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Heterogeneity and Government revenues: Higher taxes at the top?

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ABSTRACT

How effective is a more progressive tax scheme in raising revenues? We answer this question in a life-cycle economy with heterogeneity across households and endogenous labor supply. Our findings show that a tilt of the U.S. income tax schedule towards high earners leads to small increases in revenue. Maximal revenue in the long run is only 6.8% higher than in our benchmark – about 0.8% of initial GDP – while revenues from all sources increase by just about 0.6%. Our conclusions are that policy recommendations of this sort are misguided if the aim is to exclusively raise government revenue.

1. Introduction

> *Tax reform should follow the Buffett rule: If you make more than* 1 *million a year, you should not pay less than* 30% *in taxes, and you shouldn't get special tax subsidies or deductions. On the other hand, if you make under* $250,000 *a year, like* 98% *of American families, your taxes shouldn't go up.*
>
> Barack Obama. State of the Union speech, January 24, 2012

Recently, calls for closing fiscal deficits have been combined with proposals to shift the tax burden and increase marginal tax rates on high earners. The upshot is that *additional* tax revenue should come from those who earn higher incomes. As top earners account for a disproportionate share of tax revenues and face the highest marginal tax rates, such proposals lead to a natural trade-off regarding tax collections. On the one hand, increases in tax collections are potentially non trivial given the revenue generated by high-income households. On the other hand, the implementation of such proposals would increase marginal tax rates precisely where they are at their highest levels and thus, where the individual responses are expected to be larger. Therefore, revenue increases might not materialize.

In this paper, we ask: how much additional revenue can be raised by making income taxes more progressive? How does the answer depend on the underlying labor supply elasticities? How does the answer depend on tax-revenue requirements (i.e. the pre-existing level of average taxes)? To address these questions, our paper develops an equilibrium life-cycle model with individual heterogeneity and endogenous labor supply. Heterogeneity is driven by initial, permanent differences in

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labor productivity and uninsurable productivity shocks over the life cycle. There are different forms of taxes: a non-linear income tax, a flat-rate income tax (to capture state and local taxes), a flat-rate capital income tax (to mimic the corporate income tax) and payroll taxes.[1]

Our model is disciplined to account for aggregate and cross-sectional facts of the U.S. economy. Parameters are selected so the model is consistent with observations on the dynamics of labor earnings, overall earnings inequality, and the relationship between individual income and taxes paid at the Federal level. In particular, in our parameterization the model economy is consistent with the shares of labor income of top earners. To capture the relationship between income and income taxes paid at the federal level, our analysis uses a parametric *tax function* – put forward by Benabou (2002) and used recently by Heathcote et al. (2016) and others – that captures the effective tax rates emerging from the Internal Revenue Service (IRS) micro data. One of these parameters governs the *level* of average tax rates, while the other controls the *curvature*, or progressivity, of the tax function. The model under this tax function accounts well for the distribution of income taxes paid in the U.S. at the Federal level, which is critical for the question addressed in the paper. Tax liabilities are heavily concentrated in the data – more so than the distributions of total income and labor income. In the data, the first and top quintile of the distribution of income account for 0.3% and about 75% of total revenues, respectively, while the richest 1% accounts for about 23%. Our model is consistent with this rather substantial degree of concentration: the bottom quintile accounts for 0.6% of tax liabilities, the top quintile accounts for nearly 77%, while the richest 1% accounts for about 25% of total revenues. In addition, our model implies an elasticity of taxable income for top earners of about 0.4, a value in line with available empirical estimates.

We introduce changes in the shape of the tax function and shift the tax burden towards higher earners, via increases in the parameter that governs the curvature of the tax function. Across steady states, our findings are that income tax revenues at the Federal level are maximized at average and marginal tax rates at the top that are higher than at the benchmark economy. Our results show a revenue-maximizing parameter that implies an effective marginal tax rate of about 36.6% or higher for the richest 5% of households, while the corresponding value in the benchmark economy is of about 21.6%. In other words, the revenue-maximizing marginal tax rates become about 15% points higher for the richest top 5%. However, the increase in tax revenues from income taxes at the Federal level is small. Across steady states, tax revenues from the Federal income tax increase by only about 6.8% relative to the benchmark case. Moreover, as increases in the curvature of the tax function systematically lead to reductions in savings, labor supply and output, tax collections from other sources fall across steady states. At the level of progressivity that maximizes the Federal income tax revenue, output declines by about 12% while the decline in savings is almost 20%. As a result, overall tax collections – including corporate and state income taxes – increase only marginally by about 0.6%. Therefore, the progressivity that would maximize the total tax revenue is *lower*: it would imply a marginal tax rate of 31.1% for the richest 5% of the households. The associated increase in total tax revenue is 1.5%.

We subsequently conduct exercises to investigate the quantitative importance of different aspects of our analysis. We first investigate the extent to which our findings change under a small-open economy assumption. Conclusions in this case are even stronger, as the increase in revenues from increasing progressivity is smaller than in the benchmark case. Our attention then turns to the magnitude of revenue requirements or the overall average tax rate, approximated by the 'level' parameter in the tax function. Our findings show – in contrast to changes in progressivity – that there are substantial revenues available from mild increases in average rates across all households. For instance, keeping the degree of progressivity of the tax schedule intact but increasing the average tax rate around mean income from 8.9% (benchmark value) to about 13%, increases the Federal income tax revenue and total tax revenue by more than 35% and 19%, respectively. Our analysis also show that when the average taxes are higher, there is less room for a government to raise revenue by making taxes more progressive.

Finally, we increase taxes at high incomes only – instead of generically tilting the tax function towards high earners. Our focus is on the revenue-maximizing taxes applied to the richest 5% of households. Our results indicate that a marginal tax rate of about 42% on the richest 5% of households maximizes Federal income tax revenue. This is about 21 percentage points higher than the marginal tax rate on the top 5% of households in the benchmark economy, and about 6 percentage points higher than in the baseline scenario where progressivity is changed via changes of the whole tax function. The resulting increase in Federal tax revenue (8.4%) is only marginally higher than in our benchmark exercises (6.4%). The rise in total tax revenue associated to a 42% marginal tax rate on the top 5% of households is 3.3%, and higher than in the baseline analysis (0.6%).[2]

[1] Our model framework is by now standard in the macroeconomic and public-finance literature, and in different versions has been used to address a host of issues. Among others, Huggett and Ventura (1999); Conesa and Krueger (1999) and Nishiyama and Smetters (2007) used it to quantify the effects of social security reform with heterogenous households. Altig et al. (2001) used a version without uninsurable shocks to study alternative tax reforms. Ventura (1999) quantified the aggregate and distributive effects of a Hall-Rabushka flat tax. Conesa et al. (2009) assessed the desirability of capital-income taxation and non-linear taxation of labor income. Heathcote et al. (2010) studied the implications of rising wage inequality in the United States. See Heathcote et al. (2009) for a survey of papers in the area.

[2] We also evaluate the robustness of our findings to alternative assumptions on labor supply elasticities, when additional revenue is returned to households, and when average and average marginal tax rates are constant. Our conclusions are unchanged, and even stronger than in the baseline scenario in some cases.

To sum up, our quantitative findings indicate that there are only second-order additional revenues available from a tilt of the income-tax scheme towards high earners. These small increases in revenues are concomitant with substantial effects on output and labor supply, and require large increases in marginal tax rates for high earners. The upshot is that increases in progressivity lead to endogenous responses in the long run, that effectively result in the small effects on revenues found. In turn, these changes in aggregates lead to reduction in tax collection from other sources, with the net effect of even smaller increases in overall revenues. Additional revenue from higher progressivity, however, is larger in the short run since these adjustments take time. Looking at the transitional dynamics, our results show that the level of progressivity that would maximize the revenue from Federal income taxes in the long run would lead to about 16% higher Federal income tax revenue upon impact in the first year. This is more than twice the increase in the long run. After the first year, however, revenue declines rapidly and reaches its steady state level within 5–6 years.

Background: Our paper is related to several strands of literature. By its focus, it is connected to research on the magnitude of relevant labor supply elasticities for use in aggregate models, and their implications for public policy. Chetty et al. (2013), Keane (2011) and Keane and Rogerson (2015) survey recent developments in this literature. Second, it is related to large empirical literature, reviewed by Saez et al. (2012), on the reaction of incomes to changes in marginal taxes. In this area, the recent work by Mertens (2015) is particularly relevant in light of our objectives and findings. This author finds substantial responses to changes in marginal tax rates across all income levels.[3]

Finally, our paper is naturally related with recent work on the Laffer curve in dynamic, equilibrium models. Trabandt and Uhlig (2011) and Fève et al. (2012) and Holter et al. (2015) are examples of this work. Trabandt and Uhlig (2011) focus on the Laffer relationship driven by tax rates on different margins in the context of the one-sector growth model with a representative household. They find that while there is room for revenue gains in the U.S. economy, several European economies are close to the top of the Laffer relationship. Fève et al. (2012) conduct a similar exercise in economies with imperfect insurance, where they highlight the role of government debt on the revenue-maximizing level of taxes. Our analysis differs from the first two papers in key respects, as we take into account household heterogeneity and explicitly deal with the non-linear structure of taxation in practice. These features allow us concentrate on Laffer-like relationships driven by changes in the curvature (progressivity) of the current tax scheme, and investigate the interplay between the 'level' of taxation vis-a-vis the distribution of its burden across households. Holter et al. (2015), in turn, are closer to our work. These authors develop a life-cycle model with heterogeneity, non-linear taxes and labor supply decisions at the extensive margin, and study the structure of Laffer curves for OECD countries. They find that maximal tax revenues would be about 7% higher under a flat-rate tax than under the progressivity level of the U.S. They also find that at the highest progressivity levels in OECD (i.e. Denmark), substantially lower tax revenues are available.

Our paper is also related with ongoing work on the welfare-maximizing degree of tax progressivity. Conesa et al. (2009), Erosa and Koreshkova (2007), Diamond and Saez (2011), Bariş et al. (2015), Heathcote et al. (2016), among others, are examples of this line of work. In particular, our paper bears close connection with Badel and Huggett (2014) and Kindermann and Krueger (2015). Badel and Huggett (2014) study a life-cycle economy where individual earnings are the outcome of risky human-capital investments. They study the welfare effects of increasing marginal tax rates on high earners. They find welfare-maximizing marginal tax rates for top earners that are higher than current ones, but leading to minuscule effects on ex-ante welfare. They also find that such higher rates lead to very small effects on government revenues. These effects on revenues become bigger – and similar to ours – when individual human capital (i.e. hourly wage) is exogenous. Kindermann and Krueger (2015), like the current paper, study a model economy with exogenous human capital and individual idiosyncratic income risk. They model top earners as individuals who experience extreme and temporary productivity shocks, whereas the top earners in the current paper are individuals whose productivity has a substantial permanent component. Hence, top earners in Kindermann and Krueger (2015) react much less to higher taxes than they do in our work. Not surprisingly, these authors find that it is optimal to tax top earners at much higher marginal tax rates.

Our paper is organized as follows. Section 2 presents a parametric example to highlight the key forces at work in our economy. Section 3 presents the life-cycle model that defines our benchmark economy, while we discuss the assignment of parameter values in Section 4. Section 5 contains our main results. Section 6 contains a critical discussion of our results. Finally, Section 7 concludes.

2. Example: the revenue-maximizing degree of progressivity

Consider first a much simpler version of our model economy with three key features: (i) preferences with a constant elasticity of labor supply; (ii) a log-normal distribution of wage rates; (iii) taxes represented by a parametric tax function. This example allows us to highlight the forces shaping the determination of the revenue-maximizing degree of progressivity.

[3] His findings are consistent with the macro literature that finds large effects of tax changes on GDP, e.g. Barro and Redlick (2011) and Mertens and Morten (2013).

Let preferences be represented by $u(c,l)=\log(c)-\frac{\gamma}{1+\gamma}l^{1+\frac{1}{\gamma}}$, where γ is the (Frisch) elasticity of labor supply. These preferences are used later on in our analysis. Individuals are heterogenous in the wage rates they face and labor is the only source of income. Wage rates are log-normally distributed, i.e. $\log(w)\sim N(0,\sigma^2)$.

Finally, the tax function is given by $t(\tilde{I})=1-\lambda\tilde{I}^{-\tau}$, where $\tilde{I}$ stands for household income relative to mean income and $t(\tilde{I})$ is the average tax rate at the relative income level $\tilde{I}$. Hence, at income $I\equiv wl$, total taxes paid amount to $It(\tilde{I})$. This parametric tax function follows Benabou (2002) and Heathcote et al. (2016) and is the function subsequently used in our quantitative study. The parameter λ captures the need for revenue, as it defines the *level* of the average tax rate. The parameter $\tau\geq 0$ controls the curvature of the tax function. If $\tau=0$, then the tax scheme is flat. A higher τ implies higher progressivity.

The first-order conditions for labor choice imply that $l^*(\tau)=(1-\tau)^{\frac{\gamma}{1+\gamma}}$. Hence, labor supply depends only on the curvature parameter τ and the elasticity parameter γ, independently of wage rates and λ. Labor supply is affected by τ as the distortion induced by taxation, which is given by the ratio of 1 minus the marginal tax rate to 1 minus the average rate, is constant, and equal to $(1-\tau)$. Note that the tax scheme leads to changes in labor supply even for preferences for which substitution and income effects cancel out.[4]

Government revenues: Let $E(w)$ stand for mean wages. Then taxes collected from a household with wage rate w is $wl^*[1-\lambda(wl^*/E(w)l^*(\tau))^{-\tau}]$. Aggregate tax revenue, $R(\tau)$, after some algebra and using the fact that wages are log-normal, is given by

$$R(\tau)=l^*(\tau)\underbrace{\left[\exp\left(\tfrac{1}{2}\sigma^2\right)-\lambda\exp\left(\tfrac{1}{2}\left(1+\tau^2-\tau\right)\sigma^2\right)\right]}_{\equiv A(\tau)}=l^*(\tau)A(\tau). \tag{1}$$

Maximizing revenue: Notice that maximizing revenue entails a non-trivial choice of τ, as it depends on the effects of τ on labor supply and on the function $A(\tau)$. Note that the latter function is maximized by a choice of $\tau=1/2$. Thus, since the effects of the curvature of the tax function on labor supply are negative, the revenue-maximizing curvature is always less than 1/2. Under an interior choice, maximizing revenues implies

$$\frac{l^*(\tau)'}{l^*(\tau)}=-\frac{A(\tau)'}{A(\tau)}. \tag{2}$$

Hence, revenue maximization implies a trade-off between the cost of rasing τ, captured by labor supply distortions, and its benefit, captures by $A(\tau)'$ term. After some algebra, (2) becomes

$$-\frac{\gamma}{(1+\gamma)(1-\tau)}=\frac{\lambda\sigma^2(2\tau-1)}{2\left[\exp((1/2)\sigma^2(\tau-\tau^2))-\lambda\right]}. \tag{3}$$

There is a unique revenue-maximizing choice of τ. Note that the left-hand side of the expression above is a continuous function of τ, monotonically decreasing, and becomes arbitrarily small as τ approaches 1. The right-hand side is a continuous, strictly increasing function of τ. Thus, by the intermediate-value theorem, there is a unique τ that solves Eq. (3).[5]

Effects of changes in parameters: Let us now explore the implications of changes in the parameters defining the environment on the revenue-maximizing level of τ. Fig. 1 diagrammatically illustrates the effects of the changes in parameters γ, σ^2 and λ by showing movements in the left and right-hand sides of Eq. (3).

As Fig. 1a shows, an increase in the labor supply elasticity leads to a *lower* revenue-maximizing level of τ. A higher γ increases the cost of a higher τ as the left-hand side of Eq. (3) shifts down. An increase in the labor supply elasticity increases labor supply across all wage levels, but it leads to an increase in revenues – in absolute terms – that is higher at the top than at the bottom of the wage distribution. The revenue-maximizing policy is therefore to reduce the curvature parameter τ to satisfy equation (3).

Fig. 1b shows the effects of changes in the dispersion of wage rates, σ^2. A higher σ^2 increases the slope of the right-hand side of Eq. (3) and as a result a higher τ is associated with higher benefits in term of revenue. An increase in wage dispersion implies more potential revenue from high-wage individuals. This has two opposing effects. First, more potential income at the top, for a given level of labor supply, implies a higher τ. On the other hand, since labor supply is negatively affected by τ, more incomes at the top limits the scope for higher curvature and leads to a lower level of τ. The results in Fig. 1b indicate that the first force dominates, and the revenue-maximizing level of τ is *higher* when there is more wage dispersion.

Finally, Fig. 1c illustrates that a reduction in λ (i.e. an increase in average tax rates) leads to a *reduction* in the revenue-maximizing level of τ. A lower λ reduces the slope of the left-hand side of (3) and makes lower τ values more effective for revenue maximization. Since λ does not affect labor supply, a reduction in λ implies increases in revenue that are larger for higher wages. As τ negatively affects labor supply and in the same proportion for all wages, revenue maximization dictates an increase in individual labor supply to increase revenues further and a reduction in τ follows. Hence, higher revenue requirements dictate a tax schedule that is *less* progressive.

[4] On the other hand, changes in wage rates and λ generate income and substitution effects that cancel each other out exactly. This illustrates further that these preferences in conjunction with this tax function are consistent with a balanced-growth path.

[5] The condition that guarantees an interior solution is $\frac{\lambda}{(1-\lambda)}>\frac{2\gamma}{\sigma^2(1+\gamma)}$. That is, the choice of τ is guaranteed to be interior as long as (i) λ is not too small; (ii) the labor supply elasticity is not too large; (iii) there is sufficient dispersion in wages. All these are quite intuitive.

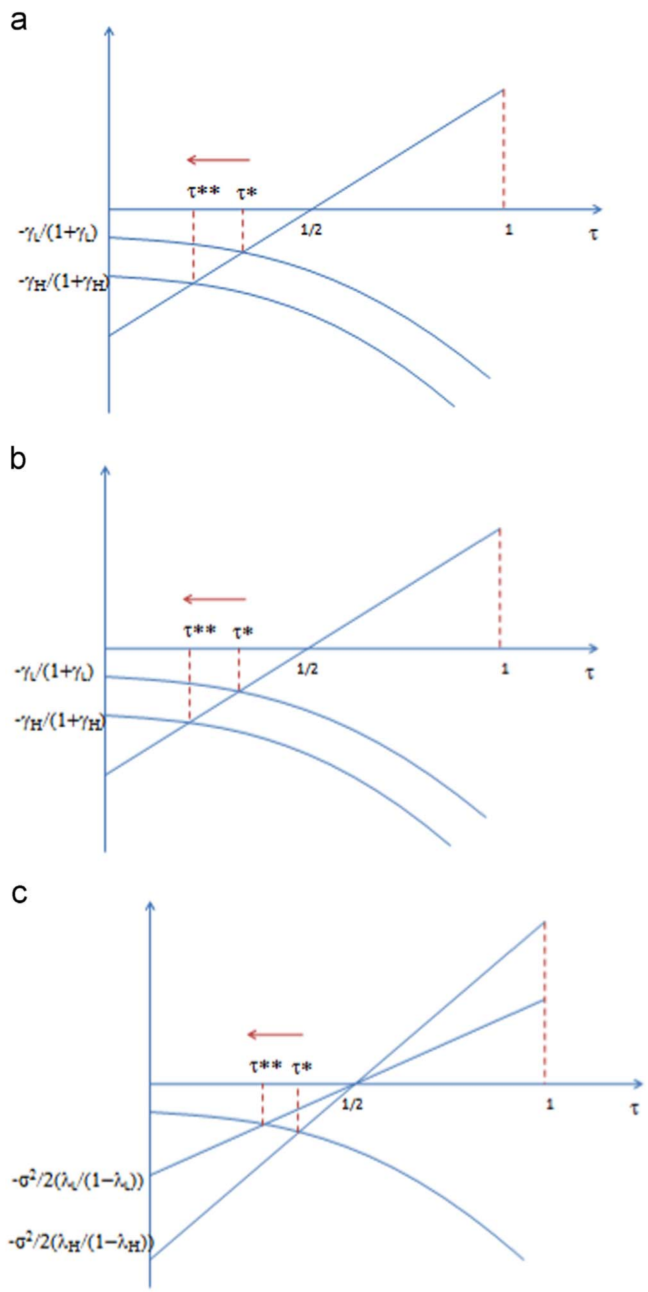

Fig. 1. (a) An increase in labor supply elasticity (γ), (b) an increase in labor supply elasticity (γ) and (c) an increase in average taxes (γ).

3. Model

We study a stationary life-cycle economy with individual heterogeneity and endogenous labor supply. Heterogeneity is driven by differences in labor productivity at the start of the life cycle, as well as by stochastic shocks as agents age. Agents have access to a single, risk-free asset, and face taxes of three types. They face flat-rate taxes on capital income and total income. They face labor income (payroll) taxes to finance retirement benefits. They also face a non-linear income tax schedule with increasing marginal and average tax rates. The first two tax rates are aimed at capturing the corporate income tax and income taxes at the state and local level. The non-linear tax schedule is the prime focus of our analysis, and aims to capture the salient features of the Federal Income Tax in the U.S.

Demographics: Each period a continuum of agents are born. Agents live a maximum of N periods and face a probability s_j of surviving up to age j conditional upon being alive at age $j-1$. Population grows at a constant rate n. The demographic structure is stationary, such that age–j agents always constitute a fraction μ_j of the population at any point in time. The weights μ_j are normalized to sum to 1, and are given by the recursion $\mu_{j+1} = (s_{j+1}/(1+n))\mu_j$.

Preferences: All agents have preferences over streams of consumption and hours worked, and maximize:

$$E\left[\sum_{j=1}^{N} \beta^j \left(\prod_{i=1}^{j} s_i\right)\left(\log(c_j) - \varphi \frac{l_j^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right)\right]. \tag{4}$$

where c_j and l_j denote consumption and labor supplied at age j. The parameter γ in this formulation – central to our analysis – governs the static Frisch elasticity as well as the intertemporal labor supply elasticity. The parameter φ controls the intensity of preferences for labor versus consumption.

Technology: There is a constant returns to scale production technology that transforms capital K and labor L into output Y. This technology is represented by a Cobb–Douglas production function. The technology improves over time because of labor augmenting technological change, X. Hence, $Y = F(K, LX) = AK^{\alpha}(LX)^{1-\alpha}$. The technology level X grows at the rate g. The capital stock depreciates at the constant rate δ.

Individual constraints: The market return per hour of labor supplied of an age-j agent is given by $we(\Omega, j)$, where w is a common wage rate, and $e(\Omega, j)$ is a function that summarizes the combined productivity effects of age and idiosyncratic productivity shocks.

There are two types of idiosyncratic shocks in our environment. A *permanent* shock (θ) and an uninsurable *persistent* shock (z). Hence, $\Omega = (\theta, z)$, with $\Omega \in \mathbf{\Omega}$, $\mathbf{\Omega} \subset \Re_{+}^{2}$. Age-1 individuals receive permanent shocks according to the probability distribution $Q_\theta(\theta)$. We refer to these shocks as permanent as they remain constant during the working life cycle. The persistent shock z follows a Markov process, with age-invariant transition function Q_z, so that $\text{Prob}(z_{j+1} = z' | z_j = z) = Q_z(z', z)$. Productivity shocks are independently distributed across agents, and the law of large numbers holds. Section 4 describes the parametric structure of shocks in detail.

All agents are born with no assets, and face mandatory retirement at age $j = J_R + 1$. This determines that agents are allowed to work only up to age J_R (inclusive). An age–j agent experiencing shocks Ω chooses consumption c_j, labor hours l_j and next-period asset holdings a_{j+1}. The budget constraint for such an agent is then

$$c_j + a_{j+1} \le a_j(1+r) + (1-\tau_p)we(\Omega, j)l_j + TR_j - T_j, \tag{5}$$

with $c_j \ge 0$, $a_j \ge 0$ and $a_{j+1} = 0$ if $j = N$, where a_j are asset holdings at age j, T_j are taxes paid, τ_p is the (flat) payroll social-security tax and TR_j is a social security transfer. Asset holdings pay a risk-free return r. In addition, if an agent survives up to the terminal period ($j = N$), then next-period asset holdings are zero. The social security benefit TR_j is zero before the retirement age J_R, and equals a fixed benefit level for an agent after retirement.

Taxes and Government consumption: The government consumes in every period the amount G, which is financed through taxation, and by fully taxing individual's accidental bequests. In addition to payroll taxes, taxes paid by individuals have three components: a flat-rate income tax, a flat-rate capital income tax and a non-linear income tax scheme. Income for tax purposes (I) consists of labor plus capital income. Hence, for an individual with $I \equiv we(\Omega, j)l_j + ra_j$, taxes paid to finance government consumption at age j are

$$T_j = T_f(I) + \tau_l I + \tau_k r a_j \tag{6}$$

where T_f is a strictly increasing and convex function. τ_l and τ_k stand for the flat income and capital income tax rates. This function T_f is later used to approximate effective Federal Income taxation in the United States. The rates τ_l and τ_k are used to approximate income taxation at the state level and corporate income taxes, and τ_p to capture payroll (social security) taxes in the United States.

It is worth noting that as an agent's income subject to taxation *includes* capital (asset) income; capital income is taxed through the income tax as well as through the specific tax on capital income. It follows that an individual with income I faces a marginal tax on capital income equal to $T_f'(I) + \tau_l + \tau_k$. Regarding labor income, marginal tax rates are affected by payroll taxes as well as by income taxes. Hence, an individual with an income I, faces a marginal tax rate on labor income equals to $T_f'(I) + \tau_l + \tau_p$.

3.1. Decision problem

Let us now state the decision problem of an individual in our economy in the recursive language. We first transform variables to remove the effects of secular growth, and indicate transformed variables with the symbol $(\hat{.})$. With these transformations, an agent's decision problem can be described in standard recursive fashion. Denote the individuals's state by the pair $x = (\hat{a}, \Omega)$, $x \in \mathbf{X}$, where $\hat{a}$ are current (transformed) asset holdings and Ω are the idiosyncratic productivity shocks. The set $\mathbf{X}$ is defined as $\mathbf{X} \equiv [0, \overline{a}] \times \mathbf{\Omega}$, where $\overline{a}$ stands for an upper bound on (normalized) asset holdings. Denote (normalized) taxes at state (x,j) by $\hat{T}(x, j)$. Consequently, optimal decision rules are functions for consumption $c(x, j)$, labor $l(x, j)$, and next period asset holdings $a(x, j)$ that solve the following dynamic programming problem:

$$V(x, j) = \max_{(\hat{l}, \hat{a}')} u(\hat{c}, l) + \beta s_{j+1} E[V(\hat{a}', \Omega', j+1)|x] \tag{7}$$

subject to

$$\begin{cases} \hat{c}+\hat{a}'(1+g) \le \hat{a}(1+\hat{r})+(1-\tau_p)\hat{w}e(\Omega,j)l+T\hat{R}_j-\hat{T}(x,j) \\ c \ge \hat{0}, \quad \hat{a}' \ge 0, \quad \hat{a}'=0 \text{ if } j=N,\ V(x,N+1)\equiv 0 \end{cases} \tag{8}$$

3.2. Equilibrium

In equilibrium, factor prices equal their marginal products. Hence, $\hat{w}=F_2(\hat{K},\hat{L})$ and $\hat{r}=F_1(\hat{K},\hat{L})-\delta$. Markets clear for goods, capital and labor services. Moreover, the government budget constraint holds, and social security payments equal tax collections from payroll taxes.

The definition of a stationary recursive equilibrium for our economy is by nowadays standard. In equilibrium, government consumption, $\hat{G}$, must be equal to total that revenue from income taxes and unintended bequests $\widehat{B}$, i.e.

$$\hat{G}=\sum_j \mu_j \int_X \hat{T}(x,j)d\psi_j+\hat{B},$$

where ψ_j stands for the measure of agents at each type at age j. The online appendix presents a formal definition of equilibria.

4. Parameter values

Our procedure to assign parameter values to the endowment, preference, and technology parameters of our benchmark economy is described below. The procedure uses aggregate as well as cross-sectional and demographic data from multiple sources. As a first step in this process, the length of a period in the model is set to be 1 year.

Demographics: Individuals start life at age 25, retire at age 65 and live up to a maximum possible age of 100. This implies that $J_R=40$ (age 64), and $N=75$. The population growth rate is 1.1% per year ($n=0.011$), corresponding to the actual growth rate for the period 1990–2009. Survival probabilities are set according to the U.S. Life Tables for the year 2005.[6]

Endowments: Let the log-hourly wage of an agent be given by the sum of a fixed effect or permanent shock (θ), a persistent component (z) and a common, age-dependent productivity profile, $\overline{e}_j$. Specifically, as in Kaplan (2012), we pose

$$\log(e(\Omega,j))=\theta+\overline{e}_j+z_j, z_j=\rho z_{j-1}+\epsilon_j, z_0=0, \tag{9}$$

where $\epsilon_j \sim N(0,\sigma_\epsilon^2)$. For the permanent shock (θ), a fraction π of the population is endowed with θ^* at the start of their lives, whereas the remaining $(1-\pi)$ fraction draws θ from $N(0,\sigma_\theta^2)$. The basic idea is that a small fraction of agents within each cohort has a value of the permanent component of individual productivity that is quite higher than the values drawn from $N(0,\sigma_\theta^2)$. These agents are occasionally referred to as *superstars*.

Our strategy for setting these parameters consists of two steps. First, use available estimates and observations on wages (hourly earnings) to set the parameters governing the age-productivity profile and the persistence and magnitude of idiosyncratic shocks over the life cycle. Then, determine the level of inequality at the start of the life so in stationary equilibrium, the economy is in line with the level of overall earnings inequality for *households*. As our relatively simple analysis abstracts from two-earner households, its implications should be broadly viewed in terms of households rather than individuals.[7]

The age-dependent deterministic component $\overline{e}_j$ is estimated by regressing log wages of households on a polynomial in age together with time effects. Data for these purposes is from the Current Population Survey (CPS) for the years 1980–2005. The Online Appendix provides details of our estimation and the resulting age profiles.

To set values for the parameters governing heterogeneity, our procedure is as follows. First, following Kaplan (2012), the autocorrelation coefficient (ρ) and the variance of the persistent innovation (σ_ϵ^2) to the estimates therein: $\rho=0.958$ and $\sigma_\epsilon^2=0.017$. These are parameters estimated at the individual level. We subsequently set $\pi=0.01$; i.e. 1% of each cohort are superstars. Then, the variance of permanent shocks for the remaining $1-\pi$ fraction and the value of the high permanent shock (θ^*) are set to reproduce two targets: (i) the level of household earnings inequality – measured by the Gini coefficient – observed in U.S. data (0.55), and (ii) the share of labor income at top 1% (14.3%).[8] This procedure yields $\sigma_\theta^2=0.45$ and $\theta^*=2.9$. That is, the procedure results in superstars that are approximately *eighteen* times more productive than the median individual in each cohort – $18 \sim \exp(2.87)$.

[6] National Vital Statistics Reports, Volume 58, Number 10, 2010.

[7] See Guner et al. (2012) and Bick and Fuchs-Schundeln (2016) for analyses of taxes in environments with two-earner households.

[8] Microdata from the Internal Revenue Service (2000 Public Use Tax File) is used to calculate statistics of earnings inequality for households. Key advantages of this data are its coverage and the absence of top-coding.

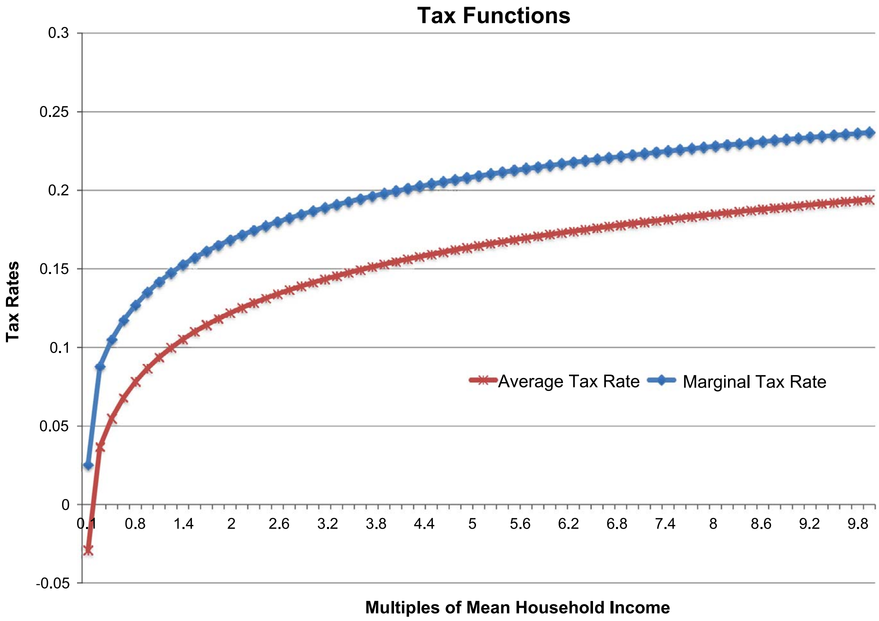

Fig. 2. Tax function.

Taxation: Following Benabou (2002), Heathcote et al. (2016) and others, our analysis uses a parametric tax function to represent the Federal Income taxes paid in the data. Specifically, the function T_f is set to $T_f(I) = It(\tilde{I})$, where

$$t(\tilde{I}) = 1 - \lambda \tilde{I}^{-\tau},$$

is an average tax function, and $\tilde{I}$ is income relative to mean income. As noted earlier, the parameter λ defines the level of the tax rate whereas the parameter τ governs the curvature or progressivity of the system.

The estimates of the effective tax rates for this tax function are taken from Guner et al. (2014) and used to set the values for λ and τ. The underlying data is tax-return, micro-data from Internal Revenue Service for the year 2000 (Statistics of Income Public Use Tax File). The estimates used are those for *all households* when refunds for the Earned Income Tax Credit are included: $\lambda = 0.911$ and $\tau = 0.053$. These estimates imply that a household around mean income faces an average tax rate of about 8.9% and marginal tax rate of 13.7%. For high income individuals, average and marginal rates are non-trivially higher. At five times the mean household income level in the IRS data (about $265,000 in 2000 U.S. dollars), the average and marginal rates for a married household amount to 16.3% and 20.8%, respectively. Fig. 2 displays the resulting average and marginal tax functions.

The tax rate τ_l is used to approximate state and local income taxes. Guner et al. (2014) find that average tax rates on state and local income taxes are essentially flat as a function of household income, ranging from about 4% at the central income quintile to about 5.3% at the top one percent of household income. From these considerations, this rate is set to 5% ($\tau_l = 0.05$).[9] The rate τ_k is used to proxy the U.S. corporate income tax. This rate is estimated as the one that reproduces the observed level of tax collections out of corporate income taxes after the major reforms of 1986. Such tax collections averaged about 1.7% of GDP for the 1987–2007 period. Using the technology parameters in conjunction with our notion of output, we obtain $\tau_k = 0.074$. Finally, the rate $\tau_p = 0.122$ is set so that the model implies an earnings replacement ratio of about 53%.[10]

Preferences and technology: The capital share and the depreciation rate are set using a notion of capital that includes fixed private capital, land, inventories and consumer durables. For the period 1960–2007, the resulting capital to output ratio averages 2.93 at the annual level. The capital share equals 0.35 and the (annual) depreciation rate amounts to 0.04 following the standard methodology; e.g. Cooley and Prescott (1995). This procedure also implies a rate of growth in labor efficiency of about 2.2% per year ($g = 0.022$).

The intertemporal elasticity of labor supply (γ) is set to a value of 1 in our benchmark exercises. It is well known that macro estimates of the elasticity of labor supply tend to be larger than micro ones. Keane and Rogerson (2015) conclude that different mechanisms at play in aggregate settings suggest values of γ in excess of 1. The values of the parameter φ and the

[9] Of course, there are variations in tax rates across states. If richer individuals live in states with low tax rates, this can increase the room to generate higher revenue by increasing the progressivity. As discussed in the online appendix, there is a negative but quite small relation between level of state taxes and concentration of high earners (measured by the income share of top 1%) across states. Note that relation between state taxes and location decisions of top earners is further muted by the fact that state taxes are deductible from income taxes at the Federal level.

[10] This is the value of the median replacement ratio in the mid 2000s for 64–65 year old retirees, according to Biggs and Springstead (2008).

Table 1
Parameter values.

Parameter	*Value*	*Comments*
Population growth rate (n)	1.1	U.S. Data
Labor efficiency growth rate (g)	2.2	U.S. Data
Discount factor (β)	0.977	Calibrated – matches K/Y
Intertemporal elasticity (γ)	1	Literature
Disutility of market work (φ)	7.90	Calibrated – matches hours
Capital share (α)	0.35	Calibrated
Depreciation rate (δ_k)	0.04	Calibrated
Autocorrelation permanent shocks (ρ)	0.958	Kaplan (2012)
Variance permanent shocks (σ_θ^2)	0.45	Calibrated – matches Earnings Gini
Variance persistent shocks (σ_ϵ^2)	0.017	Kaplan (2012)
Share of superstars (π)	0.01	
Value of superstars productivity (θ^*)	2.87	Calibrated – matches labor income share of top 1%
Payroll tax rate (τ_p)	0.122	Calibrated
Capital income tax rate (τ_k)	0.074	Calibrated
Income tax rate (τ_l)	0.05	Calibrated
Tax function level (λ)	0.911	Guner et al. (2014)
Tax function curvature (τ)	0.053	Guner et al. (2014)

Note: Entries show parameter values together with a brief explanation on how they are selected. See text for details.

Table 2
Shares of labor income (%) and tax payments (%) – model and data.

Percentiles of labor income	Data	Model	Percentiles of household income	Data	Model
Quantile			*Quantile*		
1st (bottom 20%)	2.1	3.3	1st (bottom 20%)	0.3	0.6
2nd (20–40%)	6.7	6.7	2nd (20–40%)	2.2	2.7
3rd (40–60%)	12.3	11.1	3rd (40–60%)	6.9	6.0
4th (60–80%)	21.3	18.9	4th (60–80%)	15.9	14.1
5th (80–100%)	57.6	60.0	5th (80–100%)	74.6	76.5
Top			*Top*		
90–95%	11.7	12.1	90–95%		
5%	29.1	31.9	5%	59.0	61.1
1%	14.3	14.2	1%	22.7	24.7
Gini coefficient	0.55	0.55	Tax revenue (% GDP)	10.1	11.1

Note: Entries in the left panel show the distribution of labor income in the data and the implied distribution from our model. Entries in the right panel show the distribution of taxes paid (Federal Income taxes) by income percentiles in the data and the implied distribution from our model. The labor-income data and the tax data is from the Internal Revenue Service for the year 2000 (Statistics of Income Public Use Tax File). The last row in the right panel displays Federal Income tax collections as a percentage of output (GDP). See text for details.

discount factor β are set to reproduce in stationary equilibrium a value of mean hours of 1/3 and a capital to output ratio of 2.94.

Summary: Table 1 summarizes our parameter choices. Four parameters (β, φ, θ^* and σ_θ^2) are set so as to reproduce endogenously four observations in stationary equilibrium: capital-output ratio, aggregate hours worked, earnings Gini coefficient, and the share of labor income accounted by the top 1%.

4.1. The benchmark economy

Some quantitative properties of the benchmark economy are important to evaluate for the questions that motivate our paper. Our focus is on the consistency of the benchmark economy with standard facts on cross-sectional inequality, as well as on a non-standard but critical fact: the distribution of taxes paid by income. The model implications for the elasticity of taxable income are also discussed.

Table 2 shows that the model is in close consistency with facts on the distribution of household earnings. As the table demonstrates, the model reproduces the overall inequality in household earnings as measured by the Gini coefficient. The model is in line with the shares accounted by different quintiles, ranging from just the empirical values of 2.1% in the bottom quintile to nearly 58% in the fifth quintile. The model is also in line with the share of labor earnings accounted by top percentiles, beyond the targeted share of the top 1% earners. The share accounted for by the top 90–95% earners in the data is of about 11.7% while the model implies 12.1%. Meanwhile, the share accounted for by the top 5% earners in the data is of about 29.1% while the model implies 31.9%. All this indicates that the model-implied Lorenz curve for labor earnings at the household level is in close agreement with data.

Table 3
Changes in progressivity.

Statistic	$\tau=0$	$\tau=0.04$	$\tau=0.08$	$\tau=0.10$	$\tau=0.13$	$\tau=0.16$
Output	108.7	102.2	95.9	92.8	88.4	84.1
Hours	104.3	101.1	97.6	95.9	93.0	90.2
Labor supply	104.5	101.1	97.6	95.6	92.9	90.0
Capital	116.6	103.8	92.6	87.8	80.4	73.9
Revenues						
Federal income tax	83.3	97.0	104.3	106.0	106.8	105.8
Corporate income tax	104.6	101.2	97.4	95.3	92.2	88.9
State and local taxes	107.7	101.9	96.2	93.4	89.3	85.2
All taxes	92.1	98.7	101.4	101.5	100.6	98.5

Note: Entries shows the effects across steady states of changes in the curvature (progressivity) of the tax function on selected variables. Values of all variables are normalized to 100 in the benchmark economy. The 'All Taxes' row includes Federal income and corporate taxes plus state and local taxes. See text for details.

The distribution of taxes paid: Table 2 also shows the distribution of income-tax payments at the Federal level for different percentiles of the income distribution. As the table shows, the distribution of tax payments is quite concentrated – more so than the distributions of income and labor income. The first and second income quintiles essentially do not account for any tax liabilities, whereas the top income quintile accounts for about 75% of tax payments. The top 10% account for almost 60% of all tax payments and the richest 1% for about 23% of tax payments. This is the natural consequence of a concentrated distribution of household income and a progressive income tax scheme. Table 2 shows that the model reproduces quite well the sharp rise of income tax collections across income quintiles. In particular, note that the model generates the acute concentration of tax payments among richer households. In the data, the richest 10% of households account for about 59% of tax payments while the model implies about 61%. Similarly, the richest 1% account for nearly 23% of tax payments while the model implies close to 25%.[11]

Elasticity of taxable income: The model-implied elasticities of taxable income – a concept that has recently garnered much attention in applied work – are reported below. These elasticities are calculated as the percentage change in taxable income, i.e. $we(\Omega, j)l_j + ra_j$, divided by the percentage change in one minus the marginal tax rate for these income groups. Our calculations yield an elasticity of taxable income of about 0.4–0.5 for the richest 10%, 5% and 1% of households, a value that lies well within the empirical estimates surveyed in Saez et al. (2012). Our estimates, however, are smaller than those recently estimated by Mertens (2015). This is not surprising. As discussed in the next section, our model abstracts from several features that would result in a higher value for such elasticity.[12]

5. Findings

Our findings on the consequences of shifting the tax burden towards top earners are reported next. Our approach is to fix the 'level' parameter of the tax function (λ) at its benchmark value, and then vary the parameter governing its curvature or progressivity (τ). A steady state for the model economy is computed in each case.

Table 3 shows the consequences of selected values for the curvature parameter τ, ranging from 0 (a proportional tax) to 0.16 – above and below the benchmark value case, $\tau=0.053$. Two prominent findings emerge from the table. First, it takes a non-trivial increase in the curvature parameter, from 0.053 to 0.13, in order to maximize revenues from the Federal income tax. The resulting aggregate effects associated to increasing curvature are substantial. Increasing the curvature parameter from its benchmark value to 0.13 reduces capital, output and labor supply (in efficiency units) by about 19.6%, 11.6% and 7.1%, respectively. These values are quantitatively important, and result from a significant rise in marginal rates relative to average rates, as the discussion below illustrates. This rise leads to standard reductions in the incentives on the margin to supply labor and save, which in equilibrium translate into the substantial effects on aggregates just mentioned. Fig. 3a illustrates the resulting effects on labor supply, capital and output from changing the curvature parameter τ for a wide range of values.

Second, the increase in revenues associated to the changes in progressivity are relatively small in comparison to the large implied reductions in output. Maximizing revenues implies an increase in income taxes at the Federal level of about 6.8%, or

[11] The facts on the distribution of tax payments reported in Table 2 are for the bottom 99.9% of the distribution of household income in the United States. Not surprisingly, the unrestricted data shows an even higher concentration of tax payments at high incomes. The facts are presented in this way since as documented by Guner et al. (2014) and others, a disproportionate fraction of income of the richest households is from capital-income sources. In particular, income from capital constitutes close to 65% of total household income for the richest 0.01% of households in the data. As it is well known, macroeconomic models where inequality is driven solely by earnings heterogeneity cannot account for the wealth holdings of the richest households in data.

[12] We compute the arc-elasticities resulting from variations in marginal tax rates associated to changes in the curvature parameter around its benchmark value. Considering changes from $\tau=0.04$ to $\tau=0.06$. Considering other variations in curvature around the benchmark value do not change the resulting elasticities in a significant way.

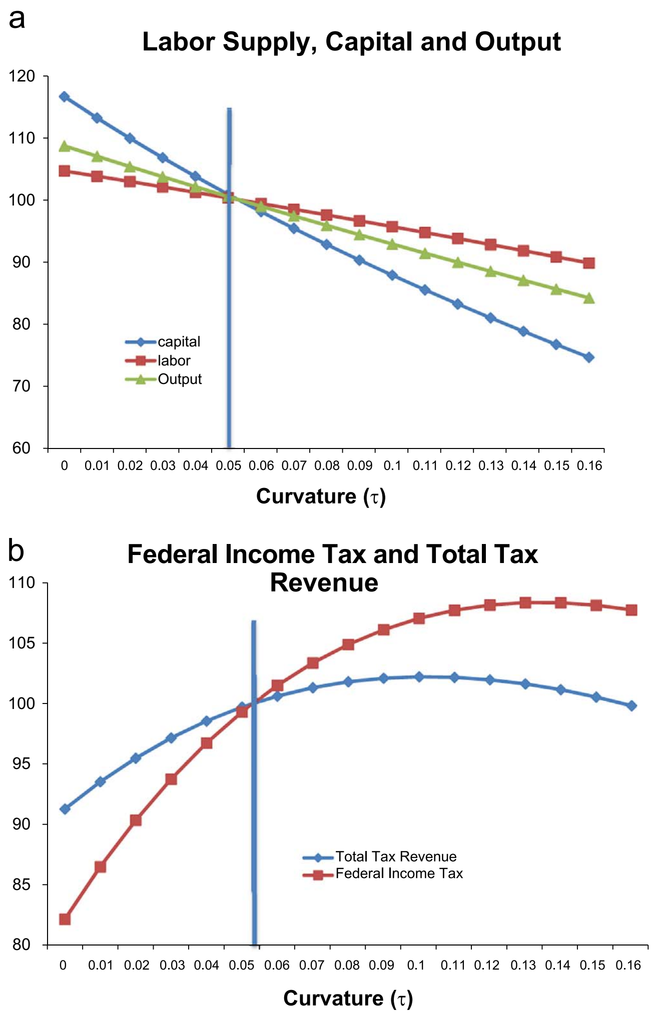

Fig. 3. (a) Labor supply, capital and output and (b) federal income tax and total tax revenue.

about 0.8% of output in the benchmark economy. Increasing progressivity also leads to a *reduction* in tax collections at the local and state level and from corporate income taxes. This occurs as tax collections from these sources are roughly proportional to the size of aggregate output and capital. As a result, tax collections from *all sources* are maximized at a lower level of progressivity (around $\tau=0.09$), and increase only by about 1.5% at the level of progressivity consistent with revenue maximization from the Federal income tax.

Fig. 3b illustrates the effects from changing the curvature parameter τ on government revenues – Federal and Total – in relation to the benchmark economy. The figure clearly depicts a Laffer-like curve associated to changes in progressivity. As the figure shows, both relationships are relative *flat* around maximal revenues, as non-trivial changes in curvature are associated with rather small changes in revenues.

Magnitude of changes in tax rates: How large are the required changes in average and marginal rates resulting from the revenue-maximizing shifts in progressivity? The implications of using the tax function in the benchmark economy are now compared with the implications resulting from using the tax function that maximizes revenue from Federal income taxes as well as total taxes (these functions have the level parameter λ as in the benchmark economy, but higher curvature parameter τ). To illustrate these changes, our focus is on the average and marginal tax rates for households at the top 10%, 5% and 1%, respectively.

As the top panel of Table 4 shows, at the benchmark economy, average rates are about 15.6, 17.2 and 20.6 percent for richest 10%, 5% and 1% of households, respectively. The corresponding marginal rates amount to 20.1, 21.6, and 24.8 percent. At maximal revenue for Federal income taxes (when $\tau=0.13$), average rates at the top levels are 23.7, 27.1 and 34.0 percent, and marginal rates amount to 33.6, 36.6 and 42.6 percent, respectively. In other words, for the richest 5 percent of households in our economy, revenue maximization dictates an increase in average rates of nearly ten percentage points, and an increase in marginal rates of about fifteen percentage points. Hence, revenue-maximizing tax rates are non-trivially larger than those at the benchmark economy. From these perspective, the concomitant large effects on aggregates are not

Table 4
Shares of tax payments and tax rates– benchmark and higher progressivity.

Percentiles of income	τ=0.053 (benchmark)	τ=0.13	τ=0.09
	Average tax rate		
Top 10%	15.6	23.7	20.8
Top 5%	17.2	27.1	23.5
Top 1%	20.6	34.0	29.3
	Marginal tax rate		
Top 10%	20.1	33.6	28.7
Top 5%	21.6	36.6	31.1
Top 1%	24.8	42.6	36.4
Quantile	*Share of tax payments*		
1st (bottom 20%)	0.6	−2.7	−3.3
2nd (20–40%)	2.7	2.8	4.1
3rd (40–60%)	6.0	2.7	4.1
4th (60–80%)	14.1	11.7	12.7
5th (80–100%)	76.5	85.6	82.3
Top			
10%	61.1	70.1	66.9
1%	24.7	29.3	27.7

Note: Entries shows average tax rates, marginal tax rates and the distribution of taxes paid (Federal Income taxes) in the benchmark economy, and at higher progressivity around revenue-maximizing levels.

Table 5
Labor supply and wealth distribution changes – higher progressivity.

Percentiles of income and wealth	τ=0.053 (benchmark)	τ=0.13	τ=0.09
Income quantiles	*Labor supply changes*		
1st (bottom 20%)	100	90.4	94.9
2nd (20–40%)	100	95.2	97.1
3rd (40–60%)	100	96.7	97.7
4th (60–80%)	100	95.3	97.6
5th (80–100%)	100	92.6	96.9
Top			
10%	100	90.6	95.0
5%	100	91.8	95.0
1%	100	91.0	95.7
Wealth quintiles	*Wealth distribution changes*		
1st (bottom 20%)	1.0	2.5	1.7
2nd (20–40%)	5.0	8.1	6.5
3rd (40–60%)	9.4	13.0	11.2
4th (60–80%)	18.3	21.2	19.8
5th (80–100%)	66.3	55.2	60.8
Top			
10%	49.1	38.0	43.5
5%	35.1	25.3	30.0
1%	15.2	9.5	12.1

Note: Entries in the upper panel show the changes, relative to benchmark economy, in aggregate labor supply associated to higher progressivity around revenue-maximizing levels. The lower panel shows the corresponding changes in the wealth distribution.

surprising. As mentioned earlier, these large effects on aggregates imply that the value of τ that maximizes total revenue – rather than Federal income revenues only – is lower as shown in the last column of Table 4.

The distribution of tax payments: Not surprisingly, the shifts in progressivity lead to non-trivial shifts on the contribution to income tax payments by households at different income levels, or tax burden for short. The bottom panel of Table 4 shows changes in the tax burden associated to the move from the benchmark level of progressivity to values around the maximal revenue levels (τ=0.13 and τ=0.09). The results show a significant shift in terms of the distribution of the tax burden, and mirror the consequences on aggregates and tax rates above. From the benchmark case to revenue-maximizing levels, the share of taxes paid by the richest 20% increase by about nine percentage points, with equivalent increases at higher income levels. The shares of taxes paid at the bottom of the income distribution change much less, with the poorest 20% changing from nearly no taxes paid to a negative contribution as their average tax rates turn negative.

Who Reacts?: As discussed above, higher values of τ result in significant declines in aggregate savings, labor supply and, as a result, in aggregate output. Let us now concentrate on the decline in labor supply and savings in more detail. The upper

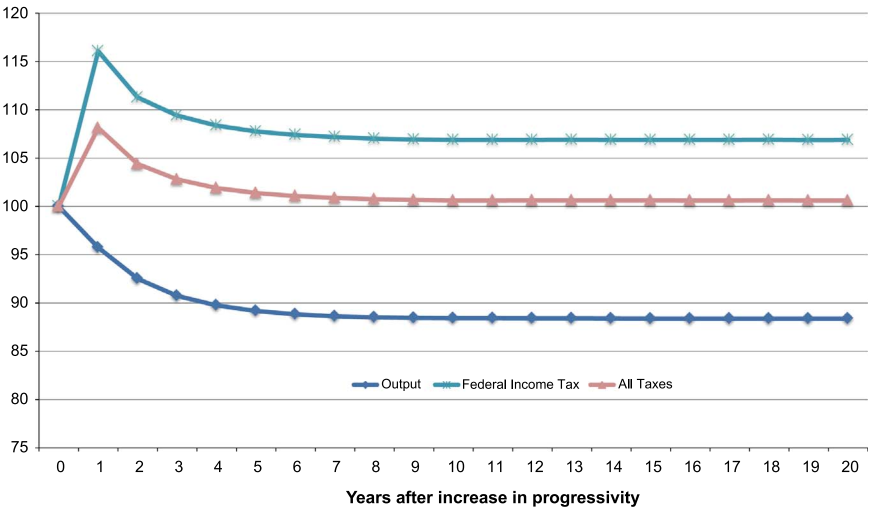

Fig. 4. Transitional dynamics.

panel of Table 5 shows how labor supply (in efficiency units) changes for households at different percentiles of the income distribution. To fix ideas, focus on two levels of curvature: $\tau=0.13$ that maximizes the Federal income tax revenue, and $\tau=0.09$ that maximizes the aggregate tax revenue. A central result in Table 5 is that the decline in aggregate labor supply, as progressivity increases, occurs at all income levels and has an inverted-U shape as a function of income. When $\tau=0.13$, labor supply declines by about 3.3% for households at the middle quintile, while the decline amounts to about 2% when $\tau=0.09$. Very productive (rich) households react slightly more; the decline in the labor supply of the households in the richest quintile is of about 7% when $\tau=0.13$ and about 3% when $\tau=0.09$.

At the conceptual level, a decline in labor supply that occurs at all income levels in a relatively uniform way is connected to (i) the functional form for individual preferences adopted and (ii), the specific tax function that used to capture the relationship between tax rates and household income. This is clear from the simple, static case discussed in Section 2, where the curvature factor τ affects *all* agents in a symmetric way. From this standpoint, the results in Table 5 are not surprising. At the empirical level, the similar reaction in labor supply across income levels is in broad consistency with the recent empirical findings of Mertens (2015, Table IV and Figure 6), who uncovers systematic effects on wage income associated to marginal-tax rate changes across all income levels.

Concentrate now on the effect of higher progressivity on savings. The lower panel of Table 5 shows how the wealth distribution implied by the model changes with the curvature parameter. The results in the table show that increasing tax progressivity leads to significant reductions in wealth concentration. In the benchmark economy, the share of wealth in the top quintile is about 66%, with an overall Gini coefficient of about 0.63.[13] Under $\tau=0.09$ the share of the top quintile drops to about 61%, and under $\tau=0.13$ it drops even further to about 55%. Overall, these findings indicate asymmetric responses in terms of household savings, which lead to a reduction in the concentration of wealth as progressivity increases. This is expected: increasing progressivity leads to *larger* differences in the after-tax rate of return on assets between richer and poorer households. These disproportionate change in incentives to accumulate assets upon changes in progressivity are reflected in ensuing wealth distributions.

Transitional dynamics: Our analysis is now completed by illustrating the reaction over time to a tilt of the income tax schedule towards high-income earners. Specifically, our focus is on the transitional dynamics between the benchmark steady state and the steady state corresponding to the revenue-maximizing curvature level for Federal income taxes.[14] Fig. 4 reports the results for revenues from the Federal income tax and all taxes, as well as for output.

The prominent finding in Fig. 4 is that revenues increase upon impact, and then gradually decline to the values reported in Table 3. The change in revenues from the Federal Income tax upon impact is of about 16% – a change that more than doubles the final change. As the economy adjusts and contracts over time, tax revenues decline as the figure illustrates.

Summary and discussion: The message from these findings is clear. There is not much available revenue from revenue-maximizing shifts in the burden of taxation towards high earners – despite the substantial changes in tax rates across

[13] The model generates substantial wealth inequality, but not as much as in U.S. data. The wealth-Gini coefficient in the model is 0.63 versus a data value of about 0.80. In particular, the model is not successful in generating the extreme wealth holdings at the top observed in the data; see for instance Budria Rodriguez et al. (2002). This is not surprising; it is well known in the literature that a model that is parameterized in line with earnings-distribution observations will have a hard time in generating the observed wealth distribution in the data.

[14] The transitional dynamics is computed under the assumption that households at the benchmark steady state are surprised at $t=0$, with an immediate shift to the revenue-maximizing curvature level ($\tau=0.13$).

income levels – and these changes have non-trivial implications for economic aggregates. As discussed in Section 6, these findings are largely robust to several departures from our baseline case.

At the big-picture level, it is important to reflect on the absence of features in our model that would make our conclusions even stronger. First, our analysis abstracts from human capital decisions that would be negatively affected by increasing progressivity. The work by Erosa and Koreshkova (2007), Guvenen et al. (2014), Badel and Huggett (2014) and others naturally implies that individual skills are not invariant to changes in tax progressivity and thus, larger effects on output and effective labor supply – relative to a case with exogenous skills – are to be expected. From this standpoint, increasing tax progressivity would lead to an even lower increase in government revenues. Second, our analysis abstracts from individual entrepreneurship decisions and their interplay with the tax system. Meh (2005), for instance, finds effects on steady-state output from a shift from a progressive income tax to a proportional tax that are larger when entrepreneurs are explicitly considered. Finally, our analysis assumes away bequest motives, or more broadly, ignores the implications that emerge in a dynastic framework. In these circumstances, it is natural to conjecture that the sensitivity of asset accumulation decisions to changes in progressivity would be larger than in a life-cycle economy. Hence, smaller effects on revenues would follow.

Our model, however, abstracts from the participation margin in labor supply. Guner et al. (2012) study tax reforms with two-earner households with an explicit participation decision for the secondary earner. They consider a move from current taxes to proportional ones and show that low-income households – for whom the participation margin is critical – react more to changes in tax schedules than high-income households. On the one hand, in a model with a participation margin, one can expect that as average taxes decline for low-income households with an increase in τ, the size of the labor force would increase, generating more revenue – although the additional revenue is likely to be small. On the other hand, with the current preference specification, labor supply decisions depend only on $1-\tau$, and a higher τ would discourage the labor supply of *all* households independent of their average tax rate. Overall, while more work is needed in this front, our conjecture is that the basic message of the paper will hold in a model with an explicit participation margin.

To sum up, our model environment provides a reasonable upper bound on the potential effects of increasing progressivity on tax revenues. Even smaller effects are likely to emerge in an environment with the features mentioned above.

6. Findings in perspective

In this section, our findings are placed in perspective. We ask three questions. First, what are the effects of increasing progressivity for aggregates and government revenues under the assumption of a small-open economy? Second, what is the quantitative importance of the 'level' of revenues for the revenue-maximizing level of progressivity? Third, what are the effects of changing only the marginal tax rate at high income levels instead of tilting the entire tax function?

Additional calculations are presented for the interested reader in the Online Appendix. Therein, the role of the labor supply elasticity for our findings is investigated, exercises are repeated when the additional revenue is returned to households, and exercises are conducted in order to keep either average or marginal tax rates constant.

6.1. The small-open economy case

To what extent our findings depend on the assumption of equilibrium prices that adjust in response to changes in progressivity? To answer this question, a small-open economy version of our model is considered where prices are set at the benchmark level and are not allowed to change.

Our findings are much stronger than in the benchmark case. While the revenue-maximizing level of progressivity is around $\tau=0.12$, the potential increase in revenues is smaller –about 3% versus 6.8%. Meanwhile, the reduction in aggregate output is much sharper, 20.8% versus 11.6%. As a result of the larger changes in aggregates, total tax revenues are *lower* at the revenue-maximizing level of progressivity in the small-open case.

In the benchmark economy, increasing progressivity leads to increases in the interest rate and reductions in the wage rate. A decline in wage rate moderates the increase in tax revenue. The increase in the interest rate, on the other hand, has the opposite effect and, in turn, moderates the reductions in asset accumulation due to higher progressivity. In addition, the reallocation of labor hours towards the young and less productive years of the life cycle, as the result of increasing progressivity, is even more muted when the interest rate increases. Our results indicate that as income (labor plus capital income) is taxed, the last two effects dominate and the increase of tax revenue as progressivity increases is larger in the benchmark economy.

6.2. What is the importance of revenue requirements?

The analysis in Section 2 showed that a higher level of revenue requirement or the average tax rate, as defined by the level parameter λ in the tax function, implies lower values of the revenue-maximizing curvature parameter τ. That is, lower distortions in labor supply choices. Quantitatively, how important is this effect in our dynamic model? More broadly, what is the role of revenue requirements on aggregates and government revenues?

Table 6
Role of revenue requirements.

Statistic	$\tau=0$	$\tau=0.04$	$\tau=0.08$	$\tau=0.10$	$\tau=0.13$	$\tau=0.16$
Benchmark ($\lambda=0.911$)						
Output	108.7	102.2	95.9	92.9	88.4	84.1
Labor supply	104.5	101.1	97.6	95.7	92.9	90.0
Federal income tax	83.3	97.0	104.3	106.0	106.8	105.8
All taxes	92.1	98.7	101.4	101.5	100.6	98.5
Higher revenue ($\lambda=0.87$)						
Output	106.3	99.8	93.6	90.6	86.2	81.9
Labor Supply	104.5	101.0	97.4	95.6	92.7	89.7
Federal Income Tax	119.6	130.0	134.9	135.4	133.9	131.1
All Taxes	114.4	119.0	119.8	119.1	117.0	113.8
Higher revenue ($\lambda=0.85$)						
Output	105.1	98.6	92.5	89.4	85.0	80.7
Labor supply	104.4	101.0	97.3	95.5	92.5	89.5
Federal income tax	136.8	145.6	148.7	148.5	146.5	143.0
All Taxes	124.9	128.5	128.4	127.3	124.7	121.0
Higher revenue ($\lambda=0.80$)						
Output	102.0	95.6	89.4	86.4	82.1	77.8
Labor supply	104.3	100.8	97.1	95.2	92.2	89.1
Federal income tax	178.2	183.0	182.5	180.8	176.5	171.0
All taxes	150.2	151.2	148.9	146.8	142.7	137.8

Note: Entries show the effects across steady states of changes in the curvature (progressivity) of the tax function for different values of 'level' parameter (λ) in the tax function. Values of all variables are normalized to 100 in the benchmark economy. The 'All taxes' row includes Federal income and corporate taxes plus state and local taxes. See text for details.

Table 6 shows the consequences of lower values of λ – $\lambda=\{0.87, 0.85, 0.80\}$ – alongside the benchmark value $\lambda=0.911$, for different values of the curvature parameter τ. Values of all variables are normalized to 100 at the benchmark economy. In understanding these results, the reader should note that by changing the value of λ, the ratio of one minus the marginal tax rate to one minus the average tax rate – the proxy for distortions – is unaltered as this ratio is independent from λ.

Table 6 shows that higher revenue requirements (lower λ), for a given value of curvature, lead to mildly lower values of labor supply and output. For instance, at the value of $\tau=0.13$, output under $\lambda=0.85$ is about 5% lower than under the benchmark value of λ. Moreover, and in line with the example in Section 2, maximal revenues for Federal income taxes indeed take place at lower values of progressivity. In the baseline case, income tax revenues are maximal at $\tau=0.13$. Under the higher revenue requirement value of $\lambda=0.85$, revenue maximization takes place at values around curvature levels of $\tau=0.08$.

Table 6 shows that there are rather substantial gains in revenues associated to changes in the level of the average tax rate for a given level of progressivity. A change in λ from 0.911 to 0.87, which translates into an increase in the average rate at mean income from 8.9% to 13%, raises revenues by more than 30% at the benchmark curvature level. This increase in revenue is rather substantial in relation to the increases in revenue available under changes in progressivity, and implies only minimal reductions in aggregates and tax collections from other sources. Of course, the welfare implications of such distinct changes in the structure of taxation are different and involve the usual equity and efficiency trade-offs.

Our quantitative experiments show that there is effectively no Laffer curve with respect to λ. Note that this is consistent with the example in Section 2. Given our preference specification, λ does not distort the labor supply decision. As discussed in the online Appendix, this would not be the case if the additional revenue is returned to households as in Trabandt and Uhlig (2011) and Holter et al. (2015).

6.3. *Higher taxes at the top – only*

In our main exercise, progressivity is increased by increasing the curvature parameter, τ. This tilt of the tax function towards high-income earners actually *reduces* tax rates for income levels at the bottom. Our focus is now on whether it is possible to increase revenues substantially from Federal income taxes by *only* taxing more heavily top incomes. For these purposes, the tax function is modified via increases in the marginal tax rates above certain high income thresholds.

Concretely, let the new tax function with higher marginal rates at top incomes be given by $T_{NEW}(\tilde{I})$. Let $\tilde{I}_H$ be the level of relative income after which higher marginal rates are imposed, and τ_H be the higher marginal tax rate above $\tilde{I}_H$. Hence, $T_{NEW}(\tilde{I})=T(\tilde{I})$ if $\tilde{I}\le\tilde{I}_H$, and $T_{NEW}(\tilde{I})=T(\tilde{I}_H)+\tau_H(\tilde{I}-\tilde{I}_H)$, if $\tilde{I}>\tilde{I}_H$.

In this case, the marginal tax rate at top incomes is constant and equal to τ_H. Let us concentrate on higher tax rates for the top 5%. Since in the benchmark case the marginal tax rate defining the richest 5% amounts to about 18.4%, we consider levels of τ_H above this value. It turns out that the marginal tax rate (τ_H) that maximizes revenues from the Federal income tax is about 42%. Revenues from Federal income taxes are effectively 8.4% higher than in the benchmark economy, while in our main exercise revenues increase 6.8%. In terms of initial output, the increase now amounts to about 0.9% versus 0.8% in our main exercise.

Our findings show, in line with previous results, that higher marginal tax rates reduce labor supply, capital and output in a significant way. Increasing the marginal tax rate for top incomes to 42% reduces labor supply, capital and output by 3.9%, 9.6% and 5.9%, respectively. Revenue maximization for all taxes takes place at a value of τ_H around 35%, with revenue increases up to 3.6%. Similar findings are obtained when higher marginal tax rates are applied to the richest 1% – albeit with smaller revenue increases.

These exercises reinforce our main conclusions that there is not much revenue available from shifting the tax burden towards top earners.

7. Concluding remarks

The effectiveness of a more progressive tax scheme in raising tax revenues is rather limited. This occurs despite the substantial increases in tax rates for higher incomes that is needed to attain maximal revenues. Large changes in output, capital and labor supply take place across steady states in response to increases in progressivity that effectively result in second-order increases in government revenues. This conclusion is robust to labor supply elasticities on the low side of the values recommended for macro models, and to whether tax rates are increased only at the top. Not surprisingly, the conclusion is stronger under the assumption of a small-open economy.

Our findings show, nonetheless, that there are substantial revenues available from 'level' shifts of the tax function. These shifts correspond to changes in average and marginal tax rates for all in about the same magnitude. In consequence, the resulting changes in macroeconomic aggregates are much smaller and the effects on tax revenues substantial. Our findings also show that when the level of taxes are high, there is even lesser room for a government to raise revenue by making them more progressive. Altogether, our findings suggest that increasing progressivity is misguided if the aim is to exclusively raise government revenue.

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Appendix A. Supplementary data

Supplementary data associated with this paper can be found in the online version at http://dx.doi.org/10.1016/j.jmoneco.2016.05.002.

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