APPENDIX A: Income inequality literature review

The progressive income tax system is designed to reduce the tax burden of those with a lower ability to pay and shift the burden increasingly to those with a higher ability to pay. Thus, it is commonly believed that an increase in tax progressivity will shift the burden of taxation from the poor to the rich.

While most experts agree that higher progressivity reduces economic growth, they remain divided as to whether tax progressivity reduces inequality or even have any effect on inequality whatsoever.

On one hand, some researchers found that by discouraging human capital investments, tax progressivity leads to higher inequality. Caucutt et al. (2003) show that reductions in the progressivity of labor income tax can positively affect growth and, furthermore, that "a less progressive tax system, which is rarely perceived as an egalitarian measure, gives rise to increased growth, decreased inequality, and greater mobility for the poor in the long run." This mobility up the ladder of success is caused by the increased incentive for human capital accumulation.[7]

Meanwhile, Heathcote, Storesletten and Violante (2010) find that even if a progressive tax succeeds in reducing inequality, such policies can have a negative effect on welfare. For example, more progressive taxation dissuades individuals from acquiring additional education more than under a flat tax. This is because the expected income increase due to additional education would be taxed less, and therefore more valuable.[8]

Gimenez and Pijoan-Mas (2006) find that more progressive tax reform reduces economic output by 2.6 percent but results in a more egalitarian after-tax income distribution.[9] Ventura (1999) also concludes that changes from tax progressivity to a flat-tax regime can bring about large gains in output and productivity at the expense of significant increases in inequality.[10] Erosa and Korkeshova (2007) find that although progressive income taxes can reduce inequality, they have a negative effect on output.[11]

Others have found that tax policy has little impact on inequality. Sarte (1997) highlights that since individuals are endowed with different rates of impatience, they face a different rate of return on both human and physical capital leading to income dispersion. It is because individuals have different rates of impatience that some states are more unequal than others and not necessarily because of their tax regime. As a result, higher top marginal tax rates seem more effective at reducing economic growth than at reducing the degree of long-run income inequality.[12]

Kaymak and Poschke (2016) use 50 years of U.S. data from 1960 to 2010 to find that reductions in the progressivity of the U.S. tax code over this time can explain nearly half of the growth in wealth inequality, but that income inequality is attributable to skill-biased technological change and changes in the wage structure.[13]

Making matters more unclear is the question of whether reductions in the progressivity of individual income taxes have reduced the progressivity of the tax code as a whole. Piketty and Sanz (2007) find the decline in top marginal individual income tax rates in the U.S. since the 1960s has contributed only moderately to the decline in tax progressivity.[14]

Roine, Vlachos and Waldenstrom (2009) found a strong positive affect on lower earners associated with a high top marginal tax rate that suggests progressivity of income taxes has equalizing effects even beyond the direct impact of taxation.[15]

Similarly, Guvenen, Kuruscu, and Ozkan (2014) found that progressive taxation was negatively correlated with a rise in wage inequality when studying the U.S. and countries in Europe.[16]

APPENDIX B: Economic growth literature review

The standard theory of optimal taxation argues that a tax system should maximize social welfare subject to a set of constraints. The goal should be to enact a tax system that maximizes households' welfare, given the knowledge that household members respond to whatever incentives the tax system provides.

Pioneering work on optimal taxation is the research of Frank Ramsey (1927), who suggested that if a social planner must raise a given amount of tax revenue, he must do so such that only commodities with inelastic demand are taxed.[17] Another important contribution on this topic is the work of James Mirrlees (1971), who posited that when a tax system aims to redistribute income to low-income individuals from high-income individuals, the tax system should provide sufficient incentive for high-income taxpayers to keep producing at the high levels that correspond to their ability, even though the social planner would like to target this group with higher taxes.[18] This is because a higher tax on high-income individuals would discourage them from exerting as much effort to earn that income.

Altig, Auerbach, Kotlikoff, Smetters and Walliser (2001) found that moving away from a flat income tax to a progressive income tax results in aggregate output losses.[19]

Bakija and Slemrod (2004) found that higher taxes on the wealthiest individuals have a significant effect on migration. High top tax rates encourage the wealthiest taxpayers to flee to states with lower top tax rates.[20] This means enacting a progressive tax could exacerbate Illinois' existing outmigration crisis.

Conesa and Krueger (2006) found that the optimal tax code is a flat tax coupled with a fixed deduction. Lowering the top tax rates encourages work and saving, while the deduction ensures that lowest earners aren't taxed.[21] Peterman (2012) obtains a similar result in a closely related paper that takes into account human capital accumulation under alternative tax specifications.[22]

Wenli and Sarte (2004) found that the decrease in progressivity from the 1986 Tax Reform Act helped raise U.S. per capita GDP growth by 0.12 to 0.34 percentage points, as individuals are encouraged to work more or accumulate more skills.[23]

When analyzing the effects of the increase in the Medicare tax and its expansion to unearned income for high-income earners under the Patient Protection and Affordable Care Act of 2010, Carroll and Prante (2012) find that higher marginal tax rates on high-income taxpayers result in a smaller economy, fewer jobs, less investment and lower wages.[24]

Echevarria (2012) similarly found that higher levels of progressivity give rise to lower long-run growth rates via a reduction in savings and capital accumulation.[25] And Rhee (2008) found that with a three-year lag, higher income tax progressivity has a significant negative effect on the economic growth.[26]

APPENDIX C: Estimating the impact of progressive taxation in the neoclassical growth model

This paper examines the effect of taxing the labor income of workers with different ability levels in a standard neoclassical economy.

Individuals make consumption, labor supply and savings decisions in each period so as to maximize their lifetime utility. Firms operate a neoclassical production technology: factors are paid their marginal products. The payments received by individuals on their factors (capital and labor) are subject to proportional taxes. The government uses the revenues from taxation to finance an exogenously given stream of government purchases. Note that for any given fiscal policy, individual behavior implies a particular allocation.

The model

This theory has a household that faces a labor-leisure decision and a consumption-savings decision. Each household is populated with household members differentiated by their earning ability. The household chooses paths of consumption and savings to solve:

$$\max_{c_t(z)\geq 0, i_t(z), 0\leq l_t(z)\leq 1} \sum_{t=0}^{\infty} \beta^t \ln C_t - \theta\left(\sum_j^J \mu_j l_t(z_j)\right)^{1+\frac{1}{\chi}} + \vartheta(G_t)$$

Such that: $$C_t(z) + I_t(z) = \left(\sum_j^J \left(1-\tau_t^l(z_j)\right)\mu_j W_t(z_j) l_t(z_j)\right) + R_t K_{t-1} + S_t + M_t$$

$$K_{t+1} = I_t + (1-\delta)K_t$$

$$K_0 > 0$$

Like Baxter and King (1993)[27] or McGrattan (1994)[28], it is assumed that government spending may be valuable only insofar as it provides utility separably from consumption and leisure. C_t, I_t, denote private consumption, investment in new physical capital. S_t is a government transfer when positive and lump sum tax when negative. Asset payments from abroad are denoted by M_t. The exogenous income or expenditure (when negative) captures a positive or negative trade balance, which introduces trade in a minimalist way. The trade balance influences the reaction of steady-state labor to tax changes. The household has to pay a tax on income τ_t^l. R_t is the interest rate. $W_t(z)$ is the wage, specific to each type of worker in the household. μ_j is the time-invariant fraction of household members with productivity z_j.

The parameter σ regulates the Frisch elasticity of labor supply and θ is a scaling factor that helps match total hours in the data. The Frisch elasticity of labor supply measures how hours respond to wage changes abstracting from its effect on wealth. The Frisch elasticity does not capture the total effect on hours from wage shocks. It captures the component due to inter-temporal substitution effects, but not the one due to wealth effects. This analysis follows Kimball and Shapiro (2008)[29] in setting this value equal to one.

The representative firm maximizes profits:

$$\max_{K_{t-1}, l_t(z_j)} Y_t - R_t K_{t-1} - \sum_j^J \mu_j W_t(z_j) l_t(z_j)$$

Where: $Y_t = K_{t-1}^{\alpha} L_t^{(1-\alpha)}$ and $L_t = \left(\sum_j^J \left(\mu_j l_t(z_j)\right)^{\rho}\right)^{1/\rho}$

In the model used for this analysis, the elasticity of substitution between different types of workers (that is, the percentage change in demand for low (high) skill workers for a percentage change in the price of high (low) skill workers) is given by $\chi \equiv 1/(1-\rho)$. The elasticity of substitution between factor inputs is a measure of the ease with which a varying factor can be substituted for others. Skilled and unskilled workers are gross substitutes, when the elasticity of substitution $\chi > 1$ (or $\rho > 0$) and gross complements when $\chi < 1$ (or $\rho < 0$). When two productive inputs are gross substitutes, a lower supply of one creates added demand for the other. When these inputs are gross complements, a lower supply of one reduces demand for the other. The consensus in the economics literature across estimates for the U.S. is that $\chi \approx 2$, with the most commonly used estimate of $\chi = 1.4$.

Government faces the budget constraint $G_t = T_t$. Tax revenues are given by:

$$T_t = \left[\left(\sum_j^J \tau_t^l(z_j)\mu_j W_t(z_j) l_t(z_j)\right)\right]$$

The aggregate resource constraint is:

$$Y_t = C_t + I_t + G_t + M_t$$

The definition of equilibrium is standard. In equilibrium, the household chooses plans to maximize its utility, the firm solves its maximization problem and the government sets policies that satisfy its budget constraint.

Model parameterization

Using regional data on Illinois from the Bureau of Economic Analysis and state tax collections from the Illinois Department of Revenue, the model is calibrated so that the steady state matches the average position of the Illinois economy between 2003 and 2015.

The characterization of the deterministic steady state of the model is of interest since the steady-state facilitates the calibration of the model. This is because, to a first approximation, the deterministic steady state coincides with the average position of the model economy. In turn, matching average values of endogenous variables to their observed counterparts (e.g., matching observed average values of the labor share, the consumption shares, or the investment to output ratio) can reveal information about structural parameters that can be exploited in the calibration of the model.

Parameters	Value	Restriction
Capital share of income	$\alpha = 0.30$	Bureau of Economic Analysis
Net flows from abroad	$M/Y = -0.06$	Implied from BEA data on consumption, investment and government expenditures
Depreciation rate of capital	$\delta = 0.08$	
Weight of labor	$\theta = 3.88$	Set to match hours L=0.21
Labor supply elasticity	$\sigma = 1$	
Elasticity of substitution between labor inputs	$\rho = 0.5$	
Fraction of individuals who earn \$0-\$50,000	$\mu_1 = 0.59$	$z_1 = 1$
Fraction of individuals who earn \$50,001-\$100,000	$\mu_2 = 0.23$	$z_2 = 3.74$
Fraction of individuals who earn \$100,001-\$500,000	$\mu_3 = 0.17$	$z_3 = 8.86$
Fraction of individuals who earn more than \$500,001	$\mu_4 = 0.01$	$z_4 = 80.85$

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Individuals within the model are subject to an effective tax rate, calculated as follows:

$$\tau_t^l(z_j) = \frac{T_t(z_j)}{W_t(z_j)l_t(z_j)}$$

APPENDIX D: Estimating the impact of progressive taxation in the overlapping generations model

This appendix introduces another model that assumes finite lives for economic agents. The results are consistent with the findings of the model used in Appendix C. The basic model is taken from Echevarria (2012).[30] The model analyzes the implications of the progressivity of income taxation in a standard two-period, overlapping generations model economy.

There are two sectors in the economy: a private one (households and firms) which makes its decisions in a perfectly competitive market framework; and a government which levies a progressive income tax to finance some exogenous level of expenditure which is neither productive nor enters households' preferences.

As for the households, this is an OLG economy, populated by a continuum of young individuals and a continuum of old individuals which coexist at any time, in which population is assumed to grow at an exogenous, constant rate. The productive sector is represented by a continuum of competitive firms of measure one. All firms use the same production technology of constant returns to scale in capital and labor and are exposed to a positive externality given by the aggregate stock of capital per unit of labor. Furthermore, all firms are exposed to the same aggregate technological shock.

Suppose an individual born at time t who lives for two periods and whose preferences over young and old period consumption ($c_{1,t}$ *and* $c_{2,t+1}$, respectively) are in the spirit of the preference class used by Weil (1990).[31] In particular, he/she maximizes the utility function:

$$V_t(c_{1,t}, c_{2,t+1}) = \frac{c_{1,t}^{1-1/\sigma}}{1-1/\sigma} + \beta \frac{c_{2,t+1}^{1-1/\sigma}}{1-1/\sigma}$$

$\beta \in (0,1)$ represents a time preference parameter which, in the case of no uncertainty, denotes the discount factor. The intertemporal elasticity of substitution for consumption (IES) being given by $\sigma > 0, \sigma \neq 1$.

Individuals inelastically supply one unit of labor in their first period and a fraction $\theta \in [0,1)$ of their time endowment in their second period. Progressive income taxation implies that individuals with different incomes face different average (and marginal) tax rates.

In this simple economy, there are only two types of individuals with, possibly, different incomes: young, whose incomes consist exclusively of wages; and old, who obtain capital and labor income (if $\theta > 0$). Thus, a distinction is made between the average tax rates faced by young and old at time t; τ_t^y and τ_t^o, respectively.

Denoting the first-period savings at *t* by *st*, the wage rate per unit of labor at *t* by *wt*, and the interest rate paid at *t + 1* by r_{t+1}, one obtains the first and second-period individual budget constraints as:

$$c_{1,t} + s_t = (1 - \tau_t^y) w_t$$

$$c_{2,t+1} = (1 + r_{t+1}) s_t (1 - \tau_{t+1}^o) + \theta (1 - \tau_{t+1}^o) w_{t+1}$$

Combining both budget constraints leads to:

$$s_t = \frac{\left[c_{2,t+1} - \theta(1 - \tau_{t+1}^o) w_{t+1}\right]}{(1 + r_{t+1})(1 - \tau_{t+1}^o)}$$

$$c_{1,t} + \frac{\left[c_{2,t+1} - \theta(1 - \tau_{t+1}^o) w_{t+1}\right]}{(1 + r_{t+1})(1 - \tau_{t+1}^o)} = (1 - \tau_t^y) w_t$$

Let us suppose that a profit-maximizing firm acts competitively in the output and production factor (capital and labor) markets without adjustment costs in production inputs. Formally, the problem this firm faces at time *t* is written as:

$$\max_{K_t^i, N_t^i} Y_t^i - (r_t + \delta) K_t^i - w_t N_t^i$$

Where:

$$Y_t^i = A_t {K_t^i}^{\alpha} {N_t^i}^{(1-\alpha)} {k_t}^{(1-\alpha)}$$

Where Y_t^i denotes output, N_t^i denotes labor, K_t^i denotes physical capital, $\alpha \in (0,1)$ denotes the capital income share, and δ is the depreciation rate of capital. First, all firms (uniformly distributed on the interval *[0,1]*) are exposed to a common stochastic shock A_t.

Total factor productivity is assumed to be generated by the following process:

$$\ln A_t = \ln \hat{A} + \epsilon_t$$

It is assumed that there is a positive externality in the production process so that *ith* firm's output depends not only on the inputs hired by that firm, but also on the average number of units of capital per unit of labor for the whole economy:

$$k_t \equiv \frac{K_t}{N_t},$$

$$K_t \equiv \int_{[0,1]} K_t^i di$$

$$N_t \equiv \int_{[0,1]} N_t^i di$$

The solution to the firm's problem (with full capital depreciation) is given by:

$$r_t = \alpha A_t - 1$$

$$w_t = (1-\alpha)A_t k_t$$

The government taxes income to finance an exogenous stream of public expenditure $G_t = \gamma Y_t$ The income tax code is similar to Li and Sarte (2004)[32], where the tax rate positively depends on an individual's income relative to average income. Thus, the average tax rate paid by individual i is given by:

$$\tau_t^i = \zeta_t \left(\frac{y_t^i}{y_t}\right)^{\phi}$$

for some $\zeta_t \in [0,1)$ and $\phi \gg 0$ where $i \in \{y, o\}$. This expression implies that the marginal tax rate faced by an individual is $(1+\phi)\tau_t^i$. Note that if $\phi = 0$ then the tax is proportional. $1+\phi$ is the ratio between the marginal and the average tax rate, a natural indicator of the progressivity of the tax schedule.

Labor market equilibrium:

Using Jt to denote the number of young individuals at t, aggregate labor demand and labor supply are Nt and $\left[\frac{1+n+\theta}{1+n}\right]Jt$ respectively, so that:

$$Nt = \left[\frac{1 + n + \theta}{1 + n}\right]Jt$$

Goods market equilibrium:

As is standard in two-period OLG models with no financial assets at birth, equilibrium in the goods market requires that young individuals' savings be equal to next period's aggregate stock of capital. Therefore, given the equilibrium condition in the labor market, equilibrium in the goods market can be written as:

$$st = (1 + n + \theta)k_{t+1}$$

Tax rates in equilibrium:

A young individual's income at time t equals:

$$y_t^y = (1-\alpha)A_t k_t$$

An old individual's income equals:

$$y_t^o = \theta(1-\alpha)A_t k_t + (1+r_t)s_{t-1} = \Omega A_t k_t$$
$$\Omega = \theta(1-\alpha) + \alpha(1 + n + \theta)$$

Echevarria (2012)[33] shows that per capita income at t is given by:

$$y_t = \frac{(1-\alpha+(1+n)^{-1}\Omega)A_t k_t}{1+(1-n)^{-1}}$$

The tax rates for the young and the old respectively are:

$$\tau_t^y = \left(\frac{(1+(1+n)^{-1})(1-\alpha)}{1-\alpha+(1-n)^{-1}\Omega}\right)^{\phi}$$

$$\tau_t^o = \zeta_t\left(\frac{(1+(1+n)^{-1})\Omega}{1-\alpha+(1-n)^{-1}\Omega}\right)^{\phi}$$

$$\zeta_t = \frac{\gamma(1+n+\theta)[(1-\alpha)(1+n)+\Omega]^{\phi}}{(2+n)^{\phi}[(1-\alpha)^{\phi+1}(1+n)+\Omega^{\phi+1}]}$$

With full capital depreciation, the equilibrium growth rate for the stock of capital per capita is given by:

$$g_t = \frac{(1-\tau_t^y)(1-\alpha)A_t}{1+n+\theta+(\beta\alpha)^{-\sigma}\Omega[1-(1+\phi)\tau_t^o]^{-\sigma}(1-\tau_t^o)A_t^{1-\sigma}} - 1$$

Where: $\Omega \equiv \theta(1-\alpha)+\alpha(1+n+\theta)$

A stationary competitive equilibrium for this economy is a set of sequences (from $t = 0, \dots \infty$) of allocations and factor prices that satisfy the individuals and the firm's problems, growth rates for the stock of capital per unit of labor and income tax rates are such that the government budget is balanced each period.

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