) demographic specific calibration ratio, $\chi^{w,f,z}$:

$$\hat{i}_{t,j}^{f,z} \equiv \begin{cases} \chi^{w,s,z}\left(n_j w_t z_j^{s,z}\right) & \text{if} \quad j \leq R \text{ and } f = s \\ \chi^{w,m,z}\left(\left(n_j^1 + \mu^z n_j^2\right) w_t z_j^{m,z}\right) & \text{if} \quad j \leq R \text{ and } f = m \end{cases}.$$

For retired households, adjusted gross labor income comes from social security income, for which we apply a single calibration ratio, χ^{SS}, for all households:

$$\hat{i}_{t,j}^{f,z} \equiv \chi^{SS} ss_{t,j}^{f,z} \quad \text{if} \quad j > R$$

Adjusted gross capital income, $r_t^p \hat{a}_{t,j}^{f,z}$, is obtained from total capital income in a different manner across the ITC and CTS tax systems because we must distinguish between ordinary and preferential capital income under the former to determine tax liabilities. Letting $s_{t,k}^o$ and $s_{t,k}^p$ denote the share of each gross capital income type k to be treated as ordinary and preferential respectively, then:

$$r_t^p \hat{a}_{t,j}^{o,f,z} \equiv r_t^p \left(\sum_k \chi_k s_{t,k}^o \right) a_{t,j}^{f,z}, \quad r_t^p \hat{a}_{t,j}^{p,f,z} \equiv r_t^p \left(\sum_k \chi_k s_{t,k}^p \right) a_{t,j}^{f,z}$$

where χ_k is a calibration ratio for each particular capital income type k, and the aggregate consistency condition $\Sigma_k \left(s_{t,k}^o + s_{t,k}^p \right) = 1$ is imposed. Total adjusted gross capital income is then the sum of $r_t^p \hat{a}_{t,j}^{o,f,z}$ and $r_t^p \hat{a}_{t,j}^{p,f,z}$. Under the CTS, adjusted gross capital income is obtained by applying the single calibration ratio, χ^K, to gross capital income:

$$r_t^p \hat{a}_{t,j}^{f,z} \equiv r_t^p \chi^K a_{t,j}^{f,z}.$$

In both tax environments, capital income calibration ratios do not depend on household age. We therefore abstract from lifecycle heterogeneity in the extent to which savings are held in tax-preferred or tax-deferred accounts.

The wage income calibration ratios are set exogenously as the ratio of wage income included in AGI to NIPA-comparable wage income as described in the "Household demographics, preferences, and characteristics" subsection in this appendix and are computed by the JCT-ITM for each (f, z) demographic. The remaining calibration ratios are uniform across demographics and internally calibrated in the steady state to match aggregate tax revenue to output targets computed by the JCT-ITM: the social security calibration ratio is set so that aggregate social security tax receipts relative to output is 0.18 percent. The capital calibration ratios are set to match the targets listed in table 4. Under the ITC tax system, it is assumed that for each capital income type, the portion of aggregate tax revenue attributable to being taxed at ordinary (preferential) rates is proportional to the share of that income type that is treated as ordinary (preferential).[42]

Calibrating tax instruments for policy changes. Both the ITC and CTS are calibrated for a given policy change by adjusting the relevant tax instruments while holding constant income, aggregates, and choice variables associated with the initial steady-state present-law equilibrium. The revenue effect achieved within the model is thus consistent with the notion of a "conventional revenue effect."[43] For each policy experiment in this article, we target the associated revenue effect over 2018 to 2027 as reported in JCT (2017).

While the changes to the taxation of household income differ across tax systems as described below, tax changes at the firm level are made identically under both the ITC and CTS. Specifically, we change the aggregate marginal tax rates on corporate income, noncorporate income, interest income, capital gains, and dividends in the model to target the portion of the total conventional revenue effect due to each respective change. For example, if the portion of the total conventional revenue effect due to the corporate rate reduction is some x dollars over the budget window, the marginal tax rate τ_t^c is changed to generate a within-model revenue effect of x dollars over the budget window, holding the initial baseline equilibrium corporate tax base constant. Any changes to deductions and credits allowed to firms are made in a similar manner.

Internal tax calculator. Changes to the taxation of household income under the ITC are explicitly incorporated in the tax calculator as specified in the statutes of the policy change. For example, when calibrating the model for the individual provisions in TCJA, we replace the original statutory tax rate schedule applied to ordinary income in the internal tax calculator with the new statutory tax rate schedule under TCJA. Following the explicit changes made within the tax calculator, we make two further adjustments: first, we adjust transfer payments $tra_t^{f,z}$ as needed to match the distributional changes of labor income tax liabilities across (f, z) demographics as projected by the JCT-ITM over the budget window. Second, we adjust the calibration ratios for both ordinary and preferential capital income, χ_k^o and χ_k^p, to target the average budget-window revenue effect attributed to each source of capital income as projected by the JCT-ITM. These adjustments ensure that we match the targeted conventional revenue effect at the aggregate level and on average at the (f, z) household demographic level.

Conventional tax specification. Changes to aggregate average and effective marginal tax rates applied to household labor income are made by reparameterizing the Bénabou (2002) tax function to match the changes to $\overline{\text{ATR}}_t^f$ and $\overline{\text{EMTR}}_t^f$ due to the proposal as projected by the JCT-ITM for each f demographic over the budget window. We allow for the parameters $\{\lambda_1^f, \lambda_2^f\}$ to be time-varying to capture different magnitudes of these aggregate rate changes over the budget window. The transfers $tra_t^{f,z}$, set to zero in the initial baseline under the CTS, are set to target the portion of the conventional revenue effect attributable to labor income taxes across (f, z) demographics as projected by the JCT-ITM. Changes to the taxation of household capital income are made by changing the average tax rates on capital income under the proposal as projected by the JCT-ITM for each (f, j) demographic over the budget window. We scale the total change in average tax rates using the calibration ratio to match the portion of the total conventional revenue effect due to capital income tax changes.

Table C1. 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	0.3265
Public capital share of output	g	0.0352
Private capital depreciation rate	δ^K	0.0799
Corporate dividend payout ratio	χ^d	0.150
Debt-capital ratio	$\chi^{b,c}, \chi^{b,n}$	0.435, 0.085
Output scale parameter	Z^c, Z^n	1.03, 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 (ITC)	h^o	1.045
Owner-occupied housing minimum(CTS)	h^o	1.08
Preferences		
Subjective discount factor	β	0.985
Nonhousing consumption share of composite	σ	0.265
Housing/nonhousing consumption substitution parameter	η	−1.053
Utility curvature parameter	$\zeta^{f,\epsilon}$	5
Intensive labor margin disutility (ITC)	$\psi^s, \psi^{m,1}, \psi^{m,2}$	477.0, 291.0, 117.9
Intensive labor margin disutility (CTS)	$\psi^s, \psi^{m,1}, \psi^{m,2}$	521.1, 324.0, 143.1
Extensive labor margin fixed cost (ITC)	ϕ^s, ϕ^m	0.375, 0.220
Extensive labor margin fixed cost (CTS)	ϕ^s, ϕ^m	0.548, 0.225
Children disutility parameter	ϕ^f	0.094
Government		
Public capital depreciation rate	δ^g	0.0317
Interest rate response to federal debt	ς	0.0145

Note: ITC = internal tax calculator; CTS = conventional tax specification.

Table C2. Targeted and Baseline Actual Employment Status by Type of Worker.

	Data (MEPS)			Internal Tax Calculator			Conventional Tax Specification		
Type of Worker	FT	PT	U	FT	PT	U	FT	PT	U
Single	.61	.24	.15	.61	.25	.14	.61	.24	.15
Married Primary	.90	.08	.02	.89	.11	.00	.90	.10	.00
Married Secondary	.42	.32	.26	.42	.33	.25	.42	.32	.26

Note: FT = full time; MEPS = Medical Expenditures Panel Survey; PT = part time; U = unemployed.

Table C3. Targeted and Baseline Actual Aggregate Ratios.

Ratio	Data	Internal Tax Calculator	Conventional Tax Specification
Homeownership ratio	.639 (AHS)	.638	.633
Private business investment to total private investment ratio	.465 (BEA)	.470	.479
Private business investment to output ratio	.162 (BEA)	.165	.170
Corporate gross interest expense to output ratio	.039 (Statistics of Income [SOI]/BEA)	.037	.035
Noncorporate gross interest expense to output ratio	.003 (SOI/BEA)	.003	.003
Corporate net dividends to output ratio	.031 (BEA)	.030	.030
Corporate gross receipts to total business gross receipts ratio	.692 (SOI)	.704	.701

Note: AHS = American Housing Survey; BEA = Bureau of Economic Analysis.

Appendix D

Trend-Stationary Equilibrium

The model is transformed into trend-stationary form as described in equation (B1) of Moore and Pecoraro (2020b), so that a stationary solution method can be used to solve the model. The solution method used here generally follows the algorithm laid out in Appendix C of Moore and Pecoraro (2020b), which finds the global optimum decision rules for households and firms using value function iteration. We define our equilibrium in terms of the transformed model where the tilde accent denotes a variable that has been detrended for exogenous population and/or technological growth.

For each age cohort, j, productivity type, z, and family composition f, households have ordinary consumption, $\tilde{c}^i$, charitable giving, $\tilde{c}^g$, market labor hours, n, n^1, and n^2, owner-occupied housing services consumption, $\tilde{h}^o$, rental housing services consumption $\tilde{h}^r$, financial wealth $\tilde{a}$, 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 childcare costs $\tilde{\kappa}$ depend exogenously on a household's contemporaneous choice of market labor supply. End-of-life expenditures $\tilde{c}^{\text{eol}}$ 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 $\tilde{\tilde{\Gamma}}$.

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 $\tilde{I}$nc, 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 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 $\{\tilde{c}_{t,j}^{i;f,z}(\tilde{y})$, $\tilde{c}_{t,j}^{g;f,z}(\tilde{y})$, $n_{t,j}^{z,s}(\tilde{y})$, $n_{t,j}^{z,m,1}(\tilde{y})$, $n_{t,j}^{z,m,2}(\tilde{y})$, $\tilde{h}_{t,j}^{o;f,z}(\tilde{y})$, $\tilde{h}_{t,j}^{r;f,z}(\tilde{y})$, $\tilde{a}_{t,j}^{f,z}(\tilde{y})$; $\tilde{y}_{t+1,j+1}^{f,z}(\tilde{y})\}$, 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 $\{\tilde{N}_t, \tilde{H}_t^o, \tilde{H}_t^r, \tilde{D}_t, \tilde{C}_t, \tilde{I}nc_t, \tilde{K}_t, \tilde{G}_t, \tilde{B}_t, \tilde{B}_t^g\}$, and the set of tax instruments and transfers 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:

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

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

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

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

$$\tilde{C}_t = \int_{\mathbb{Z}}\int_J \sum_{f=s,m} \tilde{\Omega}^{f,z}_{t,j} \left((\tilde{c}^{i;f,z}_{t,j}(\tilde{y}) - \tilde{c}^{h;f,z}_{t,j}) + \tilde{c}^{g;f,z}_{t,j}(\tilde{y}) + \tilde{\kappa}^{f,z}_{t,j} \right) dj\, dz + \tilde{c}^{\text{eol}}_t.$$

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

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

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

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

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:

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

where assets are priced to eliminate any arbitrage opportunities:

$$R^c_t = R^n_t = (1 - \tau^i_t)i_t = p^r_t - \delta^r,$$

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:

$$r^p_t = \tilde{D}^{-1}_t \tilde{\mathrm{I}}\mathrm{nc}_t.$$

7. The goods market clears such that:

$$\sum_{q=c,n} Z^q (\tilde{G}_t)^g (\tilde{K}^q_t)^\alpha (A_t \tilde{N}^q_t)^{1-\alpha-g} = \tilde{C}_t + \tilde{I}_t + \tilde{G}_t,$$

where private aggregate investment is defined as:

$$\tilde{I}_t \equiv \tilde{I}^c_t + \tilde{I}^n_t + \tilde{I}^o_t + \tilde{I}^r_t + \tilde{\Phi}^H_t,$$

with:

$$\tilde{I}^c_t = \tilde{K}^c_{t+1}(\Upsilon_P \Upsilon_A) - (1 - \delta^K)\tilde{K}^c_t + \Xi^c_t,$$

$$\tilde{I}^n_t = \tilde{K}^n_{t+1}(\Upsilon_P \Upsilon_A) - (1 - \delta^K)\tilde{K}^n_t + \Xi^n_t,$$

$$\tilde{I}^o_t = \tilde{H}^o_{t+1}(\Upsilon_P \Upsilon_A) - (1 - \delta^o)\tilde{H}^o_t,$$

$$\tilde{I}^r_t = \tilde{H}^r_{t+1}(\Upsilon_P \Upsilon_A) - (1 - \delta^r)\tilde{H}^r_t,$$

$$\tilde{\Phi}^H_t = \int_{\mathbb{Z}} \int_J \sum_{f=s,m} \tilde{\Omega}^{f,z}_{t,j} \phi\left(\tilde{h}^{o;f,z}_{t+1,j+1}(\tilde{y}) + \tilde{h}^{r;f,z}_{t+1,j+1}(\tilde{y})\right) dj\, dz,$$

and where aggregate government expenditures is defined as:

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

with:

$$\tilde{I}_t^{\text{fed}} = \tilde{G}_{t+1}^{\text{fed}}(\Upsilon_P\Upsilon_A) - (1-\delta^g)\tilde{G}_t^{sl},$$

$$\tilde{I}_t^{sl} = \tilde{G}_{t+1}^{sl}(\Upsilon_P\Upsilon_A) - (1-\delta^g)\tilde{G}_t^{sl}.$$

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

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

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:

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

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

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

and transfers are:

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

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:

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

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

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:

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

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.

Authors' Note

A previous version of this article was circulated under the title "Modeling the Internal Revenue Code in a Heterogeneous-Agent Framework: An Application to TCJA." 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.

Data Availability Statement

The macroeconomic model used in this article is developed and maintained by the authors for use by the Joint Committee on Taxation in providing the US Congress with macroeconomic analyses of major tax legislation. The computer programs used to produce the final simulation results of this article are therefore proprietary as they are also used to provide confidential estimates to the members of the US Congress. In addition, a substantial portion of the data used in this article come from confidential individual tax returns housed at the

Internal Revenue Service of the United States. Those without access may seek access through the Joint Statistical Research Program of the Internal Revenue Service. We make every effort in our article to explain how these data are used, so that outside researchers with independent access to the data may replicate our work.

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Notes

1. Ordinary capital income consists of interest income, noncorporate business distributions, short-term capital gains, and nonqualified corporate dividends. In 2017, there were seven tax brackets on the ordinary income statutory tax schedule—10, 15, 25, 28, 33, 35, and 39.6 percent—where the applicable rates depend on income ranges that vary with filing status.
2. Preferential capital income consists of long-term capital gains and qualified corporate dividends. In 2017, there were three tax brackets on the preferential capital income statutory tax schedule—0, 15, and 20 percent—where the applicable rates depend on income ranges that vary with filing status.
3. This statistic is from data created by the Statistics of Income (SOI) division of the Internal Revenue Service's 2017 sample of individual income tax returns.
4. This issue has been recognized in prior literature such as Guvenen, Kuruscu, and Ozkan (2014), who argue that the complexity of capital taxation is a reason to completely abstract from modeling it when studying labor income taxation.
5. See Joint Committee on Taxation (JCT, 2017) for a list of provisions contained in PL 115-97, colloquially known as the "Tax Cuts and Jobs Act."
6. The previous-law statutory tax rate schedule on corporate income in the United States with maximum rate of 35 percent and replaced it with a single 21 percent statutory rate beginning in calendar year 2018.
7. The major changes included an overall reduction in statutory rate tax rates on ordinary income, expansion of the standard deduction, modification of itemized

deductions, 20 percent deduction of qualified business income for pass-through entities, repeal of personal exemptions, and expansion of the child tax credit.

8. In particular, expansions to the previous work described in this article reflect a version of the overlapping generations model built by the authors for use by the JCT in providing the US Congress with macroeconomic analyses of major tax legislation.
9. These provisions include the 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; limitation on overall itemized deductions; net investment income and Medicare surtaxes; and dependent care credit.
10. See Congressional Budget Office (2019) for a historical analysis of statutory versus effective federal tax rates on labor income.
11. We do not model the choice of a given firm to be a corporate or noncorporate entity as in Raei (2020b). Rather, we allow for the relative size of the representative corporate and noncorporate firms to depend on their investment and hiring choices.
12. 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.
13. These various types of consumption are relevant for tax purposes and considered because their special tax treatment produces heterogeneity in effective marginal tax rates (Moore and Pecoraro 2020b). This consumption detail is described in Appendix A.
14. Using the internal tax calculator requires evaluating the tax consequences of every possible combination of choice variables at every possible household-level state. The number of combinations is significantly reduced by using discrete labor supply choice set instead of a continuous one.
15. As emphasized in Chang, Kim, and Schorfheide (2013), indivisible labor implies that the aggregate labor supply elasticity is endogenous and depends on the distribution of reservation wages across households, which itself does not fully depend on the parameterization of the labor subutility function.
16. The functional form for instantaneous utility is chosen because it is consistent with a balanced growth path in the presence of fixed costs from working. See Holter, Krueger, and Stepanchuk (2019) for a proof.
17. See the "Household Demographics, Preferences, and Characteristics" subsection in Appendix C for details.

18. An alternative, infinitely lived financial intermediary framework could be structured to yield the same no-arbitrage condition derived here.
19. Adjusted gross income (AGI) is a concept used by the Internal Revenue Service to measure income for tax purposes. This differs from economic income, such as the personal income measures produced by the Bureau of Economic Analysis. See Ledbetter (2007) for a discussion.
20. In the "Adjustments to Economic Income" subsection in Appendix C, we describe our process for capital income aggregation by source and the process by which adjustments are made to gross economic income to arrive at AGI.
21. JCT's Individual Tax Model (JCT-ITM) 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 more a 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).
22. The assumed portions of noncorporate business income, dividend income, capital gains, interest income, and rental income treated as ordinary are 100, 25.3, 9.5, 60, and 100 percent, respectively.
23. We omit time subscripts when referring to variables in the initial steady state.
24. The average tax rates are derived by dividing the figures in table 2 by the corresponding figures in table 3 for each (f, z) demographic. We report these components separately because, as described in the "Household Demographics, Preferences, and Characteristics" subsection in Appendix C, adjusted gross labor income for each demographic is calibrated internally by choosing individual labor productivity to meet the specified income target.
25. Since rental income is a relatively small portion of total capital income and receives the same tax treatment as noncorporate business income, the tables combine the two.
26. See Moore and Pecoraro (2020b) for a derivation.
27. Although taxes are not levied directly on the noncorporate firm, the noncorporate firm's behavior must be consistent with the tax liabilities associated with noncorporate income paid at the household level. The only tax liabilities associated with noncorporate income entering the government's budget constraint are those at the household level.
28. We compute the effective marginal tax rate (EMTR) by adding 1 percent to the taxpayer's adjusted gross labor income.
29. The EMTR is not necessarily statutory tax rate, even if the incremental income used to compute the EMTR does not cause the taxpayer to move across statutory marginal tax brackets.
30. In the baseline steady state, about 66 percent of total adjusted gross capital income is characterized as ordinary. Since every household has the same

portfolio composition, each household then faces the same proportional shock.

31. If the shock were to persist for a second period, households would have an additional incentive to change their savings in response to changes in the after-tax return to future capital income.
32. See the "Calibrating Tax Instruments for Policy Changes" subsection in Appendix C for a description of how each tax system is calibrated for policy changes.
33. Delayed adjustment of fiscal instruments to maintain fiscal sustainability minimizes the within-budget-window bias associated with the specific "fiscal closure" rule chosen. See Moore and Pecoraro (2020a) for a discussion.
34. The conventional revenue target from JCT (2017) is the estimated change in tax receipts from those projected under a present-law baseline forecast, holding constant gross national product. See JCT (2011) for a discussion of the conventional estimation methodology.
35. Noncorporate distributions increase immediately before a long-run decline because the noncorporate firms' investment expenses decline faster than noncorporate output itself.
36. Under the conventional tax specification, productivity unweighted labor hours increase throughout the budget window while productivity weighted labor supply remains roughly constant. This results from the initial labor supply response being largely driven by low-productivity workers under that tax system.
37. Parameters calibrated to the single year 2018 in Moore and Pecoraro (2020b) are calibrated to the single year 2017 here, while parameters calibrated from 2018 to 2028 projections in the former paper are calibrated from 2017 to 2027 projections presented in The Budget and Economic Outlook: 2017 to 2027.
38. Our "NIPA-comparable" measure is computed using the JCT-ITM by adding to AGI wage income (i) combat pay, (ii) employers' share of the Federal Insurance Contributions Act (FICA) tax, (iii) deferred 401k compensation, (iv) employers share of 401k compensation, (v) employer provided dependent care, (vi) employer health-insurance compensation, (vii) employer Health Savings Account (HSA) compensation, and (viii) employer life-insurance compensation.
39. We define financial wealth 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).

40. We truncate the sample by disregarding all observations in the bottom 20 percent and top 10 percent 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 percent 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 10 percent of the distribution requires that the net worth grid be impractically large, generating untenable curse of dimensionality issues.
41. See Altshuler et al. (2005) for a discussion of calibration ratios.
42. Since rental income is a relatively small portion of total capital income and receives the same tax treatment as noncorporate business income, the tables combine the two.
43. The conventional revenue effect is the estimated change in tax receipts from those projected under a present law baseline forecast, holding constant gross national product. See JCT (2011) for more details.

References

Altig, D., A. J. Auerbach, L. J. Kotlikoff, K. A. Smetters, and J. Walliser. 2001. "Simulating Fundamental Tax Reform in the United States." *American Economic Review* 91 (3): 574–95.

Altig, D., and C. T. Carlstrom. 1999. "Marginal Tax Rates and Income Inequality in a Life-cycle Model." *American Economic Review* 89 (5): 1197–215.

Altshuler, R., N. Bull, J. Diamond, T. Dowd, and P. Moomau. 2005. "The Role of Dynamic Scoring in the Federal Budget Process: Closing the Gap between Theory and Practice." *American Economic Review: Papers & Proceedings* 95 (2): 432–36.

Andreoni, J. 1989. "Giving with Impure Altruism: Applications to Charity and Ricardian Equivalance." *The Journal of Political Economy* 97 (6): 1447–58.

Bénabou, R. 2002. "Tax and Education Policy in a Heterogeneous-agent Economy: What Levels of Redistribution Maximize Growth and Efficiency." *Econometrica* 70 (2): 481–517.

Borella, M., M. De Nardi, and F. Yang. 2019. "Are Marriage-related Taxes and Social Security Benefits Holding Back Female Labor Supply?" *NBER Working Paper (26097)*. Cambridge, MA: NBER.

Bridgman, B. 2016, February. "Accounting for Household Production in the National Accounts: An Update, 1965–2014." *Survey of Current Business* 95 (5): 1–9.

CBO (Congressional Budget Office). 2019. *Congressional Budget Office: Marginal Federal Tax Rates on Labor Income: 1962 to 2028*.

Chang, Y., S.-B. Kim, K. Kown, and R. Rogerson. 2011. "Interpreting Labor Supply Regressions in a Model of Full- and Part-time Work." *American Economic Review* 101 (3): 476–81.

Chang, Y., S.-B. Kim, and F. Schorfheide. 2013. "Labor-market Heterogeneity, Aggregation and Policy (In)Variance of DSGE Model Parameters." *Journal of the European Economic Association* 11:193–220.

Cho, S.-W., and J. L. Francis. 2011. "Tax Treatment of Owner Occupied Housing and Wealth Inequality." *Journal of Macroeconomics* 33:42–60.

Conesa, J. C., S. Kitao, and D. Krueger. 2009. "Taxing Capital? Not a Bad Idea After All!" *American Economic Review* 99 (1): 25–48.

DeBacker, J., R. W. Evans, and K. L. Phillips. 2019. "Integrating Microsimulation Models of Tax Policy into a DGE Macroeconomic Model." *Public Finance Review* 47 (2): 207–75.

Díaz-Giménez, J, and J. Pijoan-Mas. 2006. "Flat Tax Reforms in the U.S.: A Boon for the Income Poor." CEPR Discussion Papers 5812, C.E.P.R. Discussion Papers. https://www.cemfi.es/ftp/wp/0611.pdf

Díaz-Giménez, J., and J. Pijoan-Mas. 2019. "Investment Expensing and Progressivity in Flat-tax Reforms." *Journal of the Spanish Economics Association* 20: 365–99.

Fernánez-Villaverde, J., and D. Krueger. 2010. "Consumption and Saving Over the Life Cycle: How Important Are Consumer Durables?" *Macroeconomic Dynamics* 15:725–70.

Gamber, E., and J. Seliski. 2019. "The Effect of Government Debt on Interest Rates." Congressional Budget Office Working Paper. https://www.cbo.gov/publication/55018

Gervais, M. 2002. "Housing Taxation and Capital Accumulation." *Journal of Monetary Economics* 49:1461–89.

Gourio, F., and J. Miao. 2011. "Transitional Dynamics of Dividend and Capital Gains Tax Cuts." *Review of Economic Dynamics* 14:368–83.

Guner, N., R. Kaygusuz, and G. Ventura. 2011. "Taxation and Household Labour Supply." *The Review of Economic Studies* 79 (3): 1113–49.

Guner, N., R. Kaygusuz, and G. Ventura. 2014. "Income Taxation of U.S. Households: Facts and Parametric Estimates." *Review of Economic Dynamics* 17 (4): 559–81.

Guvenen, F., G. Kambourov, B. Kuruscu, S. Ocamps, and D. Chen. 2019. "Use It or Lose It: Efficiency Gains from Wealth Taxation." NBER Working Paper. https://www.nber.org/papers/w26284

Guvenen, F., B. Kuruscu, and S. Ozkan. 2014. “Taxation of Human Capital and Wage Inequality: A Cross-country Analysis.” *Review of Economic Studies* 84: 818–50.

Heathcote, J., K. Storesletten, and G. L. Violante. 2017. “Optimal Tax Progressivity: An Analytical Framework.” *Quarterly Journal of Economics* 132 (4): 1693–754.

Holter, H. A., D. Krueger, and S. Stepanchuk. 2019. “How Does Tax Progessivity and Household Heterogeneity Affect Laffer Curves?” *Quantitative Economics* 10: 1317–1356.

Hotz, V. J., and R. A. Miller. 1988. “An Empirical Analysis of Life Cycle Fertility and Female Labor Supply.” *Econometrica* 56 (1): 91–118.

Hubbard, R., A. Kashyap, and T. Whited. 1995. “International Finance and Firm Investment.” *Journal of Money, Credit and Banking* 27 (3): 683–701.

JCT (Joint Committee on Taxation). 2011. “Joint Committee on Taxation: Summary of Economic Models and Estimating Practices of the Staff of the Joint Committee on Taxation.” JCX-46-11. Joint Committee on Taxation Publication. https://www.jct.gov/publications/2011/jcx-46-11/

JCT (Joint Committee on Taxation). 2015. “Joint Committee on Taxation: Estimating Changes in the Federal Individual Income Tax: Description of the Individual Tax Model.” JCX-75-15. Joint Committee on Taxation Publication. https://www.jct.gov/publications/2015/jcx-75-15/

JCT (Joint Committee on Taxation). 2017. “Estimated Budget Effects of the Conference Agreement for h.r. 1, the ‘Tax Cuts and Jobs Act’.” JCX-67-17. Joint Committee on Taxation Publication. https://www.jct.gov/publications/2017/jcx-67-17/

Kindermann, F., and D. Krueger. September 2020. “High Marginal Tax Rates on the Top 1%? Lessons from a Life Cycle Model with Idiosyncratic Income Risk.” Conditionally Accepted at American Economic Journal: Macroeconomics. 2020. https://cpb-us-w2.wpmucdn.com/web.sas.upenn.edu/dist/9/544/files/2020/09/Top1.pdf

Kitao, S. 2010. “Labor-dependent Capital Income Taxation.” *Journal of Monetary Economics* 57:959–74.

Krueger, D., and A. Ludwig. 2013. “Optimal Progressive Labor Income Taxation and Education Subsides When Education Decisions Are Intergenerational Transfers Are Endogenous.” *American Economic Review: Papers and Proceedings* 103:496–501.

Krueger, D., and A. Ludwig. 2016. “On the Optimal Provision of Social Insurance: Progressive Taxation versus Education Subsidies in General Equilibrium.” *Journal of Monetary Economics* 77:72–98.

Ledbetter, M. 2007. “Comparison of BEA Estimates of Personal Income and IRS Estimates of Adjusted Gross Income.” *Bureau of Economic Analysis: Survey of Current Business*. Bureau of Economic Analysis Publication. https://apps.bea.gov/scb/pdf/2007/11%20November/1107_pi_agi.pdf

Lopez-Daneri, M. 2016. “Nit Picking: The Macroeconomic Effects of a Negative Income Tax.” *Journal of Economic Dynamics and Control* 68:1–16.

Moore, R., and B. Pecoraro. 2020a. “Dynamic Scoring: An Assessment of Fiscal Closing Assumptions.” *Public Finance Review* 87:72–91.

Moore, R., and B. Pecoraro. 2020b. “Macroeconomic Implications of Modeling the Internal Revenue Code in a Heterogeneous-agent Framework.” *Economic Modelling* 48 (3): 340–53.

Nishiyama, S. 2015. “Fiscal Policy Effects in a Heterogeneous-agent OLG Economy with an Aging Population.” *Journal of Economic Dynamics and Control* 61: 114–32.

Poterba, J., and L. Summers. 1984. “The Economic Effects of Dividend Taxation.” NBER Working Papers 1353. Cambridge, MA: National Bureau of Economic Research.

Raei, S. 2020a. “Gradual Tax Reforms: If You Like It, You Can Keep It.” *Journal of Economic Dynamics and Control* 111:103793.

Raei, S., and K. Bilicka. 2020. “Output Distortions and the Choice of Legal Form of Organization.” Unpublished Working paper. https://sepidehraei.weebly.com/uploads/8/3/4/9/83497510/output_distortion_and_the_choice_of_legal_form_of_organization_bilicka_raei.pdf

Ventura, G. 1999. “Flat Tax Reform: A Quantitative Exploration.” *Journal of Economic Dynamics & Control* 23:1425–58.

Zodrow, G., and J. W. Diamond. 2013. “Dynamic Overlapping Generations Computable General Equilibrium Models and the Analysis of Tax Policy: The Diamond-Zodrow Model.” In *Handbook of Computable General Equilibrium Modeling*, Vol. 1, Chap. 11, edited by P. B. Dixon and D. W. Jorgenson, 743–813. Amsterdam, the Netherlands: Elsevier.

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