How Do Tax Progressivity and Household Heterogeneity Affect Laffer Curves?*

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Abstract: How much additional tax revenue can the government generate by increasing the level of labor income taxes? In this paper we argue that the degree of *tax progressivity* is a quantitatively important determinant of the answer to this question. To make this point we develop a large scale overlapping generations model with single and married households facing idiosyncratic income risk, extensive and intensive margins of labor supply, as well as endogenous accumulation of human capital through labor market experience. We calibrate the model to U.S. macro, micro and tax data and characterize the labor income tax Laffer curve for various degrees of tax progressivity. We find that the peak of the U.S. Laffer curve is attained at an average labor income tax rate of 58%. This peak (the maximal tax revenues the government can raise) increases by 7% if the current progressive tax code is replaced with a flat labor income tax. Replacing the current U.S. tax system with one that has Denmark's progressivity would lower the peak by 8%. We show that modeling the extensive margin of labor supply and endogenous human capital accumulation is crucial for these findings. With joint taxation of married couples (as in the U.S.), higher tax progressivity leads to significantly lower labor force participation of married women and substantially higher labor force participation of single women, an effect that is especially pronounced when future wages of females depend positively on past labor market experience.

Keywords: Laffer Curve, Progressive Taxation, Heterogeneous Households

JEL: E62, H20, H60

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1 Introduction

How much additional tax revenue can the government of a country generate by increasing the level of labor income taxes? That is, how far are we from the peak of the Laffer curve? In this paper we provide a quantitative, model-based answer to this question, and argue that this answer depends crucially on the degree of the *progressivity* of the tax code. Since the shape of the labor income tax schedule varies greatly across countries, a fact which we document empirically in Section 3, Laffer curves are therefore likely highly country-specific.[1] We verify this claim in the model by tracing out the response of tax revenue to changes in the level of labor income tax rates (i.e. deriving the Laffer curve) under the current U.S. tax code, and then by documenting how the relation between the level of tax rates and tax revenue is altered as the degree of tax progressivity changes from that of the U.S. status quo to tax progressivity characterizing other countries.

Our quantitative analysis is conducted in the context of an overlapping generations model, populated by single and married households that make labor supply decisions along the intensive and extensive margins, endogenously accumulate work experience and are subject to uninsurable idiosyncratic risk. In the model households make consumption-savings choices and decide on whether or not to participate in the labor market (the extensive margin), how many hours to work conditional on participation (the intensive margin), and thus how much labor market experience to accumulate which in turn impacts future earnings capacities. The government raises tax revenues through issuing government debt, and collecting a consumption-, a capital income- and a labor income tax to pay for exogenous government expenditures. To model labor income taxes, we use a tax function belonging to a two parameter family (as in Benabou (2002) and Heathcote, Storesletten, and Violante (2017)) that permits varying separately the level of tax rates and its progressivity. We calibrate the model to U.S. macroeconomic, microeconomic wage, and tax data and construct the Laffer curve

[1] We treat cross-country differences in tax progressivity as *exogenous* in this paper, submitting that they might have emerged due to country-specific tastes for redistribution and social insurance, or distinctions in the political process that maps societal preferences into actual tax policy.

by varying the *level* of labor income taxes, holding their *progressivity* constant. We then deduce the impact of tax progressivity on the Laffer curve by varying the tax progressivity parameter in the labor income tax function, covering the range of the empirical estimates for other OECD countries as well as the case of a flat tax.

We find that the peak of the U.S. Laffer curve is attained at an average labor income tax rate of 58%. At this average rate the government could increase tax revenue by approximately 59%, relative to the status quo, and keeping tax progressivity constant. Crucially for the purpose of this paper, this peak of the Laffer curve (the maximal tax revenues the government can raise) increases by 7% if the current progressive tax code is replaced with a flat labor income tax. In contrast, implementing a tax system with progressivity similar to that in Denmark[2] would lower peak revenues by 8%. We also show that the impact of tax progressivity on maximal tax revenue that can be generated (on the order of 15% when moving from a proportional to Denmark's highly progressive tax code) is substantially robust to the *use* of the extra tax revenues.[3]

Finally we argue that the extensive margin of labor supply for females responds strongly to a change in labor income tax progressivity, and thus is potentially a crucial determinant of the impact the progressivity of labor income taxes has on government revenues. In the model economy with joint taxation this mechanism works in the opposite direction for married and single women, however. With more progressive taxes, single females that tend to have low potential wages continue to work, and often *start to participate* as their average (and marginal) tax rate declines. This positive adjustment along the extensive margin of labor supply is especially pronounced when work experience positively impacts future wages. In contrast, married females are taxed jointly with their husbands, and thus families where the

[2]Denmark has the most progressive taxes in the OECD, according to the empirical analysis in Section 3.

[3]The alternatives we consider are: (i) lump-sum redistribution to households, (ii) expansion of government debt and associated interest service, and (iii) the extension of wasteful government spending, with lump-sum redistribution being fixed at the benchmark level. As a secondary result, when using the extra tax revenue for public debt service we find that the U.S. can *maximally* sustain a debt to (benchmark) GDP ratio of 345%, holding tax progressivity constant, and that this amount is decreasing in the degree of progressivity of the tax schedule.

female has low earning potential typically find it optimal to remain, or to become single-earner households when taxes become more progressive. Quantitatively, these two very sizeable effects nearly offset each other, and tax revenues in our model are only slightly less responsive to tax progressivity than in a standard single household life-cycle model with uninsurable income risk.[4] In contrast, in an economy with *only single individuals* and an extensive margin of labor supply as well as endogenous human capital accumulation, tax revenues are far less responsive to tax progressivity than in our model economy (and in the standard single household model without the extensive margin).

The quantitative importance of the extensive margin of labor supply of females (especially when combined with endogenous human capital formation through experience accumulation), as well as the strong *heterogeneity by marital status* in their response to a change in the progressivity of the labor income tax schedule justifies, in our view, the inclusion of these perhaps somewhat non-standard model elements into the otherwise fairly standard heterogeneous agent life cycle model we employ.

Our paper is structured as follows. Section 2 introduces the concept of the *Laffer curve* and summarizes the recent related literature. In Section 3 we discuss our measure of tax progressivity and develop a progressivity index by which we rank OECD countries. Section 4 studies, analytically, the impact of tax progressivity on labor supply and tax revenue. First we show that in a representative agent economy higher tax progressivity reduces tax revenue, holding the level of tax rates constant. We then demonstrate in tractable models with household heterogeneity, that along the intensive margin hours of high-income earners relative to low-income earners fall with a rise in tax progressivity, and that low (potential) income households participate more along the extensive margin if taxes become more pro-

[4]Modeling the extensive margin of labor supply and endogenous human capital accumulation, on net, also has only a moderate effect on the location of the peak of the Laffer curve (i.e. the revenue maximizing level of the tax rate). The presence of this model element, however, strongly affects the level of the Laffer curve (i.e. how much revenue can be collected at a given average tax rate). In contrast, as shown in Section 8.4 increasing the intensive margin labor supply elasticity not only decreases the level of the Laffer curve, but also significantly moves the location of its peak to the left. Therefore it would be impossible to mimic the presence of the extensive margin of labor supply in our model by simply altering the labor supply elasticity in a standard life cycle model with labor supply choice only along the intensive margin.

gressive. In Section 5 we then describe our quantitative OLG economy with heterogeneous households. Section 6 is devoted to the calibration and estimation of the model parameters, and Section 7 displays the model performance along a number of dimensions not targeted by the calibration. The main quantitative results of the paper with respect to the impact of tax progressivity and household heterogeneity are presented in Section 8. We conclude in Section 9. The appendix in Section A discusses the transformation of a growing economy with extensive labor supply margin into a stationary economy, as well as the details of the estimation of the stochastic wage processes from micro data.

2 Background, Mechanisms and Related Literature

The idea that total tax revenues are a single-peaked function of the level of tax rates dates back to at least Arthur Laffer.[5] The peak of the Laffer curve and the associated tax rate at which it is attained are of interest both from a positive and from a normative perspective. From the perspective of positive fiscal policy analysis, it measures the maximal tax revenue that a government can raise. Normatively, allocations associated with tax rates to the right of the peak lead to allocations that are Pareto-dominated by those emerging from tax rates to the left of the peak that generate the same tax revenue, at least under standard household preferences. Thus the peak of the Laffer curve constitutes the positive and normative limit to income tax revenue generation by a benevolent government operating in a market economy.

A quantitative characterization of Laffer curves for the U.S. and a group of European countries (the EU14) is contained in Trabandt and Uhlig (2011). The authors employ a model with infinitely lived representative agents, flat taxes and a labor supply choice only along the intensive margin. They find that the peak of the labor income tax Laffer curve in both regions is located at a tax rate between 50% and 70%, depending on parameter values. The authors also show, under suitable assumptions on preferences, that the Laffer

[5]In Appendix A.2 we use a static model with a representative household to show that unless the government owns all non-labor resources in the economy there is a single peaked labor income tax Laffer curve.

curve remains unchanged in the presence of progressive taxation, if the representative agent paradigm is replaced with a population that is ex-ante heterogeneous with respect to their ability to earn income. In contrast, we argue that in a quantitative life cycle model with realistically calibrated wage heterogeneity and risk, an extensive margin labor supply as well as endogenous human capital accumulation, tax progressivity significantly changes the level and location of the peak of the Laffer curve, relative to Trabandt and Uhlig (2011)'s analysis.

Why and how does the degree of tax progressivity matter for the ability of the government to generate labor income tax revenues in an economy characterized by household heterogeneity and wage risk? First, holding labor supply behavior constant, under a more progressive tax code taxes collected from high earners rise and taxes from low earners fall. However, changes in tax progressivity also induce a behavioral response in hours worked and, potentially, in labor market participation.[6] In a representative agent model, making the tax schedule more progressive reduces hours worked, due to an increase in the wedge the labor income tax creates in the household's intratemporal optimality condition (see Section 4).

In contrast, in the presence of household heterogeneity, a change in tax progressivity differentially impacts hours worked by high- and low-earners since it induces differential income and substitution effects on the workers in different parts on the earnings distribution, as we will illustrate in Section 6.5 below.[7] Furthermore, the presence of an extensive margin typically leads to a higher overall labor supply elasticity for low wage agents who decide whether to participate in the labor market. A progressive tax system with low tax rates around the participation margin may in fact help to increase revenue if more agents decide to participate in the labor market[8] especially when this labor force participation (LFP), through enhanced experience, also leads to higher wages in the future.[9] In Section 4.2

[6]In his survey of the literature, Keane (2011) argues that labor supply choices both along the intensive and extensive margin, life-cycle considerations and human capital accumulation are crucial model elements when studying the impact of taxes on individual (and thus aggregate) labor supply.

[7]Biswas, Chakraborty, and Hai (2017) analyze empirically how this mechanism impacts regional economic development in the U.S.

[8]This is precisely what we find in our model for single women. See Section, 8.3 for details.

[9]The relationship between female LFP and human capital accumulation in life-cycle models is highlighted in Attanasio, Low, and Sanchez-Marcos (2008) and Guner, Kaygusuz, and Ventura (2012). Guner, Kaygusuz,

we use a simplified model with extensive margin labor choice and heterogeneous wages to illustrate how an increase in tax progressivity can lead to increased LFP.

In addition, in life-cycle models the presence of uninsurable wage risk leads to higher labor supply elasticity for older than for younger households, since the latter have a strong incentive to earn income and save for precautionary reasons, see e.g. Conesa, Kitao, and Krueger (2009). Since older agents have higher wages due to more accumulated labor market experience, a more progressive tax system that disproportionately reduces labor supply for old and thus high wage earners, may therefore lead to a substantial reduction in tax revenue. Furthermore, when agents undergo a meaningful life-cycle, more progressive taxes reduce the incentives for young agents to accumulate labor market experience and become high, and thus more highly taxed, earners in the first place. This effect lowers tax revenues from agents *at all ages* as younger households work less and older agents have lower wages in the presence of a more progressive tax code. Thus the question of how the degree of tax progressivity impacts the tax level - tax revenue relationship (i.e. the Laffer curve) in life cycle models is a quantitative one, and the one we take up in this paper.[10]

Departing from the analysis of Laffer curves in the representative agent paradigm by Trabandt and Uhlig (2011), two papers that computationally derive this curve in a heterogeneous household economy close to that studied by Aiyagari (1994) are Feve, Matheron, and Sahuc (2017) and Ma and Tran (2016). In addition to important modeling differences, the focus in Feve, Matheron, and Sahuc (2017) is on how the Laffer curve depends on outstanding government debt, whereas we are mainly concerned with the impact of the *progressivity* of the labor income tax code on the Laffer curve. The focus in Ma and Tran (2016) is on how an ageing population affects the Laffer curve. Finally, the closely related paper by Guner, Lopez-Daneri, and Ventura (2016) also studies the impact of tax progressivity on

and Ventura (2012) emphasize how a change from joint to separate taxation of married women would increase female LFP. This is consistent with the results in Section 8.3 where we find that married, who are taxed jointly with their husbands, and single women display opposite responses to changes in tax progressivity.

[10]In an environment with labor market frictions, higher tax progressivity may also have the effect of reducing involuntary unemployment. An analysis of the effect of tax progressivity in an economy with labor market frictions is contained in Abraham, Doligalski, and Forstner (2017).

tax revenues. In addition to important differences in the modelling approach[11], their paper focuses on a different question. Whereas we study the impact of tax progressivity on the whole Laffer curve (and, specifically, on its peak), their paper explores how higher tax progressivity affects tax revenues, holding the overall level of tax rates unchanged. They find limited scope for increasing revenues through increasing the progressivity of the tax system at current tax levels, a conclusion broadly consistent with our findings.

Turning to the broader related quantitative literature on tax revenue and tax reform, Chen and Imrohoroglu (2017) study the relationship between tax levels and the U.S. debt, whereas Kindermann and Krueger (2014) characterize the optimal *top marginal tax rate* in a model fairly similar to ours, but are not concerned with deriving Laffer curves for overall labor income tax revenue.[12] Relatedly, Badel and Huggett (2017) analytically characterize the revenue-maximizing *top marginal tax rate* in a broad class of dynamic economies, relating it to several sufficient statistics that include three easy-to-interpret elasticities. They are also not concerned with deriving Laffer curves for the overall labor income tax code, but rather focus on the impact of the maximal marginal tax rate, taking other features of the tax system as given.[13] Badel, Huggett, and Luo (2017) use a life-cycle model where human capital accumulation is modeled as in Ben-Porath (1967) to study how much revenue can be raised by increasing taxes on the top earners in the economy.

3 Measuring Tax Progressivity

Labor income taxes in the OECD are generally progressive and differ by household composition. To approximate country-specific tax functions, we use the labor income tax function proposed by Benabou (2002) and recently employed by Heathcote, Storesletten, and Violante

[11]Their model does not include the extensive margin of labor supply and endogenous human capital accumulation − the features we find to be quantitatively crucial for capturing the relationship between tax progressivity and tax revenues.

[12]Our modeling strategy broadly follows the literature on quantitative general equilibrium life-cycle models. See Conesa, Kitao, and Krueger (2009) and Kubler and Schmedders (2012) for representative examples.

[13]Lorenz and Sachs (2016) develop a sufficient statistics approach to testing whether the marginal tax rate is inefficiently high.

(2017) who argue that it fits the U.S. data well.[14] Let y denote pre-tax (labor) income and ya after tax income. The tax function $T(y)$ is implicitly defined by the mapping between pre-tax and after-tax labor income ya:

$$ya = \theta_0 y^{1-\theta_1} \tag{1}$$

so that $T(y) = y - ya$. We denote by $T'(y)$ the marginal tax rate and by $\tau(y)$ the average tax rate a household with income y pays. When we estimate the tax function and apply it in our model we express y relative to average labor earnings (AE) of employed individuals.

There are many ways to measure tax progressivity. Our objective is to employ a commonly used metric from the literature that, given the functional form of the tax function implied by (1), permits a one-dimensional measure of tax progressivity that is not confounded by the level of tax rates. In accordance with this goal we summarize the progressivity of the tax code by the *progressivity tax wedge* between two arbitrary income levels y_1 and $y_2 > y_1$:

$$PW(y_1, y_2) = 1 - \frac{1 - T'(y_2)}{1 - T'(y_1)} \tag{2}$$

Such wedge based measures of progressivity are common in the literature, see Caucutt, Imrohoroglu, and Kumar (2003) and Guvenen, Kuruscu, and Ozkan (2014). As long as the tax code is weakly progressive and thus $T'(y_2) \geq T'(y_1)$ this measure takes a value between 0 and 1. It is equal to zero for a proportional tax code for all income levels y_1 and y_2, approaches 1 as the marginal tax rate at the higher income y_2 approaches 1, and in general measures how strongly marginal tax rates increase between incomes y_1 and y_2. An attractive feature of the tax function we employ is that tax progressivity, as measured by the wedge $PW(y_1, y_2)$ is determined exclusively by the parameter θ_1, and is independent of the scale

[14]See Appendix A.8 for more details on the properties of this tax function.

parameter θ_0. As Section A.8 in the appendix shows, the wedge is given, for all $y_1 < y_2$, by:

$$PW(y_1, y_2) = 1 - \frac{1 - T'(y_2)}{1 - T'(y_1)} = 1 - \left(\frac{y_1}{y_2}\right)^{\theta_1} \tag{3}$$

Thus we can raise the *level* of taxes by decreasing the parameter θ_0 without affecting tax progressivity (as measured by the wedge) at any level of incomes y_1 and y_2. At the same time, an increase in the progressivity parameter θ_1 elevates the progressivity of the tax code, independent of the level of tax rates.

For the purpose of comparing tax progressivity across countries we now use *labor income* tax data from OECD countries to estimate the parameters θ_0 and θ_1 for different family types (singles without children and married couples with zero, one and two children).[15]. We normalize earnings by average earnings of single individuals in each country, AE, and estimate $\tau(y/AE)$. Table 10 in the Appendix summarizes the results. To obtain an index of tax progressivity across countries, we then take the sum of the estimated θ_1's weighted by each family type's share of the population in the U.S.[16] Table 1 displays the progressivity index for the U.S., Canada, Japan, and Western European countries.

We observe that there is considerable cross-country variation in tax progressivity in the OECD. As measured by the tax progressivity wedge Japan has the least progressive taxes, whereas the most progressive tax code can be found in Denmark. As measured by the index, taxes in Denmark are about 2.5 times more progressive than in Japan[17]. The U.S. is among the countries with the least progressive tax code.[18] A crucial policy question we take up in

[15]When obtaining the data for married couples we assume a constant ratio between female and male income of 0.41 (the number found in the CPS). For married couples the OECD tax and benefit calculator takes the male and female gross income as separate inputs and returns the net income of the family after taxes and transfers. Thus it reflects, for each country, correctly whether spouses are taxed as singles or jointly. When we obtain the data we assume a constant ratio between female and male income. For countries with joint taxation this does not matter, but for countries with individual taxation it does. In the Appendix we reproduce the index under alternative assumptions about the ratio beteen male and female income.

[16]We use U.S. population shares to avoid conflating cross-county differences in tax progressivity with cross-country differences in family structures.

[17]In Section 8 we show that countries can raise more revenue and sustain higher debt with flatter taxes. This observation is consistent with the observation that Japan has the flattest taxes in the OECD as well as the highest debt-to-GDP ratio.

[18]The tax function in Equation 1 has also been estimated by Heathcote, Storesletten, and Violante (2017)

Table 1: Tax Progressivity in the OECD 2000-2007

Country	Progressivity Index	Relative Progressivity (U.S.=1)
Japan	0.101	0.74
Switzerland	0.133	0.97
Portugal	0.136	0.99
U.S.	0.137	1.00
France	0.142	1.03
Spain	0.148	1.08
Norway	0.169	1.23
Luxembourg	0.180	1.31
Italy	0.180	1.31
Austria	0.187	1.37
Canada	0.193	1.41
U.K.	0.200	1.46
Greece	0.201	1.47
Iceland	0.204	1.49
Germany	0.221	1.61
Sweden	0.223	1.63
Ireland	0.226	1.65
Finland	0.237	1.73
Netherlands	0.254	1.85
Denmark	0.258	1.88

this paper is how the ability of the U.S. government to generate revenue is affected if the U.S. had a tax code as progressive as the one in countries towards the bottom of Table 1.

4 Building Intuition: The Impact of Tax Progressivity on Labor Supply and Tax Revenue

In order to provide intuition for how tax progressivity impacts tax revenue in our quantitative model, and to establish a useful benchmark to compare our results against, we now study

and Guner, Lopez-Daneri, and Ventura (2016) for the U.S. The OECD tax and benefit calculator, the source of our data, reports net income after taxes and includes most direct transfers to households. Like us, Heathcote, Storesletten, and Violante (2017) estimate the tax function net of transfers. They use tax data from the NBER TAXSIM in combination with the PSID to obtain data on taxes and transfers, and estimate $\theta_1^{US} = 0.181$, slightly higher than our estimate of the progressivity parameter of $\theta_1^{US} = 0.137$ from Table 1. The reason for the higher number in Heathcote, Storesletten, and Violante (2017) is likely that their data allows them to include a more complete measure of transfers. Guner, Lopez-Daneri, and Ventura (2016), in contrast estimate the tax function on IRS income tax data which do not include transfers, and obtain a significantly smaller value of tax progressivity, $\theta_1^{US} = 0.053$.

the Laffer curve in a sequence of simple, analytically tractable versions of our model, aiming at providing intuition for the main mechanisms at the core of our quantitative results.

4.1 Tax Progressivity, Revenue and Labor Supply with Representative Agents

Consider a representative household. This household has preferences over streams of consumption and hours $\{c_t, h_t\}$ represented by lifetime utility function

$$\sum_{t=0}^{\infty} \beta^t u(c_t, h_t) = \sum_{t=0}^{\infty} \beta^t \left(\log(c_t) - \chi \frac{h_t^{1+\eta}}{1+\eta} \right) \tag{4}$$

where $\beta \in (0,1), \chi, \eta \geq 0$ are parameters. The household faces the budget constraints

$$c_t + k_{t+1} = \theta_0 \left(\frac{w_t h_t}{w_t H_t} \right)^{1-\theta_1} + k_t(1+r_t) + T_t, \tag{5}$$

where w_t, r_t are equilibrium wages and interest rates, k_t are asset holdings of the household, T_t is the transfer from the government, and H_t is the "average or aggregate" hours worked, so that after tax labor income of the household, given the assumed tax function (1), equals $\theta_0 \left(\frac{w_t h_t}{w_t H_t} \right)^{1-\theta_1}$. In equilibrium, $H_t = h_t$. Government tax revenues are:

$$TR_t = w_t H_t - \theta_0 \left(\frac{w_t H_t}{w_t H_t} \right)^{1-\theta_1} = w_t H_t - \theta_0 \tag{6}$$

We assume that the government rebates a fraction $s \in [0,1]$ of its tax revenues back to the agent in lump-sum fashion:

$$T_t = sTR_t = s\left(w_t H_t - \theta_0\right) \tag{7}$$

First, taking factor prices and government transfers constant, the partial equilibrium effect on hours worked (and thus tax revenues) of increasing tax progressivity can be deduced from the first-order condition that characterizes the choice of hours worked along the intensive margin (in conjunction with the first order condition for consumption). In a broad class of models with a continuous choice of consumption and hours, this condition is as follows[19]:

$$u_c'(c,h)w\left(1-\left[\tau\left(wh/wH\right)+\frac{wh}{wH}\tau'\left(wh/wH\right)\right]\right)=-u_h'(c,h) \tag{8}$$

where $\tau(.)$ was defined above as the average tax rate.[20]

If one increases tax progressivity θ_1 and thus the slope of the average tax function τ' but keeps the level τ of taxes constant, this magnifies the "tax wedge" term in the square brackets, which (holding c and thus the income effect on labor supply unchanged) leads to a decrease in hours worked h and thus in labor income tax revenues.[21] The next proposition states that this result carries over to the general equilibrium of the representative agent model in which private consumption as well as factor prices adjust.

Proposition 4.1. *In the complete markets, representative agent model aggregate hours worked H and government tax revenues TR strictly decrease with tax progressivity*[22] θ_1*:*

$$\frac{\partial TR}{\partial \theta_1}<0 \quad \& \quad \frac{\partial H}{\partial \theta_1}<0 \tag{9}$$

Proof. See Appendix A.3 ■

[19]One requirement to obtain this condition is that hours worked enter the budget constraint only through the $wh(1-\tau)$ term, which rules out the dynamic effects, such as the impact of hours worked on the future wages through the accumulation of the human capital. To derive equation (8), we also assumed that labor tax is a function of the income relative to the average earnings, $\frac{wh}{\mathrm{AE}}$.

[20]Recall that $\tau(y)=\frac{T(y)}{y}$ and thus $\tau'(y)=\frac{T'(y)-\tau(y)}{y}$ and therefore $T'(y)=\tau(y)+y\tau'(y)$.

[21]In the general equilibrium of any representative agent model $h_t=H_t$. Given the functional form of the tax function, we have $\tau\left(wh/wH\right)=\tau(1)=1-\theta_0$ whereas $\tau'\left(wh/wH\right)=\tau'(1)=\theta_0\theta_1$ and thus one can hold the tax level, $(1-\theta_0)$, constant, but increase its progressivity, by raising the progressivity parameter θ_1.

[22]This result may seem to contrast with Proposition 6 in Trabandt and Uhlig (2011), who state that changing the tax progressivity does not change the Laffer curves in the representative agent model similar to ours. However, they perform a different thought experiment than this paper. When they change tax progressivity, they simultaneously recalibrate the model (by changing the disutility of hours worked, χ in our utility specification) in order to keep *hours worked unchanged* when tax progressivity changes. One can see from equation (20) in the appendix that θ_1 affects hours through the $\frac{1-\theta_1}{\chi}$ ratio. Trabandt and Uhlig (2011) adjust χ to keep this ratio constant. Our focus, on the other hand, is precisely on the impact of tax progressivity on hours worked and the associated effect on tax revenue. Therefore we keep all *parameters constant* when deriving Laffer curves for varying degrees of tax progressivity θ_1.

4.2 Heterogeneity and Tax Progressivity: Labor Supply along the Intensive and Extensive Margin

The previous proposition demonstrates the negative impact of tax progressivity on aggregate labor supply and tax revenue in the representative agent model in which, by construction, every household responds equally to a change in progressivity. However, with empirically plausible household heterogeneity in labor productivity and wages, the labor supply of households at the low and the high end of the income distribution will respond differentially, both along the intensive and the extensive margin. Our quantitative results in section 8 will show the quantitative significance of this observation; here we develop the intuition for this finding in versions of the model with highly stylized degree of household heterogeneity.

First, turning to the intensive margin, consider a version of the representative agent model where each family is composed of an equal number of low-productivity members with permanent hourly productivity $w_L = \exp(-a)$ and high-productivity members with productivity $w_H = \exp(a)$ where $a > 0$ is a parameter. The family planner maximizes

$$\sum_{t=0}^{\infty} \beta^t \left(u(c_{L,t}, h_{L,t}) + u(c_{H,t}, h_{H,t}) \right) = \sum_{t=0}^{\infty} \beta^t \left(\left(\log(c_{L,t}) - \chi \frac{h_{L,t}^{1+\eta}}{1+\eta} \right) + \left(\log(c_{H,t}) - \chi \frac{h_{H,t}^{1+\eta}}{1+\eta} \right) \right) \tag{10}$$

subject to the family budget constraint

$$c_{L,t} + c_{H,t} + k_{t+1} = \theta_0 \left(\frac{we^{-a} h_{L,t}}{AE} \right)^{1-\theta_1} + \theta_0 \left(\frac{we^{a} h_{H,t}}{AE} \right)^{1-\theta_1} + k_t(1+r) + T \tag{11}$$

taking as given government transfers T, average earnings AE in the economy and wages w per efficiency units. We can show that hours worked of high-earnings members respond more strongly to an increase in tax progressivity than those of low-earnings members:

Proposition 4.2. *Relative hours worked are given by* $\frac{h_H}{h_L} = e^{\frac{2a(1-\theta_1)}{\theta_1+\eta}}$ *and thus*

$$\frac{\partial (h_H/h_L)}{\partial \theta_1} < 0 \quad \textit{and} \quad \frac{\partial^2 (h_H/h_L)}{\partial \theta_1 \partial a} < 0 \tag{12}$$

so that the relative hours worked are strictly decreasing in the degree of tax progressivity, the more so the bigger are the productivity differences

Proof. See Appendix A.4 ■

Since an increase in the progressivity parameter increases the marginal tax rate of high-productivity and thus high-income household member more strongly than that of low-income earners (whose marginal tax rate might actually decline), hours worked of high-income members decline relative to those of low income members of the family.

Now consider the extensive margin of labor supply, and for simplicity, abstract from the intensive margin and from capital accumulation (by assuming, for example, that $\beta = 0$). Consider a continuum of individuals that differ in their labor productivity realization w_i, and can only choose between zero and $\bar{h} > 0$ hours. Each individual solves

$$\max_{h \in \{0, \bar{h}\}} \log(c) - F \cdot \mathbb{1}_{[h>0]}$$
$$\text{s.t.: } c = \theta_0 \left(\frac{w_i \bar{h}}{AE} \right)^{1-\theta_0} + T$$

again taking as given transfers T and average earnings AE. The next proposition shows that an increase in tax progressivity encourages labor market participation (positive hours) at the low end of the productivity distribution but decreases tax revenues from those already working in that group, while it increases tax revenues from high income earners.

Proposition 4.3. *Suppose there is a unique labor productivity threshold $\underline{w}$ such that individuals with $w_i < \underline{w}$ do not participate and those with $w_i \geq \underline{w}$ participate in the labor market. Then a marginal increase in tax progressivity θ_1 increases participation. Among the workers that choose to work positive hours, the marginal increase in tax progressivity θ_1, ceteris paribus, increases tax revenues from those with labor income initially above average earnings AE and reduces it from those below average earnings.*

Proof. See Appendix A.5 ■

Taking together, both results in this subsection demonstrate that an increase in tax progressivity is bound to have a positive effect on the labor supply of the low earners, relative to the high earners, both along the intensive and the extensive margin. Departing from the basic results in this section, in the remainder of the paper we now explore the *quantitative* question, whether, and to what extent, tax progressivity impacts labor supply and aggregate tax revenues in a life cycle model with plausibly calibrated household heterogeneity and labor supply both along the intensive and extensive margin.

5 The Model

In this section we describe the model we use to characterize the Laffer curve, and specifically discuss the model elements that sets our heterogeneous household economy apart from the representative agent model employed by Trabandt and Uhlig (2011).

5.1 Technology

A representative firm operates a Cobb-Douglas production function of the form:

$$Y_t(K_t, L_t) = K_t^{\alpha} \left[Z_t L_t \right]^{1-\alpha}$$

where K_t is capital input, L_t is the labor input measured in efficiency units, and Z_t is labor-augmenting productivity. The evolution of capital is described by:

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

where I_t is gross investment, and δ is the capital depreciation rate. We assume that productivity Z_t grows deterministically at rate μ, starting from $Z_0 = 1$, that is $Z_t = (1 + \mu)^t$. In each period, the firm hires labor and capital to maximize its profit:

$$\Pi_t = Y_t - w_t L_t - (r_t + \delta) K_t,$$

and in a competitive equilibrium, factor prices equal their marginal products:

$$w_t = \partial Y_t/\partial L_t = (1-\alpha)Z_t^{1-\alpha}\left(\frac{K_t}{L_t}\right)^{\alpha} = (1-\alpha)Z_t\left(\frac{K_t/Z_t}{L_t}\right)^{\alpha} \tag{13}$$

$$r_t = \partial Y_t/\partial K_t - \delta = \alpha Z_t^{1-\alpha}\left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta = \alpha\left(\frac{L_t}{K_t/Z_t}\right)^{1-\alpha} - \delta \tag{14}$$

We restrict our analysis to balanced growth equilibria in which long-run growth is generated by exogenous technological progress. Following King, Plosser, and Rebelo (2002) and Trabandt and Uhlig (2011), we impose restrictions on the production technology, preferences, as well as government policies that allow us to transform the growing economy into a stationary one, using the usual transformations. Then, along a balanced growth path (BGP) $K^z = K_t/Z_t$ is constant. We define $w_t^z = w_t/Z_t$, and note that both w_t^z and r_t will also be constant along the BGP, and therefore we drop the time subscript for these variables as well.

5.2 Demographics

The economy is populated by J overlapping generations of finitely lived households, with household age indexed by $j \in J$. We model heterogeneity in family structure explicitly since in the data family type is an important determinant of the income tax code, something we wish to capture in our model.[23] Households are either single (denoted by S) or married (denoted by M), and single households are further distinguished by their gender (man or woman), denoted as $\iota \in (m, w)$. Thus there are 3 types of households; single males, single females, and married couples. We assume that within a married household, the husband and the wife are of the same age. All households start life at age 20 and retire at age 65.

A model period is one year. The probability of dying while working is zero; retired households, on the other hand, face an age-dependent probability of dying, $\pi(j)$, and die for certain at model age $J = 81$, corresponding to a real world age of 100. By assumption a husband and a wife both die at the same age. We assume that the size of the population is

[23] In his survey of the literature, Keane (2011) stresses the importance of marital status for the response of labor supply to taxes

fixed and normalize the size of each newborn cohort to 1. Using $\omega(j) = 1-\pi(j)$ to denote the age-dependent survival probability, by the law of large numbers the mass of retired agents of age $j \geq 65$ still alive at any given period is equal to $\Omega_j = \prod_{q=65}^{q=j-1} \omega(q)$. There are no annuity markets, so that a fraction of households leave unintended bequests which are redistributed in a lump-sum manner between the households that are currently alive. We use Γ_t to denote the per-household bequest.

In addition to age and marital status, households are heterogeneous with respect to asset holdings, k, exogenously determined permanent ability of its members, $a \sim N(0, \sigma_a^{\iota 2})$ drawn at birth, their years of labor market experience, e, and idiosyncratic productivity shocks u. By choosing a suitable utility function we assume that men always work positive hours during working age. However, a woman will either work or stay at home. Married households jointly decide on how many hours to work, how much to consume, and how much to save. Females who participate in the labor market accumulate one year of labor market experience. Since men always work, they accumulate an additional year of working experience in every period. Retired households make no labor supply decisions, but receive social security benefits Ψ_t.

Since, as we will show below, labor supply decisions will vary greatly by family type and age it is important that the model has an empirically plausible distribution of family types by household age. The easiest way to achieve this is to introduce into the model marriage and divorce as exogenous shocks, as in Cubeddu and Rios-Rull (2003) and Chakraborty, Holter, and Stepanchuk (2015). Single households face an age-dependent probability, $M(j)$, of becoming married whereas married households face an age-dependent probability, $D(j)$, of divorce. There is assortative matching in the marriage market, so that there is a greater chance of marrying someone with similar ability, a fact that singles rationally foresee.[24] Specifically, a single male with ability a^m faces a probability $\phi^w(a|a^m;\varphi)$ of marrying a female of type a, and symmetrically, a female of type a^w marries a male of ability a with probability $\phi^m(a|a^w;\varphi)$. The parameter φ, calibrated in section 6, captures the degree of

[24] We thank two referees for pointing out to us that the degree of assortative matching interacts with tax progressivity since it leads to a more dispersed household income distribution, ceteris paribus.

sorting in the marriage market, with $\varphi = 0$ standing in for perfectly random marriage and $\varphi = 1$ representing perfect sorting by permanent ability.[25]

5.3 Wages

The wage of an individual depends on the aggregate wage per efficiency unit of labor, $w^z = \frac{w}{Z}$, and the number of efficiency units the individual is endowed with. The latter depends on the individual's gender, $\iota \in (m, w)$, ability, a, accumulated labor market experience, e, and an idiosyncratic shock, u, which follows an AR(1) process. Thus, the wage of an individual with characteristics (a, e, u, ι) is given by:

$$log(w^z(a, e, u, \iota)) = log(w^z) + a + \gamma_0^\iota + \gamma_1^\iota e + \gamma_2^\iota e^2 + \gamma_3^\iota e^3 + u \tag{15}$$

$$u' = \rho^\iota u + \epsilon, \quad \epsilon \sim N(0, \sigma^2_{\epsilon^\iota}) \tag{16}$$

The parameters γ_0^ι encode the gender wage gap, and γ_1^ι, γ_2^ι as well as γ_3^ι capture returns to experience for women and the age profile of wages for men, respectively.

5.4 Preferences

Married couples solve a joint maximization problem with equal weights on the spouses period utilities. Their momentary utility function, U^M, depends on joint consumption, c, hours worked by the husband, $n^m \in (0, 1]$, and the wife, $n^w \in [0, 1]$. It takes the following form:

$$U^M(c, n^m, n^w) = \log(c) - \frac{1}{2}\chi_M^m \frac{(n^m)^{1+\eta^m}}{1+\eta^m} - \frac{1}{2}\chi_M^w \frac{(n^w)^{1+\eta^w}}{1+\eta^w} - \frac{1}{2} F_M^w \cdot \mathbb{1}_{[n^w>0]} + \log(G) \tag{17}$$

where $F_M^w \sim N(\mu_{F_M^w}, \sigma^2_{F_M^w})$ is a fixed disutility from working positive hours and G is a public good supplied by the government. The indicator function, $\mathbb{1}_{[n>0]}$, is equal to 0 when $n = 0$

[25]Conditional on gender, age and permanent ability, a single household rationally expects to draw a partner from the *conditional* stationary distribution along all other single household characteristics of the other gender. For example, a single male understands that if he were, by chance, to marry a high ability female, she would carry higher than average assets into the marriage -since permanent ability and assets are positively correlated among single females.

and equal to 1 when $n > 0$. The momentary utility function for singles is given by:

$$U^S(c, n, \iota) = \log(c) - \chi_S^\iota \frac{(n)^{1+\eta^\iota}}{1+\eta^\iota} - F_S^\iota \cdot \mathbb{1}_{[n>0]} + \log(G) \qquad (18)$$

We allow the disutility of work to differ by gender and marital status, and the fixed cost of work for women to differ by marital status. The participation cost of a woman is drawn only once, at the beginning of life, and thus is a fixed characteristic of a woman (but is allowed to differ when single and when married).[26] In a model without participation margin, King, Plosser, and Rebelo (2002) show that the above preferences are consistent with balanced growth. In the appendix, we demonstrate that this is also true in our model with a fixed utility cost from working positive hours, and thus an operative extensive margin.

5.5 The Government

The government runs a balanced social security system in which it taxes employees and the employer (the representative firm) at rates τ_{ss} and $\tilde{\tau}_{ss}$ and pays benefits, Ψ_t, to retirees. The government also taxes consumption, labor and capital income to finance the expenditures on pure public consumption goods, G_t, interest payments on the national debt, rB_t, lump sum redistributions, g_t, and unemployment benefits T_t. We assume that there is some outstanding government debt, and that the government debt to output ratio, $B_Y = B_t/Y_t$, is constant over time. Spending on public consumption is also assumed to be proportional to GDP so that $G_Y = G_t/Y_t$ is constant. Consumption and capital income are taxed at flat rates τ_c, and τ_k. In reality, taxation of capital is of course more complicated than in the model. In the U.S. interest income is taxed together with labor income and the corporate tax code is also non-linear. However, we follow the common practice in the macroeconomic literature to approximate the capital income tax schedule with a linear tax.

To model the non-linear labor income tax, as discussed in Section 2, we use the functional form in equation (1), proposed by Benabou (2002) and recently used in Heathcote,

[26] The state space for both cost distributions is discretized using Tauchen (1986)'s method, and a woman's position in the distribution of fixed costs remains the same throughout life.

Storesletten, and Violante (2017), that maps pre-tax (labor) income y into after-tax income $ya = \theta_0 y^{1-\theta_1}$, and where the parameters θ_0 and θ_1 govern the level and the progressivity of the tax system. In addition, the government collects social security contributions to finance the retirement benefits.

We denote with superscript Z aggregate variables deflated by the level of total factor productivity Z. That is, we define deflated tax revenue from labor, capital and consumption taxes R^z, revenues from social security taxes R^{ssz}, deflated transfers g^z, government consumption G^z, social security benefits Ψ^z, and unemployment benefits T^z as:

$$R^z = R_t/Z_t, \quad R^{ssz} = R_t^{ss}/Z_t, \quad g^z = g_t/Z_t, \quad G^z = G_t/Z_t, \quad \Psi^z = \Psi_t/Z_t, \quad T^z = T_t/Z_t$$

Along a BGP these variables remain constant (and also stay constant as a share of GDP). Denoting the fraction of women[27] that work 0 hours by ζ_t, we can write the government budget constraints (normalized by the level of technology) along a BGP:

$$g^z \left(45 + \sum_{j \geq 65} \Omega_j\right) + \frac{45}{2} T^z \zeta_t + G^z + (r - \mu) B^z = R^z$$
$$\Psi^z \left(\sum_{j \geq 65} \Omega_j\right) = R^{ssz}.$$

The second equation assures budget balance in the social security system by equating per capita benefits times the number of retired individuals to total tax revenues from social security taxes. The first equation is the regular government budget constraint on a BGP. The government spends resources on per capita transfers (times the number of individuals in the economy), on unemployment benefits for women that work zero hours, on government consumption and on servicing the interest on outstanding government debt, and has to finance these outlays through tax revenue.

[27] Recall that we assume that men always work.

5.6 Recursive Formulation of the Household Problem

At any given time, a married household is characterized by its assets k, the man's and the woman's experience levels, e^m, e^w, their transitory productivity shocks, u^m, u^w, and permanent ability levels, a^m, a^w, the female fixed cost of working, F^w_M, as well as the households' age j. Thus the list of state variables of a married household is $(k, e^w, u^m, u^w, a^m, a^w, F^w_M, j)$. Since we assumed that male experience is always equal to his age, $e^m = j$, we can therefore drop e^m from the state space for married couples. The state space for a single household is $(k, e, u, a, F^w_S, \iota, j)$. To formulate the household problem along the BGP recursively, we define deflated household consumption and assets as $c^z = c_t/Z_t$ and $k^z = k_t/Z_t$. Since on the BGP the ratio of aggregate variables[28] to productivity Z_t and to aggregate output remains constant, we posit that household-level variables, c^z and k^z, do not depend on calendar time either along a BGP, and thus we omit the time subscript for them as well. We can then formulate the optimization problem of a married household recursively as:

$$
\begin{aligned}
V^M(k^z, e^w, u^m, u^w, a^m, a^w, F^w_M, j) = & \max_{c^z,(k^z)',n^m,n^w} \Big[U\left(c^z, n^m, n^w\right) \\
& + \beta(1-D(j)) E_{(u^m)',(u^w)'} \left[V^M((k^z)', (e^w)', (u^m)', (u^w)', a^m, a^w, F^w_M, j+1) \right] \\
& + \frac{1}{2}\beta D(j) E_{(u^m)',(u^w)'} \left[V^S((k^z)'/2, u', a, m, j+1) + V^S((k^z)'/2, (e^w)', u', a, w, F^w_S, j+1) \right] \Big]
\end{aligned}
$$

s.t.:

$$
c^z(1+\tau_c) + (k^z)'(1+\mu) = \begin{cases} \left(k^z + \Gamma^z\right)\left(1 + r(1-\tau_k)\right) + 2g^z + Y^L, & \text{if } j < 65 \\ \left(k^z + \Gamma^z\right)\left(1 + r(1-\tau_k)\right) + 2g^z + 2\Psi^z, & \text{if } j \geq 65 \end{cases}
$$

[28]Including bequests $\Gamma^z = \Gamma_t/Z_t$

$$Y^L = \left(Y^{L,m} + Y^{L,w}\right)\left(1 - \tau_{ss} - \tau_l^M\left(Y^{L,m} + Y^{L,w}\right)\right) + \left(1 - \mathbb{1}_{[n^w>0]}\right)T^z$$

$$Y^{L,\iota} = \frac{n^\iota w^{z,\iota}\left(a^\iota, e^\iota, u^\iota\right)}{1 + \tilde{\tau}_{ss}}, \ \iota = m, w$$

$$(e^m)' = j + 1, \quad (e^w)' = e^w + \mathbb{1}_{[n^w>0]},$$

$$n^m \in (0,1], \quad n^w \in [0,1], \quad (k^z)' \geq 0, \quad c^z > 0,$$

$$n^\iota = 0 \quad \text{if } j \geq 65, \ \iota = m, w.$$

Y^L is household labor income, composed of labor income of the two spouses received during the working phase of their life, τ_{ss} and $\tilde{\tau}_{ss}$ are social security contributions paid by the employee and the employer. The problem of a single household (which includes the chances of marrying someone of opposite gender $-\iota$) can similarly be written:

$$\begin{aligned}
V^S(k^z, e, u, a, \iota, F_S^\iota, j) = \max_{c^z,(k^z)',n} \Big[& U\left(c^z, n\right) \\
& + \beta(1 - M(j))E_{u'}\left[V^S((k^z)', e', u', a, \iota, F_S^\iota, j+1)\right] \\
& + \beta M(j) E_{(k^{-\iota})', e^{-\iota}, (u^m)', (u^w)', a^{-\iota}, F^{S-\iota}}\left[V^M((k^z)' + (k^{-\iota})', (e^w)', (u^m)', (u^w)', a^m, a^w, j+1)\right]\Big]
\end{aligned}$$

s.t.:

$$c^z(1 + \tau_c) + (k^z)'(1 + \mu) = \begin{cases} (k^z + \Gamma^z)\left(1 + r(1 - \tau_k)\right) + g^z + Y^L, & \text{if } j < 65 \\ (k^z + \Gamma^z)\left(1 + r(1 - \tau_k)\right) + g^z + \Psi^z, & \text{if } j \geq 65 \end{cases}$$

$$Y^L = \left(Y^{L,\iota}\right)\left(1 - \tau_{ss} - \tau_l^S\left(Y^{L,\iota}\right)\right) + \left(1 - \mathbb{1}_{[n^w>0]}\right)T^z$$

$$Y^{L,\iota} = \frac{n^\iota w^{z,\iota}\left(a^\iota, e^\iota, u^\iota\right)}{1 + \tilde{\tau}_{ss}}, \ \iota = m, w$$

$$(e^m)' = e^m + 1, \quad (e^w)' = e^w + \mathbb{1}_{[n^w>0]},$$

$$n^m \in (0,1], \quad n^w \in [0,1], \quad (k^z)' \geq 0, \quad c^z > 0,$$

$$n^\iota = 0 \quad \text{if } j \geq 65, \ \iota = m, w.$$

The fixed cost of working, F_S^ι is assumed to be zero for men, and thus men optimally choose positive work hours. $E_{(k^{-\iota})',e^{-\iota},(u^m)',(u^w)',a^{-\iota},F^{S-\iota}}$ is the expectation about the characteristics of a partner in the case of marriage in addition to the expectation about next period's labor productivity of the individual. The expectation is taken conditional on the individual's age and permanent ability, because there is perfect assortative matching with respect to age, and to some (calibrated) extent with respect to permanent ability.

5.7 Recursive Competitive Equilibrium

We call a recursive competitive equilibrium of the growth-adjusted economy a stationary equilibrium.[29]. In equilibrium agents optimize, given prices, markets clear, budgets balance, and the cross-sectional distribution across household types is stationary. For sake of brevity, the formal equilibrium definition is stated in Appendix A.1.

6 Calibration

This section describes the calibration of the model parameters. We calibrate our model to match selected moments from 2001-2007 U.S. data. We choose this time frame since the tax data start in 2001, and since we want to avoid the great recession starting in 2008 for our steady state analysis. Many parameters can be calibrated directly to their empirical counterparts, without solving the model. These are listed (including their values) in Table 2. In contrast, the 11 parameters in Table 3 below are estimated using an exactly identified simulated method of moments (SMM) approach.

6.1 Technology

We set the capital share parameter α to 1/3 and choose the depreciation rate to match an investment-to-capital ratio of 9.88% in U.S. data.

[29]The associated BGP can of course be constructed by scaling all growing variables by the factor Z_t.

6.2 Demographics and Transition Between Family Types

The demographic structure of the model is completely determined by the unit mass of newborn households and the death probabilities of retirees. We obtain the latter from the National Center for Health Statistics.

We assume that there are three family types: (1) single males; (2) single females; (3) married couples. To calculate age-dependent probabilities of transitions between married and single, we use U.S. data from the CPS March supplement, covering years 1999 to 2001. We assume stationarity, that is, although we permit the probabilities of transitioning between the family types to depend on an individual's age, we rule out dependence on her birth cohort. Denoting the shares of married and divorced individuals at age j by $\bar{M}(j)$ and $\bar{D}(j)$, we compute the probability of getting married at age j, $M(j)$, and the probability of getting divorced, $D(j)$, from the following transition equations:

$$\bar{M}(j+1) = (1-\bar{M}(j))M(j) + \bar{M}(j)(1-D(j)),$$
$$\bar{D}(j+1) = \bar{D}(j)(1-M(j)) + \bar{M}(j)D(j).$$

Upon marriage, the exogenous degree of spousal sorting by ability is governed by the parameter φ, and estimated within the SMM procedure so that the model matches the empirical correlation of hourly wages of 0.407 in the CPS (2001-2007) for married couples.[30]

[30] Specifically, prior to marriage an individual of earnings type a draws random marriage quality $\varsigma \sim U[0,1]$. His/her marriage quality rank M_n is then determined by

$$M_n = (1-\varphi)\varsigma + \varphi a. \tag{19}$$

Then all individuals of the same gender are ranked according to M_n and matched with exactly the same rank of the opposite gender. If $\varphi = 0$, marriage is random, and if $\varphi = 1$, marriages are perfectly sorted by spousal ability a. Appendix A.10 contains the details of this construction, which, conditional on own ability a, induces a distribution over spousal abilities (and associated distribution over the other payoff-relevant state variables of future partners) that permits singles to rationally form expectations.

6.3 Wages

We estimate the exogenous age profile for male wages, the experience profile for female wages, and the exogenous processes for the idiosyncratic shocks using the PSID from 1968-1997. After 1997, it is not possible to obtain years of actual labor market experience from the PSID. Appendix A.9 describes the estimation procedure in more detail. We use a 2-step approach to control for selection into the labor market, as described in Heckman (1976) and Heckman (1979). After estimating the returns to age for males and to experience for females, we use the residuals from the regressions and the panel data structure of the PSID to estimate the parameters for the productivity shock processes, ρ_ϵ^ι and σ_ϵ^ι, and the variance of individual ability, σ_a^ι. We normalize the mean female wage parameter γ_0^w to 1 and estimate the mean male wage parameter γ_0^m internally in the model[31]. The associated data moment is the ratio between male and female earnings.

6.4 Preferences

The period utility functions for both family types are given in equations (17) and (18). The discount factor, β, the cross-sectional means and variances of the fixed costs of working, $\mu_{F_M^w}$, $\mu_{F_S^w}$, $\sigma^2_{F_M^w}$ and $\sigma^2_{F_S^w}$, and the disutility parameters of working more hours, χ_M^m, χ_M^w, χ_S^m and χ_S^w, are parameters estimated through the SMM approach. The empirical moment that mainly identifies the time discount factor β is the capital-output ratio K/Y, taken from the BEA. The mean participation costs for women, $\mu_{F_M^w}$, $\mu_{F_S^w}$, are identified by the employment rates of married and single females aged 20-64, taken from the CPS. To pin down the cross-sectional variance of the participation costs, $\sigma^2_{F_M^w}$ and $\sigma^2_{F_S^w}$, we use the *persistence* of labor force participation of married and single females (again aged 20-64) from the PSID. If the cross-sectional dispersion of the participation cost is high, some women will work all the time, and some women will always be out of the labor force. We regress this year's participation status on last year's participation status in the data and obtain an R^2 for single and married

[31] The value of γ_0^m does not reflect the difference between the wages of 20-year old men and women because the age profile for men starts at 20 years, whereas the experience profile for women starts at 0 years.

women. We then use the R^2s as moments. The parameters governing the disutility of working more hours, χ_M^m, χ_M^w, χ_S^m and χ_S^w, are identified by hours worked per person aged 20-64 by marital status and gender, again taken from the CPS.

There is considerable debate in the economic literature about the Frisch elasticity of labor supply, see Keane (2011) for a thorough survey. However, there seems to be consensus that female labor supply is much more elastic than male labor supply.[32] We set $1/\eta^m = 0.4$, in line with the contemporary literature in quantitative macroeconomics, see for instance Guner, Kaygusuz, and Ventura (2012). $1/\eta^w$ we set to 0.8. Note that $1/\eta^w$ is here to be interpreted as the intensive margin Frisch elasticity of female labor supply, while $1/\eta^m$ is the Frisch elasticity of male labor supply. The $1/\eta$ parameter cannot be interpreted as the *macro elasticity* of labor supply with respect to tax rates, see Keane and Rogerson (2012) for a detailed discussion.

6.5 Taxes and Social Security

As described in Section 3 we employ the labor income tax function in equation (1), as proposed by Benabou (2002). We use U.S. labor income tax data provided by the OECD to estimate the parameters θ_0 and θ_1 for different family types.[33]

For future reference, the left panel of Figure 1 shows the average tax rate function we obtain for U.S. singles (dashed line), plotted against labor earnings relative to average earnings, AE. It also contains the tax functions as we multiply θ_1 by 0 (converting it to a flat tax) or by two (roughly the progressivity of the Danish tax system); these two functions are used in counterfactual analyses below. The right panel plots the tax wedge $\tau\left(wh/wH\right) + \frac{wh}{wH}\tau'\left(wh/wH\right)$ against labor earnings.

As can be seen from the left panel of Figure 1, making taxes more progressive increases the average tax rate for those with above average earnings and decreases it for those with

[32] The recent paper by Blundell, Pistaferri, and Saporta-Eksten (2016) estimates the intensive margin Frisch elasticity for men and women between the ages of 30 and 57 as 0.53 and 0.85, respectively.

[33] Table 10 in the Appendix summarizes our findings for the U.S., but also for other countries. Table 12 displays the share of labor income taxes paid by different income deciles in our U.S. benchmark economy.

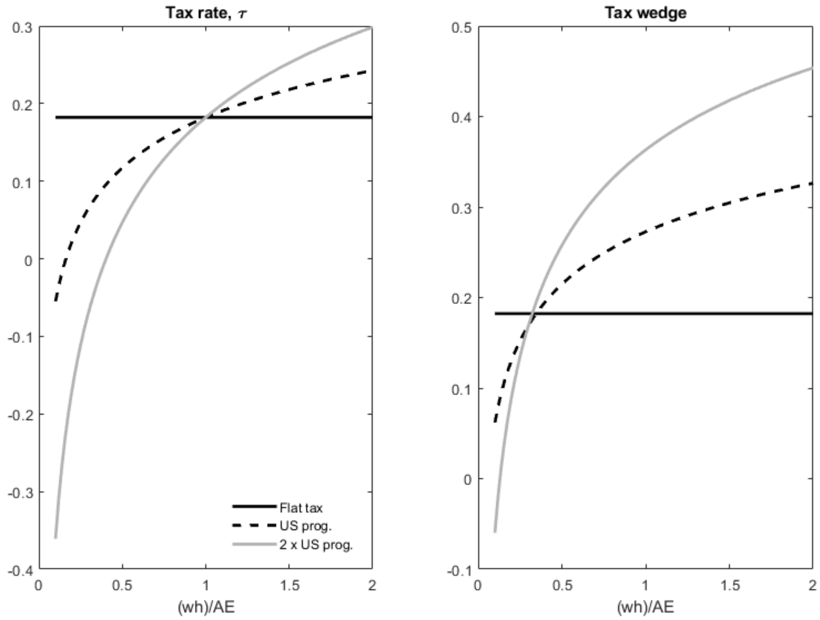

Figure 1: Changing Tax Progressivity

below average earnings. A more progressive tax system would thus create a positive income effect on the labor supply of agents with above average earnings and a negative income effect on the labor supply of agents with below average earnings. The right panel shows that, increasing tax progressivity increases the distortive tax wedge, and thus induces a negative substitution effect on the work hours, of all but the lowest wage earners. Workers with wages below 30% of average earnings instead experience a smaller tax wedge and a positive substitution effect from an increase in tax progressivity.

For the government-run social security system we assume that payroll taxes for the employee, τ_{SS}, and the employer, $\tilde{\tau}_{SS}$ are flat taxes, and use the rate from the bracket covering most incomes in the U.S., 7.65% for both τ_{SS} and $\tilde{\tau}_{SS}$. Finally, we follow Trabandt and Uhlig (2011) and set $\tau_k = 36\%$ and $\tau_c = 5\%$ for consumption and capital income tax rates.

6.6 Transfers and Government Consumption

People who do not work have other source of income such as unemployment benefits, social aid, black market work etc. They also have more time for home production. Pinning down the consumption equivalent of income when not working therefore is a difficult task, and

Table 2: Parameters Calibrated Outside of the Model

Parameter	Value	Description	Target
$1/\eta^m, 1/\eta^w$	0.4, 0.8	$U^M(c, n^m, n^w) = \log(c) - \chi_M^m \frac{(n^m)^{1+\eta^m}}{1+\eta^m} - \chi_M^w \frac{(n^w)^{1+\eta^w}}{1+\eta^w} - F_M^w \cdot \mathbb{1}_{[n^w>0]}$	Literature
$\gamma_1^m, \gamma_2^m, \gamma_3^m$	$0.109, -1.47 * 10^{-3}, 6.34 * 10^{-6}$	$w_t(a_i, e_i, u_i) = w_t e^{a_i+\gamma_0^m+\gamma_1^m e_i+\gamma_2^m e_i^2+\gamma_3^m e_i^3+u_i}$	PSID (1968-1997)
$\gamma_1^w, \gamma_2^w, \gamma_3^w$	$0.078, -2.56 * 10^{-3}, 2.56 * 10^{-5}$	$w_t(a_i, e_i, u_i) = w_t e^{a_i+\gamma_0^w+\gamma_1^w e_i+\gamma_2^w e_i^2+\gamma_3^w e_i^3+u_i}$	
$\sigma_\epsilon^m, \sigma_\epsilon^w,$	0.319, 0.310	$u' = \rho_{jg} u + \epsilon$	
$\rho_\epsilon^m, \rho_\epsilon^w$	0.396, 0.339	$\epsilon \sim N(0, \sigma_{jg}^2)$	
σ_a^m, σ_a^w	0.338, 0.385	$a^\iota \sim N(0, \sigma_{a_m}^2)$	
$\theta_0^S, \theta_1^S, \theta_0^M, \theta_1^M$	0.8177, 0.1106, 0.9420, 0.1577	$ya = \theta_0 y^{1-\theta_1}$	OECD tax data
τ_k	0.36	Capital tax	Trabandt and Uhlig (2011)
$\tau_{ss}, \tilde{\tau}_{ss}$	(0.0765, 0.0765)	Social Security tax	OECD
τ_c	0.05	Consumption tax	Trabandt and Uhlig (2011)
T	$0.2018 \cdot AW$	Income if not working	CEX 2001-2007
G/Y	0.0725	Pure public consumption goods	2X military spending (World Bank)
B/Y	0.6185	National debt	Government debt (World Bank)
$\omega(j)$	Varies	Survival probabilities	NCHS
$M(j)$, $D(j)$	Varies	Marriage and divorce probabilities	CPS
k_0	$0.4409 \cdot AW$	Savings at age 20	NLSY97
μ	0.0200	Output growth rate	Trabandt and Uhlig (2011)
δ	0.0788	Depreciation rate	$I/K - \mu$ (BEA)
α	1/3	$Y_t(K_t, L_t) = K_t^\alpha [Z_t L_t]^{1-\alpha}$	Historical capital share

Table 3: Parameters Calibrated Endogenously

Parameter	Value	Description	Moment	Moment Value
γ_0^m	-1.207	$w_t(a_i, e_i, u_i) = w_t e^{a_i+\gamma_0^\iota+\gamma_1^\iota e_i+\gamma_2^\iota e_i^2+\gamma_3^\iota e_i^3+u_i}$	Gender earnings ratio	1.569
β	1.009	Discount factor	K/Y	2.640
$\mu_{F_M^w}$	-0.047	$F_M^w \sim N(\mu_{F_M^w}, \sigma^2_{F_M^w})$	Married fem employment	0.676
$\sigma_{F_M^w}$	0.183	$U^M(c, n^m, n^w) = \log(c) - \chi_M^m \frac{(n^m)^{1+\eta^m}}{1+\eta^m} -$	R^2 from $\mathbb{1}_{[n_t>0]} = \rho_0 + \rho_1 \mathbb{1}_{[n_{t-1}>0]}$	0.553
χ_M^w	4.080	$\chi_M^w \frac{(n^w)^{1+\eta^w}}{1+\eta^w} - F_M^w \cdot \mathbb{1}_{[n^w>0]}$	Married female hours	0.224 (1225 h/year)
χ_M^m	21.000		Married male hours	0.360 (1965 h/year)
$\mu_{F_S^w}$	-0.055	$F_S^w \sim N(\mu_{F_S^w}, \sigma^2_{S_M^w})$	Single fem. employment	0.760
$\sigma_{F_S^w}$	0.333	$U^S(c, n, \iota) = \log(c) - \chi_S^\iota \frac{(n)^{1+\eta^\iota}}{1+\eta^\iota}$	R^2 from $\mathbb{1}_{[n_t>0]} = \rho_0 + \rho_1 \mathbb{1}_{[n_{t-1}>0]}$	0.463
χ_S^w	8.945	$-F_S^\iota \cdot \mathbb{1}_{[n>0]}$	Single female hours	0.251 (1371 h/year)
χ_S^m	60.800		Single male hours	0.282 (1533 h/year)
φ	0.467	$M_n = (1-\varphi)\varsigma + \varphi a$	$corr(w^m, w^w)$	0.407

the number we choose will impact the calibrated fixed costs of working, chosen to match the employment rate for women by marital status. To approximate the income when not working, we take the average value of non-housing consumption of households with income less than \$5000 per year from the Consumer Expenditure Survey.[34]

To determine pure public consumption G we follow Prescott (2004) and assume that government expenditure on pure public consumption goods is equal to two times expenditure on national defense. In addition the government must pay interest on the national debt before the remaining tax revenues can be redistributed lump sum to households.

6.7 Estimation Method

Eleven model parameters are estimated using an exactly identified simulated method of moments approach. We minimize the squared percentage deviation between simulated model statistics and the eleven data moments in column 5 of Table 3. Let $\Theta = \{\gamma_0^m, \beta, \mu_{F_M^w}, \sigma_{F_M^w}, \chi_M^w, \chi_M^m, \mu_{F_S^w}, \sigma_{F_S^w}, \chi_S^w, \chi_S^m, \varphi\}$, and let $V(\Theta) = (V_1(\Theta), \ldots, V_{11}(\Theta))'$ with $V_i(\Theta) = (\bar{m}_i - \hat{m}_i(\Theta))/\bar{m}_i$ measuring the percentage difference between empirical and simulated moments. Then Θ is chosen to minimize $V(\Theta)'V(\Theta)$. Table 3 summarizes the estimated parameter values and the data moments. Since we match all moments exactly, $V(\Theta)'V(\Theta) = 0$.

[34]When we perform policy experiments we keep the fraction of income of those not working to those working constant.

7 Model Performance

To verify that our benchmark model is a reasonable model of the U.S. economy, in this subsection we display the model performance along a number of dimensions not targeted by the calibration. In Figure 2 we plot the life-cycle profiles of labor income for working men[35] and all women in the CPS 2001-2007, together with the corresponding profiles from the model. Figure 3 contains the life-cycle profile of assets from the PSID 2001-2007, and from the model economy. The model captures well the qualitative features of the data, and is successful in matching, quantitatively, the increase in earnings and assets of households over the life cycle in the data.[36]

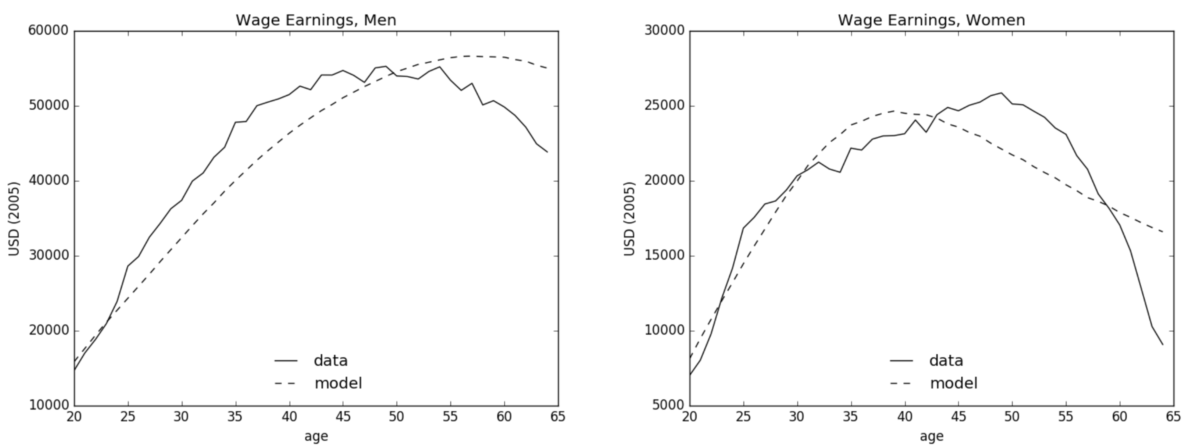

Figure 2: Labor Income over the Life-Cycle for Men and Women

In our model, one key margin of adjustment to the progressivity of the tax code is female participation in the labor market. It is therefore important that the model captures well the heterogeneous participation decision of females with different characteristics. In the model households are born with different abilities and thus earnings capacities a. If we interpret a to stand in for (unmodeled) differences in education levels acquired prior to labor market

[35] Our model only has working males.

[36] Our model has not been calibrated to match average asset holdings in the PSID, but to match the capital-output ratio from BEA data. Households in the PSID, on average, hold slightly more assets than what is implied by this calibration target.

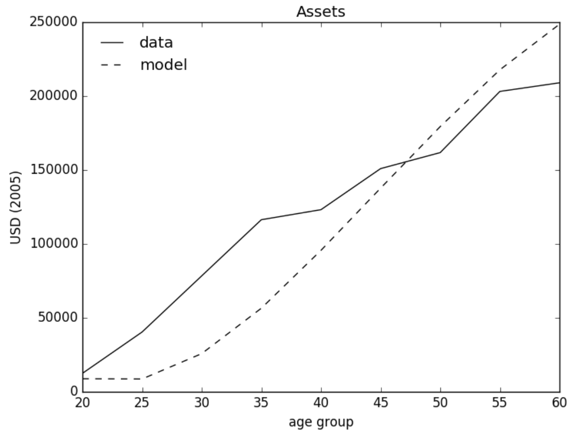

Figure 3: Asset Holdings Over the Life-Cycle in the Model and Data

entry when our life cycle model starts, we can ask whether the model captures well labor market participation rates of females with different educational attainment.

To do so, we group women into five education groups,[37] and in Figure 4 we plot female labor force participation for each of these groups, both in the CPS for 2001-2007, as well as in our model. We observe that both in the model and data labor force participation increases with educational attainment, although the gradient is somewhat steeper in the model than in the data.

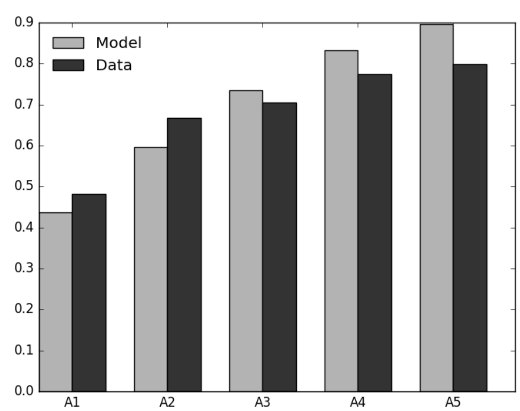

Figure 4: Female Labor Force Participation by Skill Level in the Model and Data. In the data, the skill groups correspond to education levels. A1: less than high school, A2: high school graduate, A3: some college, A4: college graduate, A5: graduate or professional degree

[37] Level 1 stands for less than high school 2 for high school graduates, 3 for some college, 4 for college graduates and 5 for professional or graduate degrees

Overall, we conclude that qualitatively, and for the most part quantitatively, the model is consistent with the most salient cross-sectional facts from U.S. micro data. We therefore now employ it as an empirically informed cross-sectionally rich laboratory to deduce how government tax revenue depends on the progressivity of the income tax code.

8 The Impact of Tax Progressivity and Household Heterogeneity on the Laffer Curve

In this section we display the main quantitative results of our paper, to make the points that a) the progressivity of the tax code is a key determinant of the shape of the Laffer curve, and that b) the precise form of household heterogeneity present in the model is crucial for the quantitative magnitude of this impact of tax progressivity on the Laffer curve. To do so, the analysis will proceed in three steps:

1. For fixed tax progressivity, defined by the parameter θ_1, we derive the Laffer curve by scaling up the tax *level* by adjusting θ_0 for both married and singles by the same constant and plotting BGP tax revenue against the level of taxes. In Section 8.1 we study the impact of tax progressivity for the Laffer curve by tracing out Laffer curves for different degrees of progressivity, as measured by θ_1. We do so under the assumption that the increase in revenue is redistributed lump-sum to households, and call the resulting Laffer curves g-curves, following Trabandt and Uhlig (2011)'s terminology[38].

2. Section 8.2 derives Laffer curves under two alternative assumptions about the use of the additional tax revenue. First, we assume that additional revenue is used to service a larger stock of outstanding government debt (b-Laffer curves).[39] This exercise also characterizes the maximal sustainable government debt. Second, additional revenue is

[38]Note that our g-curves are the analogue of s-curves in Trabandt and Uhlig (2011) because they denote the lump-sum transfer by s and we denote it by g.

[39]Note that in the representative agent setting, g- and b-Laffer curves coincide (see Feve, Matheron, and Sahuc (2017)), whereas in a model with heterogeneous agents and incomplete asset markets, they differ.

used for wasteful government spending (s-Laffer curves). The reduction of lump-sum transfers relative to the benchmark will reduce the negative income effect on labor supply, and thus lead to a larger increase in revenues when raising tax levels.[40]

3. Finally, we study how the *interaction* between household heterogeneity and tax progressivity impacts the Laffer curve. In Section 8.3, we first investigate, holding tax progressivity θ_1 fixed, what forms of household heterogeneity impact Laffer curves the most in a quantitative sense. In a second step, in section 8.3.2 we display how maximal tax revenue depends on the progressivity of the tax code in a selection of models that differ in their degree of household heterogeneity.

8.1 The Impact of Tax Progressivity

In this section we characterize U.S. Laffer curves under the assumption that additional tax revenue is redistributed uniformly to all households (the g-curve). In Figure 5, we plot Laffer curves (tax revenue plotted against the average tax rate, which we adjust through multiplying θ_0 by a constant) for varying degrees of progressivity (multiplying θ_1 for all family types by the same constant). Recall that an increase in θ_1 increases the progressivity wedge defined in equation (2) for all income levels. The current U.S. benchmark tax system corresponds to the diamond ($\bar{\tau}(y) \approx 17\%$, with tax revenue of 100% relative to the benchmark) on the black solid line displaying the Laffer curve associated with current U.S. tax progressivity. We observe that, according to our results, the U.S. is currently still relatively far from the peak of its Laffer curve. Under current progressivity, tax revenues can be increased by about 59% if the average tax rate on labor income is raised from 17% today to approximately 58%, the peak of the Laffer curve[41]

[40]For the b-curves, in addition, an increase in public debt crowds out physical capital, raising the equilibrium interest rate and lowering the equilibrium wages, thereby reducing the labor income tax base, and leading to a smaller increase in tax revenues when increasing the tax level. Furthermore, the extra debt is owned by households, increasing their asset income and the associated capital income taxes, which in turn leads to a larger increase in tax revenues when increasing the labor income tax level.

[41]Figure 12 in the Appendix provides a breakdown of revenue from labor, consumption and capital income taxes, and Figures 7 and 11 display how different labor market statistics vary with the level of taxes.

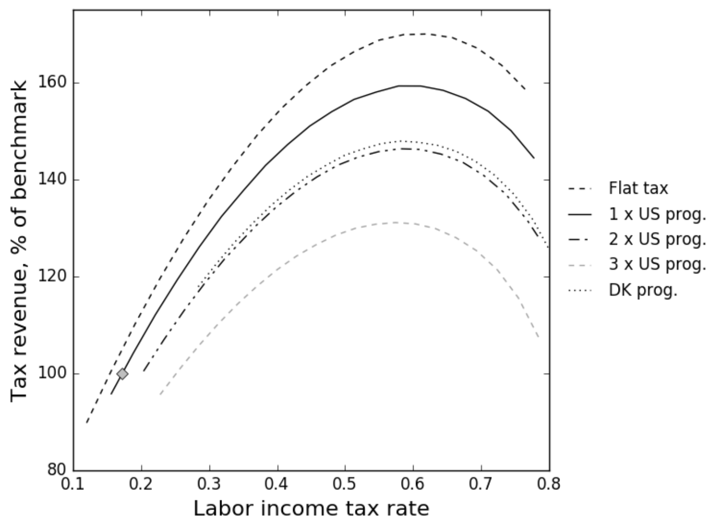

Figure 5: Impact of Tax Progressivity on the Laffer Curve (holding debt to GDP constant)

The main observation we wish to highlight from Figure 5 is that the progressivity of the tax system has considerable impact on the Laffer curve. The maximal revenue that can be raised with a flat tax system is about 7% higher than peak revenue under current U.S. progressivity, and about 15% higher than with a tax system twice as progressive as in the U.S., very similar to the tax system in Denmark.[42]

Figure 5 also allows us to assess how important tax progressivity is relative to the tax level in achieving the maximum labor income tax revenues. Let TR_{cur} be the tax revenues under current labor income tax in the U.S. (the grey diamond in the figure), TR_{lev} be the maximum tax revenues that can be attained by changing the tax level at current U.S. progressivity (the peak of the "1 x US prog." curve), and finally let TR_{flat} be the maximum tax revenues one can achieve with flat taxes (the peak of the "Flat tax" curve in the figure). Then the total maximum change in tax revenues is $\Delta_{\text{Tot}} = TR_{\text{flat}} - TR_{\text{cur}} = (1.59 \cdot 1.07 - 1)TR_{\text{cur}}$, while the change due to abolishing tax progressivity is $\Delta_{\text{prog}} = TR_{\text{flat}} - TR_{\text{level}} = (1.59 \cdot 1.07 - 1.59)TR_{\text{cur}}$. Thus changing tax progressivity can account for up to $\Delta_{\text{prog}}/\Delta_{\text{tot}} = 15.9\%$ of

[42]Note that the Danish tax system is generally more progressive than the U.S. tax system, however, as we scale the progressivity of the U.S. system we never precisely obtain the Danish system since the U.S. and Danish systems also differ in the relative tax burdens of different family types.

all additional tax revenues that can be generated by changing the current U.S. labor income system to the revenue-maximizing one.[43]

Tax progressivity does not only impact maximally obtainable government revenue, but revenue at all levels of tax rates. Table 4 displays revenue at different average tax rates (including the benchmark level of 17.3%), relative to revenue that can be raised with the current U.S. progressivity of the tax system. Consistent with Figure 5, the table shows that the increase in tax revenues induced by higher average tax rates slows down with higher tax progressivity. At current U.S. progressivity doubling the level of average tax rates from the benchmark of 17.3% to 35% raises revenue by 37.6 percentage points; the same experiment increases revenues by 40.4 percentage points under a flat tax system (first row of the table), but only by 32 percentage points if taxes are three times as progressive as in the U.S.

Table 4: The Impact of Progressivity on Revenue at Different Tax Rates

Prog. $= X\theta_{1US}$	$\bar{\tau}(y) = 17.3\%$	$\bar{\tau}(y) = 25\%$	$\bar{\tau}(y) = 35\%$
0.0	105.1	124.8	145.5
1.0	100.0	118.5	137.6
2.0	93.2	110.3	127.7
3.0	84.3	99.7	115.3

The table shows how progressivity affects revenue at different tax rates. It measures how much revenue is raised relative to the calibrated benchmark model (second row, second column).

To give these numbers empirical content, Table 5 shows how cross-country differences in actual tax progressivity affect maximal revenue, for a selected sample of countries. In our sample of selected OECD economies, Japan has the least progressive tax system, 0.74 times as progressive as the U.S. on our progressivity index, and Denmark has the most progressive tax system, 1.88 times more progressive than the U.S. With progressivity similar to Japan, the U.S. could increase revenue by a maximum 63%, relative to the calibrated benchmark. With Denmark's progressivity, the feasible increase in revenue is only 45%, relative to the current U.S. benchmark.

[43] Under the restriction that the tax system remains in the class of tax functions considered in this paper and that we do not consider regressive taxes.

Table 5: The Impact of Tax Progressivity on International Laffer Curves

Country	Progressivity Index	Relative Progressivity (U.S.=1)	Max Revenue (% of benchmark)
Japan	0.101	0.74	163.27
Switzerland	0.133	0.97	159.99
U.S.	0.137	1.00	159.26
France	0.142	1.03	159.48
Spain	0.148	1.08	159.31
Italy	0.180	1.31	155.57
Canada	0.193	1.41	154.09
U.K.	0.200	1.46	153.81
Germany	0.221	1.61	152.05
Denmark	0.258	1.88	147.92

The table shows how tax progressivity affects the maximum revenue that can be raised in selected countries. The second column displays the progressivity index that we estimated in Section 3. The third column shows progressivity relative to the U.S. The third column shows the maximum revenue that can be raised if the U.S. adopted a tax code with progressivity similar to column two.

What causes the decline in tax revenues as the tax schedule becomes more progressive? Table 6 displays different model statistics for three different levels of progressivity.[44] The table indicates that, for a given tax level, a more progressive tax schedule leads to lower aggregate labor supply and savings, and consequently, lower revenues. We note especially that the progressivity of the tax system strongly impacts female labor force participation, and that this impact differs fundamentally for married and for single women, in turn justifying why we model heterogeneity in family structure explicitly in this paper. Women are often low earners and for single women a more progressive tax system increases the benefits from work. This illustrates the potential positive effect of higher progressivity on the labor force participation of low-earners. In contrast, married women are taxed jointly with their husbands, and if the male member of the household has high wages, the additional benefits from the wife participating in the labor force are smaller with a more progressive tax system. For example, at the current U.S. average level of taxes (17.3%), reverting to a flat tax increases the labor force participation rate of married females by 7%, but lowers it for single females by 13%. Reversely, applying Denmark's higher tax progressivity to the U.S.,

[44] We vary θ_0 such that each economy has the same *average* tax rate, and display results of average rates of 17.3% (the benchmark tax level), 25% and 35%.

labor force participation of married females would fall by 8%, whereas single females would participate in the labor market at a 12% higher rate. This result applies to all tax levels along the Laffer curve, and is an important driver of the impact of tax progressivity on tax revenue.

Table 6: Selected Statistics for Different Tax Progressivity, at Average Tax Rates of 17.3%, 25% and 35%

	$\bar{\tau}(y) = 17.3\%$			$\bar{\tau}(y) = 25\%$			$\bar{\tau}(y) = 35\%$		
	Flat tax	US Prog.	2×US Prog.	Flat Tax	US Prog.	2×US Prog.	Flat Tax	US Prog.	2×US Prog.
Tax Revenue	105.1	100.0	93.2	124.8	118.5	110.3	145.5	137.6	127.7
Labor Supply	103.9	100.0	94.0	97.6	94.0	88.6	89.4	85.8	81.1
Male Labor Supply	103.5	100.0	95.7	101.2	97.8	93.5	97.9	94.8	90.5
Single Male Labor Supply	102.2	100.0	97.1	99.3	97.4	94.7	95.2	93.8	91.4
Married Male Labor Supply	104.1	100.0	95.0	102.1	98.0	93.0	99.1	95.2	90.1
Female Labor Supply	104.4	100.0	91.6	92.6	88.6	81.6	77.4	73.2	67.8
Single Female Labor Supply	90.1	100.0	107.1	77.4	86.9	95.5	61.9	70.0	79.1
Married Female Labor Supply	114.4	100.0	80.9	103.1	89.7	72.0	88.1	75.4	59.9
Female LFP	97.4	100.0	99.5	89.7	92.2	92.4	79.4	80.7	81.7
Single Female LFP	87.1	100.0	112.0	78.5	90.8	103.9	67.7	78.1	91.4
Married Female LFP	104.6	100.0	90.8	97.5	93.1	84.4	87.5	82.6	74.9
Female Intensive Margin	107.2	100.0	92.1	103.2	96.1	88.3	97.5	90.7	82.9
Single Female Intensive Margin	103.5	100.0	95.7	98.6	95.7	91.8	91.4	89.7	86.5
Married Female Intensive Margin	109.3	100.0	89.1	105.7	96.4	85.3	100.7	91.3	79.9
Savings	107.2	100.0	91.7	98.9	92.4	84.9	88.6	83.0	76.4

Column 3 is the U.S. bechmark. All numbers are in % of the U.S. Benchmark.

8.2 Alternative Uses of Tax Revenue

Thus far, we have derived Laffer curves under the assumption that the government lump-sum rebates the extra revenue back to private households, thereby generating an income effect on labor supply (so-called g-curves). In this section we document that our results concerning the *impact of tax progressivity* on the Laffer curve does not hinge on this assumption.[45] Specifically, Figure 13 in the Appendix displays b-Laffer curves in which the additional revenue brought about by an increase in the tax level θ_0 is used to service interest payments on additional government debt (left panel), and the associated maximally sustainable government debt (right panel). Table 7, middle panel (b-curves), summarizes the key results.

Using extra tax revenue for interest payments on additional government debt results in a higher peak of the Laffer curve, relative to lump-sum rebates, since i) the latter reduce

[45] In Appendix A.2 we argue, given our utility function, that as long as households have some non-labor income (either through assets or government transfers), then there exists a Laffer curve in that tax revenue initially rises, but eventually falls as average tax rates increase.

labor supply though an income effect, which is absent if extra tax receipts flow into debt service and ii) the larger holdings of government debt generates increased capital income tax receipts from the household sector. These two effects dominate the impact of debt crowding out productive capital. As the middle column of Table 7 shows, under current U.S. progressivity ($X\theta_{1US} = 1$), revenue can maximally be increased by 102.2%, and is achieved if the average labor income tax rate is increased to 54%. The right panel of Figure 13 shows that the U.S. could maximally sustain a debt burden of about 340% times of its benchmark GDP by increasing the average tax rate to 48%.[46]

Table 7: The Impact of Progressivity for Different Uses of Additional Revenue

g-curves		
Progressivity = $X\theta_{1US}$	Max. TR (% of benchmark)	$\frac{Max.TR(prog=X)}{Max.TR(prog=1)}$
0	170.0	106.7
1	159.3	100.0
2	146.3	91.9
3	131.1	82.3
b-curves		
Progressivity = $X\theta_{1US}$	Max. TR (% of benchmark)	$\frac{Max.TR(prog=X)}{Max.TR(prog=1)}$
0	218.8	108.2
1	202.2	100.0
2	182.8	90.4
3	160.1	79.2
s-curves		
Progressivity = $X\theta_{1US}$	Max. TR (% of benchmark)	$\frac{Max.TR(prog=X)}{Max.TR(prog=1)}$
0	179.4	107.4
1	167.1	100.0
2	152.4	91.2
3	135.7	81.2

The middle column displays the maximum attainable tax revenue, relative to revenue in the calibrated benchmark economy. The right column displays the maximum tax revenue that can be raised relative to the peak of the i-Laffer curve, ($i \in \{g, b, s\}$), with U.S. progressivity.

[46] Note from Figure 13 that the tax rate which maximizes debt is substantially lower than the tax rate maximizing revenue. As government debt increases, the capital stock shrinks and the equilibrium interest rate rises, making it more expensive to service the debt.

Most importantly, as the last column of Table 7 displays, the impact of tax progressivity on the ability to generate revenue is qualitatively, and to a very large degree quantitatively robust to the alternative use of tax revenue (compare the last column across the top and the middle panel of the table). For the b-Laffer curve, a flat tax system raises 8.2% higher revenue than is feasible under current U.S. progressivity (previously 6.7%), whereas doubling progressivity results in revenue losses of 9.6% (previously 8.1%).

Finally, Figure 14 in the Appendix displays s-Laffer curves under the assumption that the increase in revenue is wasted (equivalently, enters household utility separately), and the bottom panel of Table 7 summarizes the salient observations. As with b-Laffer curves the absence of the income effect on labor supply from the benchmark g-curves implies that the ability of the government to generate extra revenue is strengthened (comparing middle column across the top and the bottom panel). Most crucially, however, the impact of tax progressivity on the peak of the Laffer curve (third column of the table) is largely unaffected by the specification of what the government does with the extra revenue that is being generated with higher average tax rates.

8.3 Household Heterogeneity and the Laffer Curve

In Section 8.1 we have shown that tax progressivity is an important determinant of the government's ability to generate revenue when raising the level of taxes, and have argued that the differential labor supply response of single and married females is important for this finding. In this section we document this last point in greater detail, by analyzing the Laffer curve in a sequence of alternative models, both in terms of its level as well as, crucially, in terms of the impact of tax progressivity.

8.3.1 Household Heterogeneity and the Level of Tax Revenues

In Figure 6, starting from the benchmark model of Section 5 (black solid line), we sequentially remove its key features pertaining to female labor supply: i) the returns to female labor market experience (dotted line), ii) the female participation margin (dashed line), and iii) heterogeneity in family types, thus eliminating the distinction between single and married females. In the end, we arrive at a canonical standard life-cycle model inhabited by single households, differing only in initial earnings ability, and who are subject to idiosyncratic income risk (dash-dotted line). In that version of the model, we set the parameter η which governs the Frisch elasticity of labor supply equal to 1/0.6, the average for men and women used in the other models.

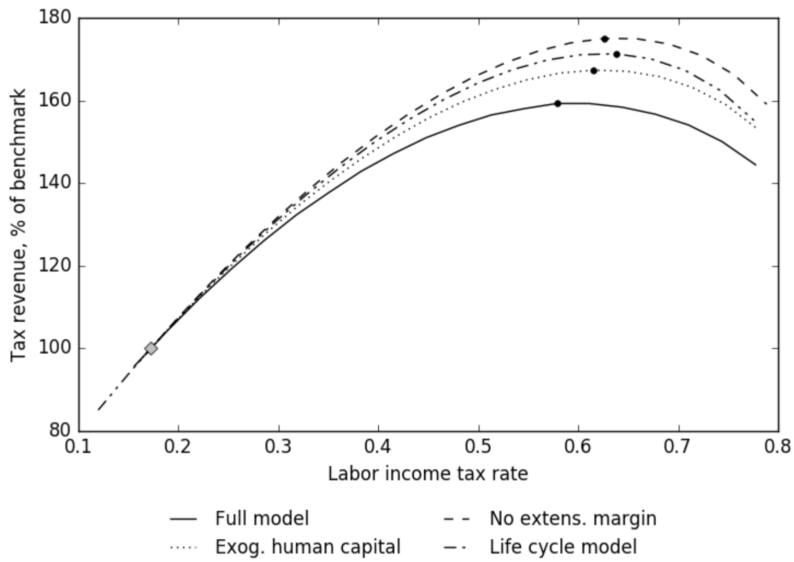

Figure 6: Laffer Curves for Different Models

The figure shows that, relative to the standard life cycle model, female labor supply along the extensive margin, its associated impact on female wages, and the family structure in which females live in our benchmark model strongly reduce both the location of the peak of the Laffer curve as well as its level. The revenue-maximizing average tax rate falls from 64% to 58%, and the additional revenue the government can raise from 71% to 59%. Quantitatively, both the reduction of experience and thus wages of women working less, as well as their reduced labor force participation are important for this result, although the first effect is slightly more potent (moving from the solid to the dotted line in Figure 6) than the second (comparing the dotted to the dashed Laffer curve). Finally, the impact of heterogeneous families (and especially single and married females) on the Laffer curve is more modest because, as we will document in the next section single and married females respond very differently to a change in average taxes.

Table 8: Simulated Labor Supply Elasticities and Peak of Laffer Curve in Different Models

Model	Frisch	Marshall	Frisch (male)	Frisch (fem.)	Peak τ	Max Tr (% of BM)
Full model	0.595	0.292	0.289	1.028	57.9	159.3
Exog. human cap.	0.591	0.195	0.203	0.971	61.5	167.3
No extens. margin	0.381	0.115	0.215	0.568	62.6	175.0
Life cycle model	0.452	0.118	-	-	63.8	171.3

The impact of average tax rates on revenue crucially depends on how responsive labor supply is to tax changes. Therefore, Table 8 displays simulated Frisch- and Marshall labor supply elasticities in the four different models.[47] The table clearly indicates that the Frisch labor supply elasticity is highest in the two models with an extensive margin of labor supply for women, and the Marshall elasticity is highest in the full model.[48] As the last column of the table demonstrate, the size of the peak of the Laffer curve across models is tightly linked to the corresponding labor supply elasticity.[49]

8.3.2 The Interaction Between Heterogeneity and Progressivity

We now argue that the way female labor supply and family structure is modelled not only fundamentally impacts the government's ability to raise extra revenue (as documented in the previous subsection), but also alters the impact of tax progressivity on maximal tax revenues.

[47]The estimated Frisch elasticity is obtained by changing the wage at one age at a time, and then solving the model, keeping prices constant. Doing this for all ages and obtaining the average change in hours worked, we obtain an estimate of the Frisch elasticity. The Marshall elasticity, which is smaller than the Frisch elasticity due to the income effect, is obtained by changing the wage at all ages simultaneously. Note that even though $1/\eta = 0.6$ in the simple life-cycle model, the simulated Frisch elasticity is not equal to 0.6, due to the progressive tax system in the model.

[48]In Section 8.4 below we analyze the effect of changing the parameter, η, which governs the intensive margin labor supply elasticity, on the Laffer curve. We will document that the impact of making labor supply more or less elastic along the intensive margin on tax revenue differs significantly from the effect of adding human capital or an extensive margin of labor supply for women.

[49]The key distinction between the basic life cycle model and the model with different types of families (3rd and 4th row of the table) is the existence of low-elasticity high tax-paying males in the latter model, whereas the canonical life cycle model features homogeneous household types with higher labor supply elasticities (relative to males in the 3rd model).

To show this, Table 9 displays the peak of the g-Laffer curve in the four different models from the previous subsection, as a function of the progressivity of the labor income tax code. For each model, we show peak tax revenue both relative to the calibrated benchmark revenue (the left column for each model) and relative to the peak of the Laffer curve with U.S. progressivity (the right column, so that the second row equals 100 for each model).

Table 9: The Impact of Progressivity on Maximum Revenue in Different Models

Prog.	Full model		Exog. human capital		No ext. margin		Life cycle	
$= X\theta_{1US}$	$\frac{TR}{TR_{Bench}}$	$\frac{TR(prog=X)}{TR(prog=1)}$	$\frac{TR}{TR_{Bench}}$	$\frac{TR(prog=X)}{TR(prog=1)}$	$\frac{TR}{TR_{Bench}}$	$\frac{TR(prog=X)}{TR(prog=1)}$	$\frac{TR}{TR_{Bench}}$	$\frac{TR(prog=X)}{TR(prog=1)}$
0.0	169.9	106.7	179.5	107.3	186.5	106.5	183.5	107.1
1.0	159.2	100.0	167.3	100.0	174.9	100.0	171.2	100.0
2.0	146.3	91.8	152.9	91.4	160.6	91.8	156.7	91.5
3.0	131.1	82.3	136.1	81.4	142.7	81.6	139.3	81.3

The columns labeled TR/TR_{Bench} display how much revenue that is raised relative to the calibrated benchmark for each model. The columns labeled $TR(prog = X)/TR(Prog = 1)$ display how much revenue that is raised relative to the maximum that can be raised under current U.S. progressivity.

We observe that the negative impact of progressivity on total tax revenue is *smaller* in the benchmark model than in the simplified versions that abstract from various sources of household heterogeneity. Quantitatively, however, the impact of tax progressivity on the peak of the Laffer curve is quite robust across the different versions of the model. A priori, one would expect that an operative extensive margin of female labor supply weakens the impact of an increase in tax progressivity on revenue since the reduction of average tax rates at the low end of the wage distribution induces more females to participate. However, this logic only holds for single women. For married women, who are taxed jointly with their husbands, the effect is exactly the opposite. Many two-earner households with high-earning males find it optimal, with a more progressive tax system, to only have the male working. In Figure 7 we plot female labor force participation for single (left panel) and married women (right panel) by tax level and progressivity. As can be seen from the figure higher progressivity consistently leads to higher labor force participation for single women and lower labor force participation for married women.

This differential labor force participation response strongly affects the group-specific Laf-

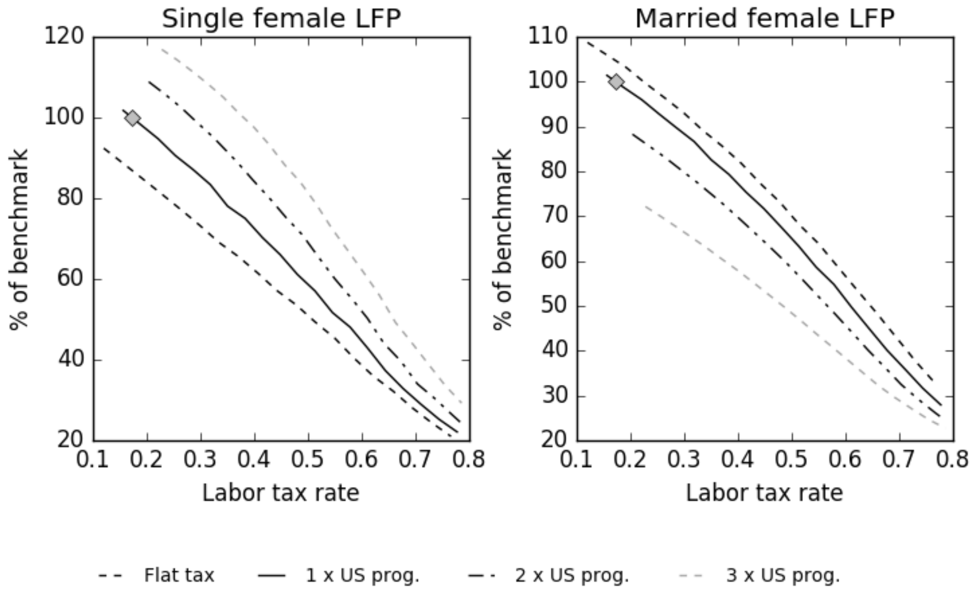

Figure 7: Labor Force Participation for Married and Single Women by Tax Progressivity and Level for g-Laffer Curves

fer curves, which we plot in Figure 8. As can be seen from the figure the effect of progressivity is very different for single and married women. Around the peak rate of the Laffer curve for the population as a whole (approximately 59%), revenue generated from single females is *increasing* in tax progressivity (see the left panel), whereas the effect of progressivity is strongly negative for married females. Once aggregating across different family types the effect of progressivity on single females dominates and thus the peak of the Laffer curve is less responsive in the full benchmark model than in versions that abstract from extensive margin and family type differences. However, due to strongly offsetting effect on married female participation, quantitatively the impact of progressivity on tax revenue for the economy as a whole population does not differ fundamentally between our model and the simple life-cycle structure.[50]

[50]One may wonder what the presence of an extensive margin and endogenously accumulated labor market experience would do in a model with only single households. In Figure 15 in the Appendix we plot the peaks of the Laffer curves for the four models in this section, as a function of tax progressivity, together with the peaks for a model with single households who has an extensive margin of labor supply and accumulate experience. The figure demonstrates that tax progressivity has a much smaller effect on the Laffer curve in

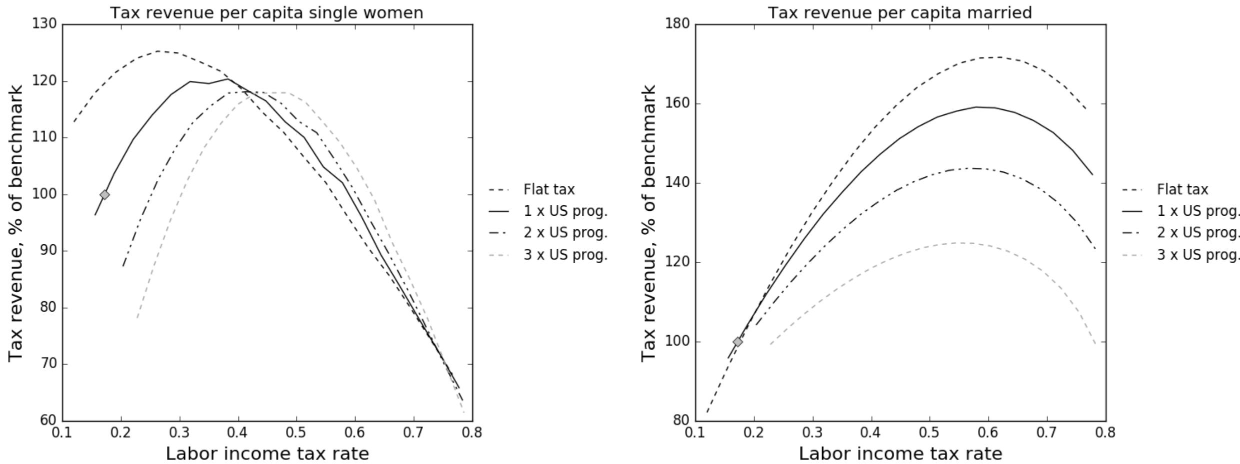

Figure 8: Laffer Curves for Single and Married Women by Progressivity

Finally, note that progressivity mattering slightly less when introducing endogenous human capital accumulation (full vs exogenous human capital model in Table 9) can be interpreted as labor supply becoming more inelastic around the female extensive margin.[51]

8.4 Sensitivity Analysis: The Importance of the Labor Supply Elasticity

The elasticity of labor supply along the *intensive* margin naturally also plays a key role for the shape of the Laffer curve. In our benchmark calibration we set the values of the parameters η^m and η^w that govern the intensive margin labor supply elasticity[52] to 1/0.4

a model with only singles and extensive margin labor choice.

[51]Note that the finding that introducing endogenous human capital accumulation slightly reduces, and does not increase the impact of tax progressivity may depend crucially on how human capital accumulation is modelled. When human capital is interpreted as years of labor market experience, making taxes more progressive increases the short term benefit of acquiring human capital. This effect counteracts the impact of progressive taxes reducing the longer time returns to human capital. In this context, progressive taxes affect the human capital accumulation decisions of those on the margin between working and not working. These are typically low earners who will obtain a higher net wage (at least in the short run) when taxes become more progressive. If human capital was instead modelled as an investment of resources in education quality or as a time-investment in learning, the introduction of human capital may instead amplify the negative impacts of tax progressivity. See Holter (2015) for a model where human capital accumulation is modelled as a continuous investment of resources in education quality and Badel, Huggett, and Luo (2017) for a model where human capital accumulation is modelled as investment of time in learning. Both of these studies apply a Ben-Porath (1967) human capital production technology. The human capital investment decisions of the whole distribution of workers and not only those at the margin between working and not working will be affected by tax progressivity under these alternative modelling strategies.

[52]Note that since the tax system is progressive, the intensive margin labor supply elasticity in the model is in general smaller than $1/\eta$.

and 1/0.8. In Figure 10 in Appendix A.11 we plot Laffer curves for different levels of tax progressivity when we double the Frisch labor supply elasticity of both males and females, and when we cut it in half.[53].

The intensive margin labor supply elasticity has significant impact on the level of the Laffer curve and the location of its peak. With current U.S. progressivity doubling the elasticity parameters $1/\eta$ reduces the peak from $(\tau = 57.9\%, TR = 159.3\%)$ to $(54.9\%, 147.3\%)$ and cutting it in half shifts the peak up to $(67.5\%, 171.8\%)$. Compared to changing the model's labor supply elasticity along the extensive margin, as we did in the previous section by shutting down the key model elements associated with the extensive margin of labor supply of females, simply adjusting the intensive margin of labor supply leads to much stronger changes in the *location* of the peak (the revenue-maximizing rate), but smaller impact on the associated revenue.[54] Finally, the impact of tax progressivity is unambiguously and very significantly larger (and negative), the larger is the intensive margin labor supply elasticity. This is in stark contrast with the findings in Section 8.3.2, Table 9, which showed that shutting down the extensive margin made the impact of tax progressivity larger. We conclude that simply changing the intensive margin labor supply elasticity has very different effects on the shape of Laffer curve, and especially the impact of tax progressivity on the curve, than introducing an explicit extensive margin of female labor supply and its impact on human capital accumulation. Both thought experiments are important when conducting applied policy analysis, but in our view they complement, rather than substitute each other.

9 Conclusion

In this paper we quantify the impact of the progressivity of the labor income tax code on the Laffer curve, and thus, on the maximal ability of the government to raise revenue. We

[53]In both cases we recalibrate the model to match the same data moments as the original benchmark model, by changing the parameters listed in Table3

[54]For example, compare the change of maximal revenue from cutting the Frisch elasticity in half (from 159.3% to 171.8%) to the effect of removing the extensive margin and associated human capital accumulation, (from 159.3% to 175.0%, last column of Table 8).

conclude that the U.S. is currently far from the peak of its Laffer curve and could increase tax revenue by an additional 59% if the government were to raise the average labor income tax rate to 58%. A more progressive tax code raises significantly less revenue. Since, as we document in the paper, there is substantial variation across countries in the shape of the income tax code, cross-country heterogeneity in tax progressivity is an important aspect for international comparisons of Laffer curves.

We have argued that in order to quantify the effect of tax progressivity on the Laffer curve it is crucial to model explicitly the extensive margin of labor supply, the associated accumulation of experience, and the heterogeneity across families in the number of income earners. We found that in the presence of an extensive margin of labor supply, making taxes more progressive increases the labor force participation of single women. Higher labor force participation and more labor market experience thus counteract the negative effect of tax progressivity on labor supply along the intensive margin. For married women, who are taxed jointly with their husbands, the effect is exactly the opposite. When taxes become more progressive, the labor force participation and labor market experience of these females declines very significantly.

In this paper we have focused on a positive analysis of fiscal policy. Given the very substantial effect of tax progressivity on revenue and the cross-country differences in this progressivity, our results beg the question: what degree of progressivity is optimal from a normative perspective, in the context of our model? Furthermore, what political factors determine why Denmark has chosen such substantially more progressive tax code than the U.S.? We view these as natural next questions for future work.

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A Appendix

A.1 Definition of a Recursive Competitive Equilibrium

We call an equilibrium of the growth adjusted economy a stationary equilibrium.[55] Let $\Phi^M(k^z, e^w, u^m, u^w, a^m, a^w, F^{Mw}, j)$ be the measure of married households with the corresponding characteristics and $\Phi^S(k^z, e, u, a, \iota, F_S^\iota, j)$ be the measure of single households. We now define such a stationary recursive competitive equilibrium as follows:

Definition:

1. The value functions $V^M(\Phi^M)$ and $V^S(\Phi^S)$ and policy functions, $c^z(\Phi^M)$, $k^z(\Phi^M)$, $n^m(\Phi^M)$, $n^w(\Phi^M)$, $c(\Phi^S)$, $k(\Phi^S)$, and $n(\Phi^S)$ solve the consumers' optimization problem given the factor prices and initial conditions.

2. Markets clear:

$$K^z + B^z = \int k^z d\Phi^M + \int k^z d\Phi^S$$

$$L^z = \int \left(n^m w^{zm} + n^w w^{zf}\right) d\Phi^M + \int (nw^z)\, d\Phi^S$$

$$\int c^z d\Phi^M + \int c^z d\Phi^S + (\mu+\delta)K^z + G^z = (K^z)^\alpha (L^z)^{1-\alpha}$$

3. The factor prices satisfy:

$$\begin{aligned} w^z &= (1-\alpha)\left(\frac{K^z}{L^z}\right)^\alpha \\ r &= \alpha\left(\frac{K^z}{L^z}\right)^{\alpha-1} - \delta \end{aligned}$$

[55] the associated BGP can of course trivially be constructed by scaling all appropriate variables by the growth factor Z_t.

4. The government budget balances:

$$g^z\left(2\int d\Phi^M + \int d\Phi^S\right) + \int_{j<65,n=0} T^z d\Phi^M + \int_{j<65,n=0} T^z d\Phi^S + G^z + (r-\mu)B^z$$
$$= \int \left(\tau_k r(k^z + \Gamma^z) + \tau_c c^z + \tau_l^M \left(\frac{n^m w^{mz} + n^w w^{wz}}{1+\tilde{\tau}_{ss}}\right)\right) d\Phi^M$$
$$+ \int \left(\tau_k r(k^z + \Gamma^z) + \tau_c c^z + \tau_l^S \left(\frac{n w^z}{1+\tilde{\tau}_{ss}}\right)\right) d\Phi^S$$

5. The social security system balances:

$$\Psi^z\left(\int_{j\geq 65} d\Phi^M + \int_{j\geq 65} d\Phi^S\right) = \frac{\tilde{\tau}_{ss} + \tau_{ss}}{1+\tilde{\tau}_{ss}}\left(\int_{j<65} (n^m w^{mz} + n^w w^{wz}) d\Phi^M + \int_{j<65} n w^z d\Phi^S\right)$$

6. The assets of the dead are uniformly distributed among the living:

$$\Gamma^z\left(\int \omega(j) d\Phi^M + \int \omega(j) d\Phi^S\right) = \int (1-\omega(j))\, k^z d\Phi^M + \int (1-\omega(j))\, k^z d\Phi^S$$

A.2 The Labor Income Tax Laffer Curve in a Simple Static Economy with a Representative Household

Here we argue that, given our choice of the utility function, there is always a Laffer curve, in the sense that tax revenue initially rises, but eventually falls as average tax rates increase as long as households have some non-labor income, either through government transfers or capital income. We demonstrate this in a static, representative household economy, but the argument extends directly to our dynamic economy with heterogeneous households.

Consider a simple static consumer optimization problem with preferences of the form used in this paper:

$$\max_{c,h} \quad \log(c) - \chi \frac{h^{1+\eta}}{1+\eta}$$
$$\text{s.t. } c = g + wh(1-\tau)$$

where g is the government transfer, c is consumption and h is labor supply. We assume that the government transfers back to the consumer a share s of its tax revenues, and thus $g = swh\tau$.

Combining the first order condition with respect to h and c we obtain:[56]

$$\chi h^{\eta} = \frac{w(1-\tau)}{g + w(1-\tau)h} = \frac{w(1-\tau)}{sw\tau h + w(1-\tau)h}$$

so that:

$$h = \left(\frac{1-\tau}{\chi(s\tau + 1 - \tau)} \right)^{1/(1+\eta)}$$

How labor supply depends on the tax rate τ depends crucially on s, and thus on the extent to which households receive non-labor income (here in the form of government transfer income). In the extreme case where $s = 0$, then the government wastes all tax revenue, the only source of household income is labor income, and labor supply is given by:

$$h = \left(\frac{1}{\chi} \right)^{1/(1+\eta)}$$

and is independent of τ. In this case, total tax revenue is given by:

$$TR(\tau) = wh(\tau)\tau = w \left(\frac{1}{\chi} \right)^{1/(1+\eta)} \tau$$

which is an increasing linear function of τ, and thus there is no Laffer curve. In contrast, for

[56]In the dynamic model we obtain an identical condition, but where g would also include asset income.

any $s > 0$, we have $h(\tau = 1) = 0$, and labor supply is strictly decreasing in τ:

$$\frac{\partial h(\tau)}{\partial \tau} = -\frac{1}{1+\eta}\left(\frac{1-\tau}{\chi(s\tau+1-\tau)}\right)^{-\eta/(1+\eta)}\left(\frac{s\tau}{\chi(s\tau+1-\tau)^2}\right) < 0$$

for all $\tau > 0$, and $\frac{\partial h(\tau=0)}{\partial \tau} = 0$. Thus, for all $s > 0$ total tax revenue $TR(\tau) = wh(\tau)\tau$ satisfies $TR(\tau = 0) = TR(\tau = 1) = 0$, as well as $\frac{\partial Tr(\tau=0)}{\partial \tau} > 0$. Therefore, there is a well-behaved Laffer curve with revenue-maximizing tax rate $\tau \in (0, 1)$.

Figure 9 shows how tax revenues change with τ for 4 different values of s: $s = 0$, $s = 0.3$, $s = 0.6$ and $s = 0.9$, assuming that $w = 1$, $\eta = 1/0.6$ and $\chi = 1$. Note that we obtain $\frac{\partial h}{\partial \tau} < 0$ even if $s = 0$ as long as the household has other, non-labor income sources, such as capital income (as in our full dynamic model). This is shown using the implicit function theorem since with capital income the optimal hours choice h has no closed-form solution. This result in turn again leads to a Laffer curve with interior revenue maximizing tax rate $\tau \in (0, 1)$.

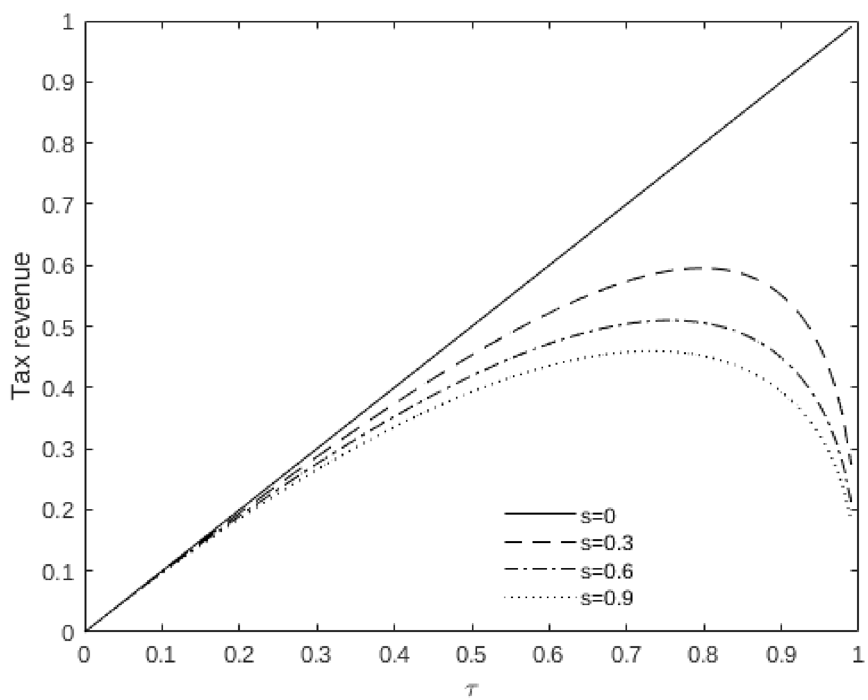

Figure 9: The Laffer Curves in a Static Model with a Representative Household for Different Values of s

A.3 The Impact of Tax Progressivity in a Complete Markets Model with a Representative Agent: Proof of Proposition 4.1

Proof. FOCs:

$$\chi h^{\eta} = \lambda \theta_0 (1-\theta_1) H^{\theta_1 - 1} h^{-\theta_1},$$
$$\lambda = \frac{1}{c}.$$

In equilibrium, $H = h$, so:

$$h^{1+\eta} = \frac{\theta_0(1-\theta_1)}{\chi}\lambda$$

Taking logs and solving for $\log(h)$:

$$\log(h) = \frac{1}{1+\eta}\left(\log(\lambda) + \log(\theta_0) + \log(1-\theta_1) - \log(\chi)\right)$$

so that:

$$\frac{\partial \log(h)}{\partial \theta_1} = -\frac{1}{(1+\eta)(1-\theta_1)} < 0$$

This is the "partial equilibrium effect" of the change in progressivity, which we have described in the main text for a general utility function.

From the firms' FOCs:

$$w = (1-\alpha) K^{\alpha} H^{-\alpha},$$
$$r = \alpha K^{\alpha-1} H^{1-\alpha} - \delta.$$

Equilibrium (steady-state) conditions:

$$c + k = \theta_0 \left(\frac{wh}{wH}\right)^{1-\theta_1} + k\left(1+r\right) + s\left(wH - \theta_0\right),$$
$$1 = \beta\left(1 + \alpha\left(\frac{k}{h}\right)^{\alpha-1} - \delta\right),$$
$$h^{1+\eta} = \frac{\theta_0(1-\theta_1)}{c\chi}$$

From the second equation:

$$\frac{k}{h} = \left(\frac{\frac{1}{\beta} + \delta - 1}{\alpha}\right)^{\frac{1}{\alpha-1}}$$

This implies that in equilibrium:

$$w = (1-\alpha)\left(\frac{k}{h}\right)^{\alpha} = (1-\alpha)\left(\frac{\frac{1}{\beta} + \delta - 1}{\alpha}\right)^{\frac{\alpha}{\alpha-1}}$$
$$r + \delta = \alpha\left(\frac{k}{h}\right)^{\alpha-1} = \alpha\left(\frac{\frac{1}{\beta} + \delta - 1}{\alpha}\right)$$

which do not depend on either θ_0 or θ_1.

Then from the third equation:

$$c = \frac{\theta_0(1-\theta_1)}{\chi h^{1+\eta}}$$

Plugging this all into the first equation:

$$\frac{\theta_0(1-\theta_1)}{\chi h^{1+\eta}} + \left(\frac{k}{h}\right)h = \theta_0 + \left(\frac{k}{h}\right)h(1+r) + s\left(wh - \theta_0\right)$$

or:

$$\frac{\theta_0(1-\theta_1)}{\chi} = \theta_0(1-s)h^{1+\eta} + \left(r\left(\frac{1+\beta(\delta-1)}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} + sw\right)h^{2+\eta} \tag{20}$$

which pins down h.

Differentiating both sides with respect to θ_1, we get:

$$-\frac{\theta_0}{\chi} = \left((1+\eta)\theta_0(1-s)h^{\eta} + \left(\left(\frac{1+\beta(\delta-1)}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} r + sw\right)(2+\eta)h^{1+\eta}\right)\frac{\partial h}{\partial \theta_1}$$

so that:

$$\frac{\partial h}{\partial \theta_1} = -\frac{\theta_0}{\chi\left((1+\eta)\theta_0(1-s) + \left(\left(\frac{k}{h}\right) r + sw\right)(2+\eta)h\right)h^{\eta}} < 0.$$

We are also interested in $\frac{\partial TR}{\partial \theta_1}$. We have:

$$\frac{\partial TR}{\partial \theta_1} = w\frac{\partial h}{\partial \theta_1} < 0.$$

In a similar way, differentiating both sides of 20 with respect to θ_0, we get:

$$\frac{1-\theta_1}{\chi} = (1-s)h^{1+\eta} + \left((1+\eta)\theta_0(1-s)h^{\eta} + \left(\left(\frac{1+\beta(\delta-1)}{\alpha\beta}\right)^{\frac{1}{\alpha-1}} r + sw\right)(2+\eta)h^{1+\eta}\right)\frac{\partial h}{\partial \theta_0}$$

so that:

$$\frac{\partial h}{\partial \theta_0} = \frac{\frac{1-\theta_1}{\chi} - (1-s)h^{1+\eta}}{\chi\left((1+\eta)\theta_0(1-s) + \left(\left(\frac{k}{h}\right) r + sw\right)(2+\eta)h\right)h^{\eta}}$$

Since 20 implies that $\frac{1-\theta_1}{\chi} > (1-s)h^{1+\eta}$, we get:

$$\frac{\partial h}{\partial \theta_0} > 0.$$

■

A.4 Proof of Proposition 4.2

Proof. FOCs with respect to c_H and c_L:

$$\frac{1}{c_{L,t}} = \lambda, \quad \frac{1}{c_{H,t}} = \lambda \quad \Rightarrow \quad c_{L,t} = c_{H,t} = c.$$

FOCs with respect to h_H and h_L:

$$\chi h_{L,t}^{\eta} = \lambda\theta_0(1-\theta_1)\left(\frac{we^{-a}}{AE}\right)^{1-\theta_1} h_{L,t}^{-\theta_1}$$
$$\chi h_{H,t}^{\eta} = \lambda\theta_0(1-\theta_1)\left(\frac{we^{a}}{AE}\right)^{1-\theta_1} h_{H,t}^{-\theta_1}$$

which implies:

$$\left(\frac{h_H}{h_L}\right)^{\theta_1+\eta} = (e^{2a})^{1-\theta_1} \quad \Rightarrow \quad \frac{h_H}{h_L} = e^{\frac{2a(1-\theta_1)}{\theta_1+\eta}}$$

so

$$\frac{\partial(h_H/h_L)}{\partial\theta_1} = -\frac{2a(1+\eta)}{(\theta_1+\eta)^2}e^{\frac{2a(1-\theta_1)}{\theta_1+\eta}} < 0$$

and

$$\frac{\partial^2(h_H/h_L)}{\partial\theta_1\partial a} = -\frac{2(1+\eta)}{(\theta_1+\eta)^2}e^{\frac{2a(1-\theta_1)}{\theta_1+\eta}} < 0.$$

■

A.5 Proof of Proposition 4.3

Proof. Let $U_{\bar{h}}(w_i)$ be the utility from working $h=\bar{h}$ hours for the individual with productivity w_i, and let U_0 be the utility from not working. We have:

$$U_{\bar{h}}(w_i) = \log\left(\theta_0\left(\frac{w_i\bar{h}}{AE}\right)^{1-\theta_1} + T\right) - F$$

and

$$U_0 = \log(T).$$

The individual with productivity w_i decides to work if and only if $U_{\bar{h}}(w_i) \geq U_0$.

Suppose there is $\underline{w}$ such that $U_{\bar{h}}(\underline{w}) = U_0$ or:

$$\log\left(\theta_0\left(\frac{\underline{w}\bar{h}}{AE}\right)^{1-\theta_1} + T\right) - F = \log(T). \tag{21}$$

Equation 21 implicitly defines $\underline{w}$ as a function of θ_1.

We have:

$$\frac{\partial U_{\bar{h}}(\underline{w})}{\partial \theta_1} = -\frac{\theta_0 \left(\frac{\underline{w}\bar{h}}{AE}\right)^{1-\theta_1} \times \log\left(\frac{\underline{w}\bar{h}}{AE}\right)}{\theta_0 \left(\frac{\underline{w}\bar{h}}{AE}\right)^{1-\theta_1} + T} > 0$$

since $\underline{w}\bar{h} < AE$ (AE is the average earnings of employed individuals), and thus $\log\left(\frac{\underline{w}\bar{h}}{AE}\right) < 0$.

We also have:

$$\frac{\partial U_{\bar{h}}(\underline{w})}{\partial w} = \frac{\theta_0(1-\theta_1)\bar{h}^{1-\theta_1}\underline{w}^{-\theta_1}}{\theta_0 \left(\frac{w_i\bar{h}}{AE}\right)^{1-\theta_1} + T} > 0$$

and thus:

$$\frac{\partial \underline{w}}{\partial \theta_1} = \frac{\frac{\partial U_{\bar{h}}(\underline{w})}{\partial \theta_1}}{\frac{\partial U_{\bar{h}}(\underline{w})}{\partial w}} < 0.$$

This means that higher tax progressivity parameter (θ_1) leads to higher labor market participation.

Now, let $TR(w_i)$ be the tax revenues collected from the productivity type $w_i > \underline{w}$:

$$TR(w_i) = w_i\bar{h} - \theta_0 \left(\frac{w_i\bar{h}}{AE}\right)^{1-\theta_1}$$

so that:

$$\frac{\partial TR(w_i)}{\partial \theta_1} = \theta_0 \left(\frac{w_i\bar{h}}{AE}\right)^{1-\theta_1} \times \log\left(\frac{w_i\bar{h}}{AE}\right)$$

We get that $\frac{\partial TR(w_i)}{\partial \theta_1} > 0$ for $w_i\bar{h} > AE$, and $\frac{\partial TR(w_i)}{\partial \theta_1} < 0$ for $w_i\bar{h} < AE$.

■

A.6 Balanced Growth with Labor Participation Margin

As is well-known[57], for balanced growth we need to assume labor-augmenting technological progress. In this case, consumption, investment, output and capital all grow at the rate of labor-augmenting technical progress, while hours worked remain constant. King, Plosser, and Rebelo (2002) show that the momentary preferences that deliver first-order optimality conditions consistent with these requirements can take one of the following two forms:

[57] See King, Plosser, and Rebelo (2002) for details

$$U(c,n) = \frac{1}{1-\nu} c^{1-\nu} v(n) \quad \text{if } 0 < \nu < 1 \text{ or } \nu > 1,$$
$$U(c,n) = \log(c) + v(n) \quad \text{if } \nu = 1.$$

To reformulate the household problem recursively, one replaces consumption with its growth-adjusted version in both the household's budget constraint and the household's objective function (see the next subsection for the details). With the second version of the momentary utility function, such "adjustment terms" drop out into a separate additive term which can be ignored:

$$E_t \sum_{j=j_0}^{J} \beta^j \left[\log(c_{t,j}) + v(n_j) - F\mathbb{1}_{[n_j>0]}\right] = E_t \sum_{j=j_0}^{J} \beta^j \left[\log(c_{t,j}/Z_t) + v(n_j) - F\mathbb{1}_{[n_j>0]} + \log(Z_t)\right]$$
$$= E_t \sum_{j=j_0}^{J} \beta^j \left[\log(c^z_j) + v(n_j) - F\mathbb{1}_{[n_j>0]}\right] + E_t \sum_{j=j_0}^{J} \beta^j \log(Z_t)$$

where $c^z_j = c_{t,j}/Z_t$.

This procedure would not work with the first version of the momentary utility function. Proceeding the same way, we would obtain:

$$E_t \sum_{j=j_0}^{J} \beta^j \left[\frac{1}{1-\nu} c_{t,j}^{1-\nu} v(n_j) - F\mathbb{1}_{[n_j>0]}\right] =$$
$$E_t \sum_{j=j_0}^{J} \tilde{\beta}^j \left[\frac{1}{1-\nu} (c^z_j)^{1-\nu} v(n_j)\right] - E_t \sum_{j=j_0}^{J} \beta^j F\mathbb{1}_{[n_j>0]}$$

where $\tilde{\beta} = \beta Z^{1-\nu}$. This means that as time passes by, fixed participation costs become "more important" for the houshold (since it uses the original discount factor, β).

A.7 Recursive Formulation of the Household Problem

Married households of age j_0 in period t maximize

$$U = E_t \sum_{j=j_0}^{J} \omega(j) \left(\log(c_{t,j}) - \chi^m \frac{(n^m_{t,j})^{1+\eta^m}}{1+\eta^m} - \chi^w \frac{(n^w_{t,j})^{1+\eta^w}}{1+\eta^w} - F \cdot \mathbb{1}_{[n^w_{t,j}>0]} \right)$$

subject to the sequence of budget constraints:

$$c_{t,j}(1+\tau_c) + k_{t+1,j+1} = \begin{cases} (k_{t,j} + \Gamma_t)\,(1 + r_t(1-\tau_k)) + g_t + W^L_{t,j}, & \text{if } j < 65 \\ (k_{t,j} + \Gamma_t)\,(1 + r_t(1-\tau_k)) + g_t + \Psi_t, & \text{if } j \geq 65 \end{cases}$$

where W^L is the household labor income (and unemployment benefits in case wife doesn't work):

$$W^L_{t,j} = \left(W^{L,m}_{t,j} + W^{L,w}_{t,j}\right)\left(1 - \tau_{ss} - \tau_l\left(W^{L,m}_{t,j} + W^{L,w}_{t,j}\right)\right) + \left(1 - \mathbb{1}_{[n^w_{t,j}>0]}\right) T_t,$$

$W^{L,m}_{t,j}$ and $W^{L,w}_{t,j}$ are the labor incomes of the two household members:

$$W^{L,\iota}_{t,j} = \frac{n^\iota_{t,j} w_t e^{a^\iota + \gamma^\iota_0 + \gamma^\iota_1 e^\iota_{t,j} + \gamma^\iota_2 (e^\iota_{t,j})^2 + \gamma^\iota_3 (e^\iota_{t,j})^3 + u^\iota_{t,j}}}{1 + \tilde{\tau}_{ss}}, \quad \iota = m, w$$

which depend on the individual's fixed type a^ι, experience $e^\iota_{t,j}$ (which we assume equals age for men) and productivity shock $u^i_{t,j}$.

To reformulate this household problem recursively, we divide the budget constraints by the technology level Z_t. Recall that with our normalization of Z_0 and K_0, we have $Z_t = Y_t$. Also, recall that on the balanced growth path, $\Gamma^z = \Gamma_t/Z_t$, $g^z = g_t/Z_t$, $\Psi^z = \Psi_t/Z_t$, $T^z = T_t/Z_t$, $w^z = w_t/Z_t$ and r_t must remain constant. We define $c^z_j = c_{t,j}/Z_t$ and $k^z_j = k_{t,j}/Z_t$ and conjecture that they do not depend on the calendar time t either. This allows us to rewrite the budget constraints as:

$$c_j^z(1+\tau_c)+k_{j+1}^z(1+\mu)=\begin{cases}(k_j^z+\Gamma^z)\,(1+r(1-\tau_k))+g^z+W_j^L, & \text{if } j<65\\ (k_j^z+\Gamma^z)\,(1+r(1-\tau_k))+g^z+\Psi^z, & \text{if } j\geq 65\end{cases}$$

Substituting $c_{t,j}=c_j^z Z_t$ into the objective function, we get an additive term that depends only on the sequence of Z_t and drops out of the maximization problem, and finally get the recursive formulation stated in the main text.

Similar trasformation can be applied for the single households.

A.8 Tax Function

Given the tax function

$$ya=\theta_0 y^{1-\theta_1}$$

we employ, the average tax rate is defined as

$$ya=(1-\tau(y))y$$

and thus

$$\theta_0 y^{1-\theta_1}=(1-\tau(y))y$$

and thus

$$\begin{aligned}1-\tau(y) &= \theta_0 y^{-\theta_1}\\ \tau(y) &= 1-\theta_0 y^{-\theta_1}\\ T(y) &= \tau(y)y=y-\theta_0 y^{1-\theta_1}\\ T'(y) &= 1-(1-\theta_1)\theta_0 y^{-\theta_1}\end{aligned}$$

Thus the tax wedge for any two incomes (y_1, y_2) is given by

$$1 - \frac{1 - T'(y_2)}{1 - T'(y_1)} = 1 - \left(\frac{y_2}{y_1}\right)^{-\theta_1} = 1 - \frac{1 - \tau(y_2)}{1 - \tau(y_1)} \tag{22}$$

and therefore independent of the scaling parameter θ_0 [58]. Thus by construction one can raise average taxes by lowering θ_0 and not change the progressivity of the tax code, since (as long as tax progressivity is defined by the tax wedges) the progressivity of the tax code[59] is uniquely determined by the parameter θ_1. Heathcote, Storesletten, and Violante (2017) estimate the parameter $\theta_1 = 0.18$ for all households. Above we let θ_1 vary by family type.

A.9 Estimation of Returns to Experience and Shock Processes From the PSID

We take the log of equation 15 and estimate a log(wage) equation using data from the non-poverty sample of the PSID 1968-1997. Equation 16 is estimated using the residuals from 15.

To control for selection into the labor market, we use Heckman's 2-step selection model. For people who are working and for which we observe wages, the wage depends on a 3rd order polynomial in age (men), t, or years of labor market experience (women), e, as well as dummies for the year of observation, D:

$$log(w_{it}) = \phi_i(constant + D_t'\zeta + \gamma_1 e_{it} + \gamma_2 e_{it}^2 + \gamma_3 e_{it}^3 + u_{it}) \tag{23}$$

Age and labor market experience are the only observable determinants of wages in the model apart from gender. The probability of participation (or selection equation) depends

[58] It should be noted that the last inequality only holds in the absence of additional lumpsum transfers.

[59] Note that

$$1 - \tau(y) = \frac{1 - T'(y)}{1 - \theta_1} > 1 - T'(y)$$

and thus as long as $\theta_1 \in (0, 1)$ we have that

$$T'(y) > \tau(y)$$

and thus marginal tax rates are higher than average tax rates for all income levels.

on various demographic characteristics, Z:

$$\Phi(participation) = \Phi(Z_{it}'\xi + \upsilon_{it}) \tag{24}$$

The variables included in Z are marital status, age, the number of children, years of schooling, time dummies, and an interaction term between years of schooling and age. To obtain the parameters, σ^{ι}, ρ^{ι} and $\sigma_{\alpha^{\iota}}$ we obtain the residuals $u_i t$ and use them to estimate the below equation by fixed effects estimation:

$$u_{it} = \alpha_i + \rho u_{it-1} + \epsilon_{it} \tag{25}$$

The parameters can be found in Table 2.

A.10 Matching of Individuals in Marriage

Single households face an age-dependent probability, $M(j)$, of becoming married, whereas married households face an age-dependent probability, $D(j)$, of divorce. There is assortative matching in the marriage market, in the sense that there is a greater chance of marrying someone with similar ability, a fact that singles rationally foresee.

To implement assortative matching numerically, we introduce the match index, M_n, in the simulation stage of our computational algorithm. M_n is a convex combination of a random shock, $\varsigma \sim U[0,1]$ and permanent ability, a:

$$M_n = (1-\varphi)\varsigma + \varphi a \tag{26}$$

where $\varphi \in [0,1]$. Single men and women matched to get married in this period are sorted, within their gender, based on M_n, and assigned the partner of the opposite gender with the same rank. The parameter, φ, thus determines the degree of assortative matching, based on ability. If $\varphi = 0$, then matching is random and if $\varphi = 1$ spouses will have identical ability.

Singles have rational expectations with respect to potential partners. The matching function in Equation 26 implies conditional probabilities for marrying someone of ability, a', given an individual's own ability, a. Conditional on gender, age and permanent ability, we also keep track of the distribution of singles with respect to assets, labor market experience, female participation costs and idiosyncratic productivity shocks. A single individual can thus have a rational expectation about a potential partner with respect to these characteristics and the expectation will be conditional on the individual's own gender, age and permanent ability.

In section 6 we calibrate the parameter φ to match the correlation of the wages of married couples in the data. We model the normal distributions of abilities, $a \sim N(0, \sigma_a^{\iota 2})$, using Tauchen (1986)'s method and 5 discrete values of a, placed at $\{-1.5\sigma_a^\iota, -0.75\sigma_a^\iota, 0, 0.75\sigma_a^\iota, 1.5\sigma_a^\iota\}$. Given our calibrated value of φ we obtain the below matrix of marriage probabilities across ability levels:

$$\phi^{-\iota}(a|a^\iota;\varphi) = \begin{bmatrix} 0.509 & 0.442 & 0.049 & 0.000 & 0.000 \\ 0.189 & 0.325 & 0.404 & 0.081 & 0.000 \\ 0.071 & 0.258 & 0.343 & 0.256 & 0.072 \\ 0.000 & 0.076 & 0.401 & 0.330 & 0.193 \\ 0.000 & 0.000 & 0.046 & 0.445 & 0.509 \end{bmatrix}$$

The reason that this matrix is not exactly symmetric is that it comes out of our simulation with 160000 households.

A.11 Details on the Sensitivity Analysis with Respect to the Size of the Labor Supply Elasticity

In this appendix we provide the details of our sensitivity analysis with respect to the elasticity of labor supply along the *intensive* margin. In Figure 10 we plot Laffer curves for different levels of tax progressivity when we double the Frisch labor supply elasticity of both males and females (left panel, $\eta^m = 1/0.8$ and $\eta^w = 1/1.6$) and when we cut it in half (right panel, $\eta^m = 1/0.2$ and $\eta^w = 1/0.4$), and recalibrate the model to match the same data moments as the original benchmark model.

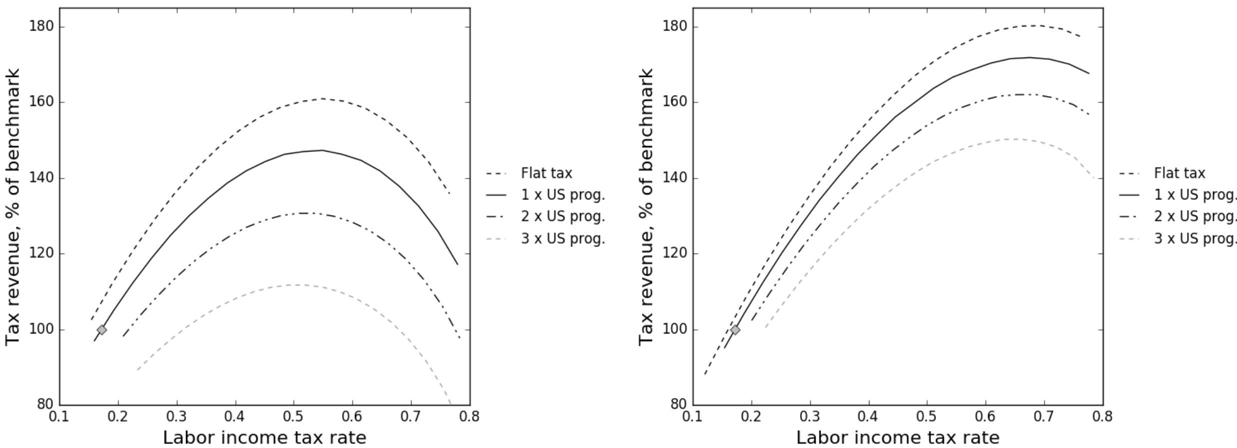

Figure 10: Laffer Curves by Tax Progressivity, High (left panel) and Low (right panel) Intensive Margin Labor Supply Elasticity

We observe that the intensive margin labor supply elasticity has significant impact, both on the level of the Laffer curve, but also on the location of its peak. Qualitatively, a more elastic intensive margin labor supply reduces the ability of the government to raise higher revenue through higher averages taxes (the level of the Laffer curve), and makes that ability more sensitive to the progressivity of the tax code, in that the impact on the peak of a more progressive tax system is stronger with more elastic labor supply. We discuss the main quantitative implications in the main text.

A.12 Additional Tables and Figures

Table 10: Tax Functions by Country and Family Type, OECD 2000-2007

Country	Married 0C		Married 1C		Married 2C		Single 0C	
	θ_0	θ_1	θ_0	θ_1	θ_0	θ_1	θ_0	θ_1
Austria	0.926427	0.150146	1.003047	0.198779	1.076124	0.23796	0.854448	0.175967
Canada	0.901481	0.155047	0.981109	0.228148	1.066354	0.296329	0.789222	0.147083
Denmark	0.787587	0.229954	0.874734	0.305302	0.920347	0.331685	0.690296	0.220311
Finland	0.868634	0.223116	0.92298	0.261043	0.976928	0.293236	0.763024	0.207634
France	0.917449	0.119957	0.944289	0.133912	1.019455	0.174277	0.85033	0.137575
Germany	0.892851	0.203455	0.956596	0.238398	1.022274	0.272051	0.77908	0.198354
Greece	1.060959	0.161687	1.088914	0.178131	1.127027	0.19963	1.019879	0.228461
Iceland	0.872072	0.194488	0.932844	0.243148	0.990471	0.287094	0.784118	0.153982
Ireland	0.946339	0.162836	1.101397	0.282089	1.187044	0.326003	0.85533	0.188647
Italy	0.900157	0.15939	0.949843	0.198573	1.00814	0.241968	0.822067	0.153275
Japan	0.948966	0.073769	0.971621	0.086518	0.992375	0.097036	0.916685	0.121497
Luxembourg	0.947723	0.15099	1.024163	0.190363	1.113409	0.231438	0.849657	0.163415
Netherlands	0.958121	0.219349	1.004174	0.245393	1.025102	0.256418	0.863586	0.272312
Norway	0.838322	0.148316	0.894721	0.194368	0.932718	0.218213	0.76396	0.146082
Portugal	0.948209	0.119169	0.97794	0.138682	1.009808	0.157309	0.882183	0.132277
Spain	0.923449	0.130171	0.93517	0.134039	0.949941	0.14052	0.862569	0.164186
Sweden	0.782747	0.166797	0.865716	0.240567	0.919471	0.276415	0.717018	0.217619
Switzerland	0.925567	0.116475	0.968531	0.136431	1.008289	0.15569	0.878904	0.128988
UK	0.908935	0.165287	0.994826	0.233248	1.049323	0.273376	0.836123	0.168479
US	0.873964	0.108002	0.940772	0.158466	1.006167	0.203638	0.817733	0.1106

Table 11: Distribution of households (with a head between 20 and 64 years of age) by the number of children and marital status, IPUMS USA, 2000-2007

		Marital status		
		Single	Married	Total
# of children	0	29.28	20.86	50.15
	1	7.49	13.27	20.76
	2	4.41	14.26	18.67
	3	1.65	5.81	7.46
	4	0.50	1.61	2.11
	5	0.14	0.42	0.56
	6	0.04	0.14	0.18
	7	0.01	0.05	0.07
	8	0.00	0.02	0.03
	9+	0.00	0.02	0.02
	Total	43.54	56.46	100.00

Table 12: Labor Income Taxes Paid by Income Deciles (benchmark calibration)

Income Decile	Share of Total	Cumulative Share
1	0.000	0.000
2	0.011	0.011
3	0.022	0.033
4	0.036	0.069
5	0.050	0.119
6	0.067	0.187
7	0.093	0.279
8	0.133	0.412
9	0.200	0.612
10	0.388	1.000

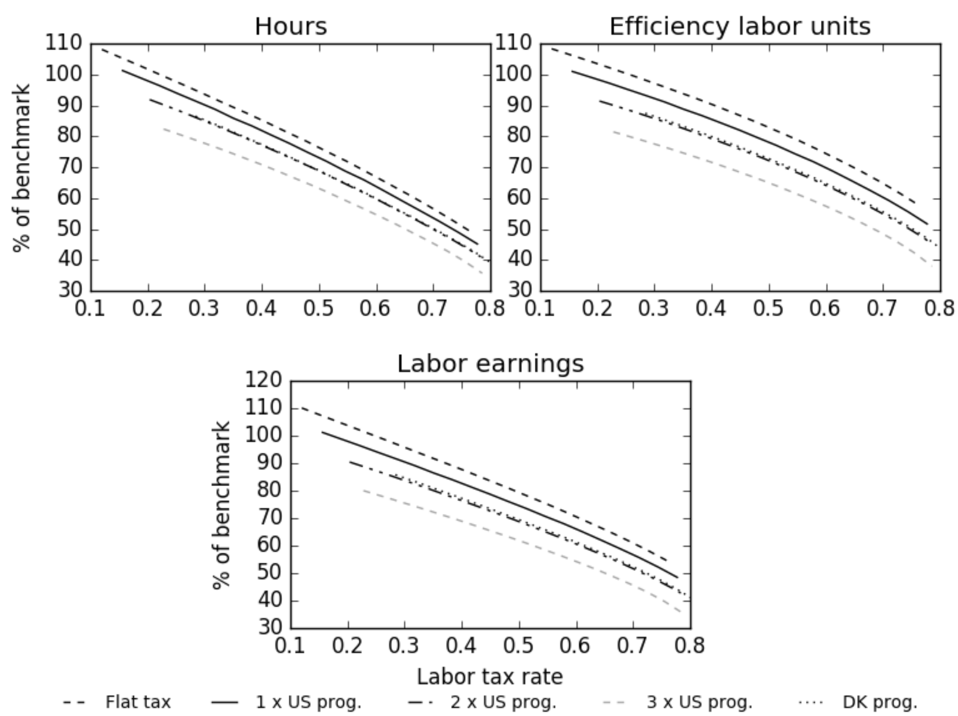

Figure 11: Labor Supply and Earnings Statistics by Tax Progressivity and Level for g-Laffer Curves

Table 13: Relative Tax Progressivity in the OECD 2000-2007 (sensitivity analysis)

Country	$y_w = y_m$	$y_w = 0.41y_m$	$y_w = 0.1y_m$
Japan	0.82	0.74	0.77
Switzerland	1.06	0.97	0.93
Portugal	1.04	0.99	0.91
U.S.	1.00	1.00	1.00
France	1.08	1.03	1.07
Spain	1.16	1.08	1.13
Norway	1.19	1.23	1.37
Luxembourg	1.37	1.31	1.25
Italy	1.28	1.31	1.40
Austria	1.42	1.37	1.41
Canada	1.34	1.41	1.59
U.K.	1.31	1.46	1.74
Greece	1.48	1.47	1.67
Iceland	1.35	1.49	1.61
Germany	1.63	1.61	1.60
Sweden	1.72	1.63	1.75
Ireland	1.61	1.65	1.78
Finland	1.66	1.73	1.88
Netherlands	1.98	1.85	1.99
Denmark	1.82	1.88	2.05

The table displays tax progressivity across countries relative to the U.S. under varying assumptions about the ratio between female and male incomes for married couples. The middle column is the benchmark assumption of $y_w = 0.41y_m$ in the CPS (2001-2007) that is used earlier in the paper.

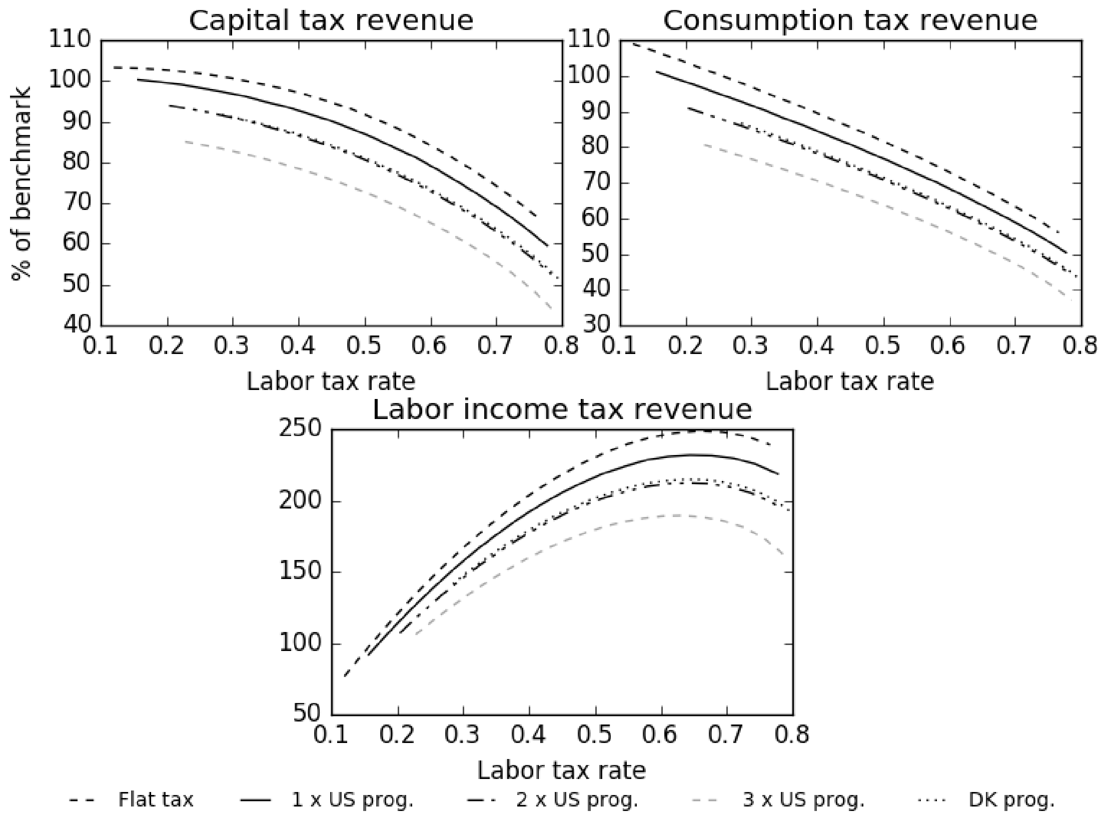

Figure 12: The Impact of Tax Progressivity on Revenue From Labor Income Taxes, Consumption Taxes and Capital Income Taxes

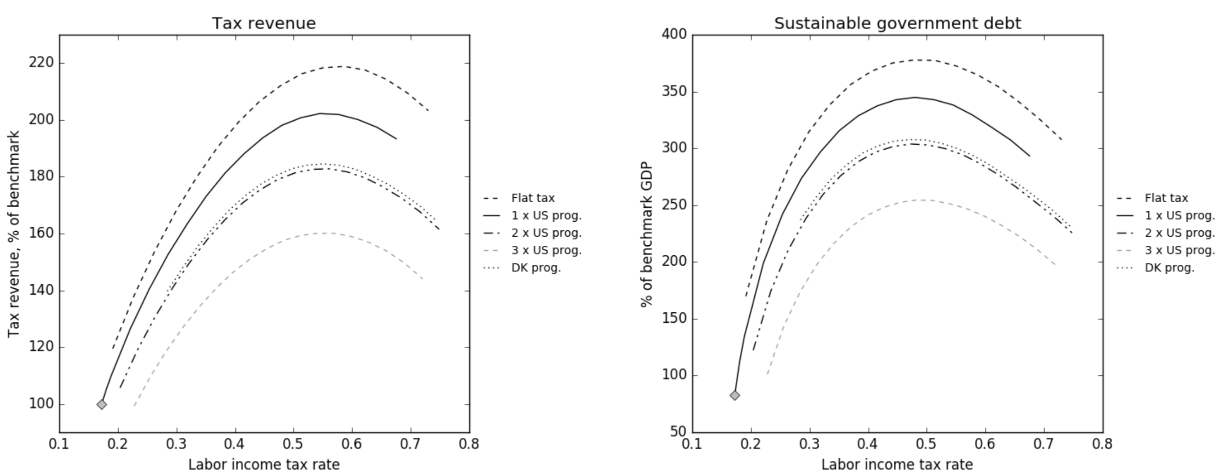

Figure 13: Tax Revenue and Maximum Sustainable Debt Level by Tax Level and Progressivity

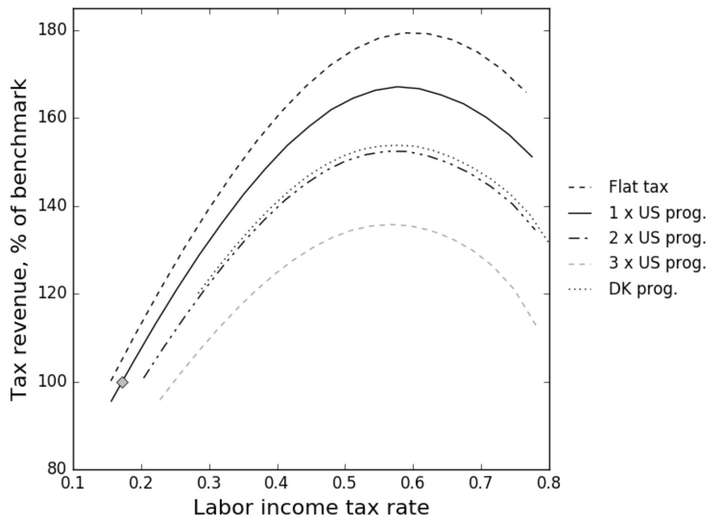

Figure 14: The Impact of Tax Progressivity on the s-Laffer Curve (wasting additional revenue)

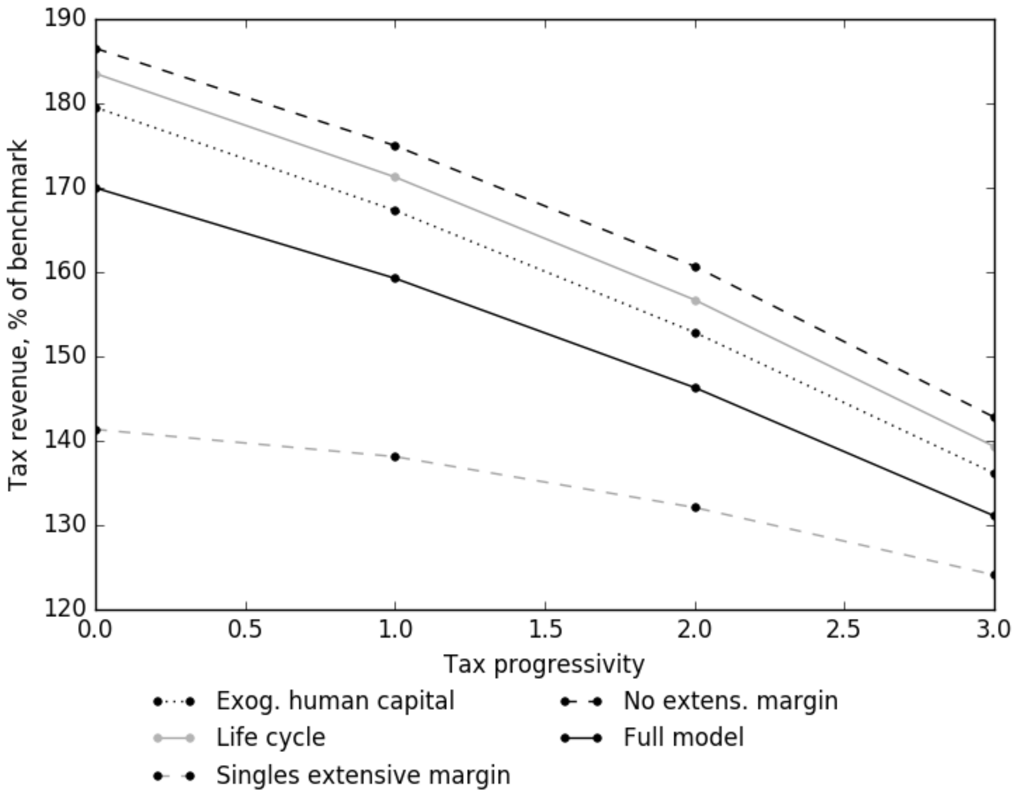

Figure 15: The Impact of Tax Progressivity on Maximum Revenue in Different Models