Till the IRS Do Us Part: (Optimal) Taxation of Households*

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Abstract: This paper argues that a progressive tax system combined with individual taxation of married couples can generate more revenue than the current household-based U.S. system, especially when the extra revenues do not induce negative labor supply effects through increased government transfers. A progressive system that taxes individuals rather than couples jointly leads to larger labor force participation and higher average human capital, creates more "fiscal space", Laffer curves are higher and welfare is potentially higher. In our model with one- and two-earner households, human capital and an extensive margin labor supply decision, the peak of the Laffer curve is 12 percentage points higher with an individual-based, progressive tax system than with the current U.S. tax system. The maximum revenue is attained with 60% more progressivity than the current system, and at an average tax rate of 41%. Progressive taxation, when imposed on individuals rather than households, lowers the average tax rate for individuals with low income that are close to the participation margin. At the same time it creates a positive income effect on the labor supply of these individuals by reducing the net income of their higher earning spouses and limiting their net earnings potential in the case of a high temporary labor productivity. Whereas steady state welfare under a joint tax system is maximized when the tax system features no progressivity at all, under individual-based taxation the optimal tax system features significant tax progressivity (albeit slightly less than the current U.S. status quo), and welfare gains relative to this status quo of 4.9% in consumption-equivalent variation. Cohorts born during the transition realize significant welfare gains from this reform.

Keywords: Tax Progressivity, Taxation of Couples, Joint vs. Individual Taxation, Optimal Taxation, Government Revenue, Laffer Curve, Labor Force Participation
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1 Introduction

How can it be that Scandinavian countries with their high labor income tax rates have employment rates and GDPs per capita that rank among the highest in the world? Following the work of Prescott (2004) and Rogerson (2006), who studied the impact of taxes on labor supply, we would expect labor supply and output to be low in these countries. This paper argues that a government can generate large tax revenue and facilitate high labor market participation, per capita output and incomes with a progressive tax code as long as the tax unit is the individual rather than the household, as is generally the case in Scandinavia and many other countries.

In this paper we quantify the importance of the interaction between tax progressivity and the choice of the tax unit (an individual or a married couple) for tax revenue and welfare. We first empirically document that across countries and time there is a positive relationship between tax progressivity and the employment rates of *single* households. To implement our empirical analysis, we construct a country panel dataset with 19 years of data on taxes and employment rates for 17 developed economies, and we develop indexes for tax progressivity and the degree to which married couples are taxed jointly or individually. We then show empirically that for *married* couples, with joint taxation higher tax progressivity is associated with lower employment rates of *both* men and women. However, moving from joint to individual taxation reduces the negative impact of tax progressivity on employment, and can turn the relationship positive, especially for married women.

Motivated by our empirical findings and to study the quantitative importance of the progressivity and jointness of the tax system on tax revenues and welfare, we develop a life-cycle, overlapping generations economy with households that are either composed of singles or married couples. Individuals in our economy are subject to idiosyncratic wage risk, as well as exogenous marriage and divorce risk. Individuals and couples are heterogeneous with respect to innate ability, asset holdings and labor market experience, and they make decisions about whether or not to participate in the labor market (the extensive margin) and, conditional on participation, how many hours to work (the intensive margin). Individuals who work accumulate labor market experience which increases future wages. Couples make decisions jointly, i.e., we employ a unitary model of the household. The government taxes consumption, capital and labor income. The focus of our policy analysis is on the level, progressivity and jointness of the labor income tax code.

We find that an increase in the progressivity of labor income taxes, when combined with a shift to individual taxation of married couples, has the potential to generate more revenue and higher welfare. When married couples are taxed individually, a more progressive tax system leads to higher labor force participation and thus more labor market experience (higher human capital) in the economy. This occurs, first, because as tax progressivity increases, the average tax rate is lowered for low-earners who are typically the ones on the margin between working and not working. In addition, progressive taxation can have a positive income effect on labor supply of couples when they are taxed as individuals. For married couples with one high income-earner and one low income-earner, the high earner brings home less net income as tax progressivity increases, creating an additional incentive to work for the low earner of the family (who at the same time is making a higher net income conditional on working due to lower marginal tax rates for this worker). Even for a single individuals there may be a positive income effect on labor supply from progressive taxation. Such a worker takes home less pay in case of (temporarily) high productivity, but obtains more net pay in case of low productivity. The strategy of working all the time thus becomes relatively more attractive compared to the strategy of working only when productivity is high for single households.

Let us contrast these results to a world when married couples are taxed jointly. Now the effect of higher tax progressivity on labor market participation tends to negative. Spouses now share the average and marginal tax rate. If one spouse, empirically still typically the male member of the household is a high-earner, the additional benefit of the second spouse participating becomes smaller as taxes are made more progressive.Only in a household where *both* spouses are low-earners does more progressive taxes encourage participation for both.

In the traditional literature on optimal taxation, the question of optimal tax progressivity involves a clear trade-off between efficiency on the one hand and redistribution and insurance on the other hand, see e.g. Heathcote, Storesletten, and Violante (2017), Kindermann and Krueger (2021). In standard macroeconomic models focusing on the intensive margin of labor supply (see e.g. Guner, Lopez-Daneri, and Ventura (2016)), higher tax progressivity leads to lower labor supply at a given average tax rate because the marginal tax rate is higher. This is also true for the labor supply choice along the intensive margin in our model. Progressive taxation thus distorts this decision and leads to lower revenue. The upside is redistribution from high-earners to low-earners as well as insurance against idiosyncratic labor productivity risk. However, with an operative extensive margin of the labor supply choice and human capital accumulation that works through labor market experience, this trade-off is no longer so clear-cut. A certain level of tax progressivity may now be beneficial for aggregate labor supply and output *if and only if* married couples are taxed individually, because it encourages labor force participation and human capital accumulation of the secondary earner of a married couple. At the same time, the extent of redistribution between low- and high-income earners is not necessarily increasing in tax progressivity because now some low-earners enter the labor market, start paying taxes and stop receiving unemployment benefits (or other transfers that are conditional on not working or on low income).

As a consequence of this micro behavior the aggregate Laffer curve, which plots total revenue from labor income taxation against the level of the tax rate, shifts up with an individual-based, progressive tax system for labor income, relative to a proportional tax system or a progressive tax system in which the tax unit is the household. This is especially true under the assumption that the additional tax revenue generated when raising the average tax rate is used for additional public goods (we call this the g-Laffer curve) rather than returned back to households in the form of lump-sum transfers (which in turn negatively affect labor supply). We also demonstrate that this positive impact of tax progressivity on revenue in the presence of individual taxation is quantitatively muted when the extra revenues are returned to households in the form of transfers, because the associated negative income effect on labor supply, and especially on participation partially offsets the impact of tax progressivity described above.

In the paper we focus on the g-Laffer curve since the need to raise extra tax revenue typically emerges in the context of increased government funding needs. The government can raise maximal revenue with a system that is approximately 60% more progressive than the current U.S. system (roughly the tax progressivity of Denmark) based on an index of progressivity that we define and measure empirically. This tax system has the potential to generate 12% more revenue than the current U.S. system. The peak is attained at an average tax rate of approximately 41%. This is lower than in some recent papers (see e.g. Guner, Lopez-Daneri, and Ventura (2016), Holter, Krueger, and Stepanchuk (2019)) and is explained by the fact that we, in contrast to those papers, model extensive margin of labor supply and human capital accumulation for *both* men and women.

Welfare, measured in terms of steady state consumption-equivalent variation relative to the U.S. benchmark tax system, is also higher with an individual-based, progressive tax system. The optimal individual-based system has an average tax rate of 8% and is approximately 10% less progressive than the current U.S. system. The welfare gain in consumption equivalents is 4.9%, relative to the current U.S. status quo. Cohorts born during the transition realize significant welfare gains from this reform. In contrast, with joint taxation of married couples, the optimal tax system has no tax progressivity at all (i.e. is a flat tax) with a rate of about 9.7% and yields a welfare gain of 2.2% relative to the benchmark.

An optimal average tax rate of 8% may at first sound somewhat low. It should, however, be noted that the optimal tax experiment that we consider is a reform of the labor income tax. In addition to labor income taxes our economy has a social security system[1] and taxes on capital and consumption that we hold constant during our labor income tax experiments.

[1] The social security tax is 15.3%, combining the taxes paid by the employee and the employer. The combined average tax rate on labor income is thus about 23%.

The remainder of this paper is organized as follows. In Section 2 we review the related literature. Section 3 develops simple empirical measures of tax progressivity and the degree to which married couples are taxed jointly. In Section 4 we conduct our empirical analysis exploring the relationship between tax progressivity, tax jointness and employment rates across countries and time. Section 5 develops a labor market and macroeconomic model of the labor market with single and married households, human capital and labor supply decisions along the intensive and extensive margins. Section 6 describes the calibration, and in Section 7 we present our results on the impact of individual-based, progressive taxation on the Laffer curve, including the key role labor supply adjustments along the extensive margin play for these findings. Section 8 contains the optimal policy analysis and Section 9 concludes; details of the model, its calibration and additional results are contained in Appendix A.

2 Related Literature

Our paper contributes to the literature on the impact and optimal design of progressive income taxes in dynamic quantitative macroeconomic models. Two recent papers that study the impact of tax progressivity on government tax revenues are Guner, Lopez-Daneri, and Ventura (2016) and Holter, Krueger, and Stepanchuk (2019). Both of these papers find that more tax progressivity leads to lower revenue for a given average tax rate. In Guner, Lopez-Daneri, and Ventura (2016), who model single individuals and intensive margin labor choice only, this happens because the marginal tax rate at a given average tax rate is higher. This distorts the household's first order condition for labor and the household optimally chooses to work less. Holter, Krueger, and Stepanchuk (2019) model one- and two-person households and extensive margin labor choice for women. However, their tax system is based on the current U.S. system, does and therefore features *joint* taxation of married couples. With this system they find that more progressive taxation leads to higher labor force participation for single women but lower labor force participation for married women. When it comes to the effect on revenue, these two opposite effects on female labor force participation nearly cancel out. Overall, more progressive taxation reduces revenue due to a fall in labor supply along the intensive margin for both men and women.

The first work in the quantitative literature in macroeconomics that explicitly considers the differences between individual-based and houehold-based taxation in a model with dual earners is Guner, Kaygusuz, and Ventura (2012). They develop a model with one- and two-earner households where women have an extensive margin labor choice and consider two *separate* tax reforms: first, the shift to an individual-based tax system of married couples, but keeping tax progressivity at the current level in the U.S., and second, a reform towards a proportional tax system.[2] The paper shows shows that both these reforms lead to a substantial increase in the labor force participation of married women, as well as higher welfare.[3] Compared to Guner, Kaygusuz, and Ventura (2012), our focus, first empirically and then in the model results, is on the *interaction* between progressive taxation and the joint or individual taxation of married couples, and how this interaction shapes the *optimal* design of the tax code. Our results suggest that progressive taxation may lead to higher tax revenues compared to proportional taxes only when combined with a move to individual-based taxation of married couples. Our paper emphasizes the crucial importance of the extensive margin of labor supply (especially for married women, but also for men) for this finding, an emphasis shared by Borella, Nardi, and Yang (2023).

The recent work by Kato (2022) also investigates the optimal design of the income tax

[2] Eckstein, Keane, and Lifshitz (2019) present a structurally estimated empirical micro model of education-, marriage and labor supply choices and also study the consequences of a tax policy reform from joint to individual taxation.

[3] Our paper demonstrates that when both men and women have an extensive margin of labor supply, they both also increase their labor force participation with the reform to an individual-based system. The response is strongest for married women because they are more often the secondary earner but, it is also present for men, which is important from an applied perspective since the gender wage gap is rapidly declining in many countries, and male and female employment rates are no longer so different, suggesting that it is important to also model the extensive margin of men. In our U.S. data from the CPS 2010-2019, the male employment rate, age 20-64, is 0.78 and the female employment rate is 0.68. Even if male employment remains higher, taking for granted that men always work is an increasingly strong assumption.

code (including the question whether it should be individual-based or household-based) of couples, but models these couples non-cooperatively and focuses on the impact of endogenous marriage and divorce decisions for the optimal structure of the tax code. These papers, ours included, extend the literature that has studied the impact of the choice of the tax unit (individuals versus the family or the household) on optimal tax progressivity in static models in the Mirrleesian tradition of optimal fiscal policy, see, e.g., da Costa and Lima (2020), Bierbrauer, Boyer, Peichl, and Weishaar (2023) and the references therein.

Finally, our paper contributes to the literature on the cross-country variation in taxation and work hours, see, e.g., Prescott (2004), Rogerson (2006), Ohanian, Raffo, and Rogerson (2008), Chakraborty, Holter, and Stepanchuk (2015), Bick and Fuchs-Schündeln (2017), Bick and Fuchs-Schündeln (2018). Whereas the first three papers consider the impact of average tax levels on labor supply across countries and time, Chakraborty, Holter, and Stepanchuk (2015), Lehmann, Lucifora, Moriconi, and der Linden (2016) and Bick and Fuchs-Schündeln (2018) study the impact of the details of the tax system, including progressivity and the degree to which married couples are taxed jointly, on labor supply across countries. The focus of these papers is on explaining the cross-country variation in total work hours and unemployment. The empirical study of the relationship between the extensive margin of labor supply (employment rates), and the interaction of tax progressivity and tax jointness across countries and time undertaken in Section 4 is a novel contribution to this literature that might be of independent interest.

3 Measuring Tax Progressivity and Tax Jointness

To measure the concepts of tax progressivity and tax jointness in the model and data, we use simple parametric, but commonly used tax functions. For single individuals, we assume the following tax function, which we will also be using in the model in Section 5:

$$y_{\text{net}} = \theta_0 y^{1-\theta_1} \tag{1}$$

This tax function was proposed by Benabou (2002) and recently employed by Heathcote, Storesletten, and Violante (2017) and Holter, Krueger, and Stepanchuk (2019), who argue that it fits the U.S. data well. With this tax function, the tax paid on income y is $T(y) = y - y_{\text{net}}$, and we let $T'(y)$ denote the marginal tax rate and $\tau(y) = 1 - \theta_0 y^{-\theta_1}$ denote the average tax rate for a tax unit with income y.[4] To obtain tax functions that are comparable across countries and time, and not sensitive to model units of measurement, we normalize all incomes by Average Earnings (AE) in the economy when computing tax liabilities.

3.1 Measuring Tax Progressivity

A commonly used measure of tax progressivity in the literature (see e.g. Caucutt, Imrohoroglu, and Kumar (2003), Guvenen, Kuruscu, and Ozkan (2014), Holter (2015)) is the *progressivity tax wedge* between two arbitrary income levels y_1 and $y_2 > y_1$:

$$PW(y_1, y_2) = 1 - \frac{1 - T'(y_2)}{1 - T'(y_1)} = 1 - \left(\frac{y_1}{y_2}\right)^{\theta_1} \tag{2}$$

where the second equality expresses the tax wedge for the specific parametric tax function used in this paper. As long as the tax code is weakly progressive ($\theta_1 \geq 0$) 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 ($\theta_1 = 0$) for all income levels y_1 and y_2, converges to zero as y_2 converges to y_1 for all continuously differentiable tax functions, and approaches 1 as the marginal tax rate at the higher income y_2 approaches 1. In general, the tax wedge measures how strongly marginal tax rates increase between incomes y_1 and y_2.

A convenient property of our tax function is that tax progressivity, as measured by the wedge $PW(y_1, y_2)$ is uniquely determined by the parameter θ_1, see Holter, Krueger, and Stepanchuk (2019)). One can then increase the *level* of taxes by decreasing the parameter θ_0 without affecting tax progressivity (as measured by the wedge) at any two levels of incomes y_1 and y_2. At the same time, an increase in the progressivity parameter θ_1 increases the

[4] See Appendix A.3 for more details on the properties of this tax function.

progressivity of the tax code, but leaves the level of tax rates unchanged.

3.2 Measuring Tax Jointness

If the labor income tax for married couples in a country is levied on the sum of husband's and wife's earnings, we say they are subject to joint taxation or household-based taxation. If instead the tax unit is the individual, then we say that taxation is separate or individual-based. We consider both options in our model. Empirically most countries do not have a completely joint or fully separate tax system, however, but somewhat of a mixed system. One reason for this is that there are various transfers, such as child support or housing support to low-income households, that follows the household, whereas the income tax schedule itself is fully separate. Another complication is that there are several tax authorities, and local taxes could, e.g., be separate while national taxes joint. To empirically capture the fact that OECD countries vary greatly in the degree to which married couples are taxed individually or jointly, we specify the tax function by the following equation for net of tax income:

$$y_{\text{net}} = y_1 + y_2 - T(y_1, y_2) = \theta_0 \left((y_1)^\rho + (y_2)^\rho\right)^{\frac{1-\theta_1}{\rho}} \tag{3}$$

which implies the tax function:

$$T(y_1, y_2) = y_1 + y_2 - \theta_0 \left((y_1)^\rho + (y_2)^\rho\right)^{\frac{1-\theta_1}{\rho}} \tag{4}$$

The parameter ρ governs the degree of tax jointness. We obtain fully joint taxation for $\rho = 1$, whereas $\rho = 1 - \theta_1$ defines a fully separate tax system.[5] To aid with the interpretation of

[5] However, we do not impose the restriction that $1 - \theta_1 \leq \rho$, allowing for "negative tax jointness". We say there is "positive tax jointness" if the marginal tax rate of one spouse depends positively on the income of the other spouse, that there is exactly separate taxation if the marginal tax rate of one spouse is independent of the income of the other spouse, and there is "negative tax jointness" if the marginal tax rate of one spouse depends negatively on the income of the other spouse. Formally,

$$\begin{aligned} T_1' &= 1 - \theta_0(1-\theta_1)\left(x_1^\rho + x_2^\rho\right)^{(1-\theta_1-\rho)/\rho} x_1^{\rho-1} \\ T_{12}'' &= -\theta_0(1-\theta_1)(1-\theta_1-\rho)\left(x_1^\rho + x_2^\rho\right)^{(1-\theta_1-2\rho)/\rho} x_1^{\rho-1} x_2^{\rho-1} \end{aligned}$$

our empirical regression results, we also define a measure of "tax separateness" as:

$$\varphi = \frac{1-\rho}{1-(1-\theta_1)}. \tag{5}$$

With this definition, the tax function can be written as

$$y_{\text{net}} = \theta_0 \left((y_1)^{1-\theta_1\varphi} + (y_2)^{1-\theta_1\varphi} \right)^{\frac{1-\theta_1}{1-\theta_1\varphi}} \tag{6}$$

and fully joint taxation is given by $\varphi = 0$, fully separate taxation by $\varphi = 1$ and if the tax system is proportional ($\theta_1 = 0$), then the tax unit parameterized by φ is irrelevant and $y_{\text{net}} = \theta_0 (y_1 + y_2)$, independent of φ.

4 Tax Progressivity, Tax Jointness and Employment Across Time and Space

In this Section we study the empirical relationships between tax progressivity and the employment rate of single men and women and between tax progressivity, the degree to which married couples are taxed jointly, and the employment rate of married men and women, across countries and time.

4.1 Data Description

To estimate measures of tax progressivity and tax jointness (the degree to which married couples are taxed jointly), we use data from the OECD Tax-Benefit web calculator.[6] It allows us to generate data on the personal income taxes of single and married households, with and without children, in 17 countries over the 2001-2019 period, for individual incomes ranging from 0% to 200% of the *Average Earnings* per person. Since we are interested in the tax

and thus there is positive jointness if $1-\theta_1-\rho < 0$ and thus $T''_{12} > 0$ and negative jointness if $1-\theta_1-\rho > 0$ and thus $T''_{12} < 0$.

[6] https://taxben.oecd.org/index.html

schedule for people who are working significantly more than zero hours, for our estimation, we use the data with individual incomes ranging from 20% to 200% of average earnings, in increments of 2%. Since the tax code typically differs by the number of children, we obtain the tax data for families with different number of children and we weight the observations by the share of each family type in the U.S. data.

We obtain data on employment by gender and marital status in Western Europe and the U.S. from the EU Labor Force Survey and the CPS. This gives us 17 countries in our sample[7], with 19 observations per country (covering the period from 2001-2019). Appendix A.7 provides a more detailed description of the data.

4.2 Empirical Approach

Using the data collected from the OECD Tax-Benefit web calculator, we estimate the parameters $(\theta_0, \theta_1, \varphi)$ of the tax functions for singles and married that best fit this data. We then use the estimated parameters to construct measures of the average tax level, tax progressivity and tax jointness. As our measure of the tax level, we use $1-\theta_0$, which determines the tax rate at average earnings, $y = AE$. We use θ_1 as our measure of tax progressivity. Table 8 displays the average values of the estimated tax function parameters by country.

Below, we show the results of regressing the employment rates of married men, married women, single men and single women on the tax measures. The main coefficient of interest in the regression for married is the interaction term between our measure of tax progressivity, θ_1, and φ, the degree to which spouses are taxed individually. In the regression for singles, the main coefficient of interest is the one on tax progressivity.

4.3 Regression Results

We consider 2 different groups of regressions: (1) fixed-effects estimates with country-fixed effects only, (2) fixed-effects estimates with both country- and year-fixed effects. Tables 1 and 2 display the main regression results when all tax measures are present in the regression for

[7] Austria, Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, Great Britain, Greece, Ireland, Iceland, Italy, Netherlands, Portugal, Sweden, the U.S.

married women and men and single women and men. A more detailed analysis for married women and men, starting from including one tax measure at the time and gradually adding variables can be found in Tables 9-12 in Appendix A.9.[8]

For all regression specifications we consider, the main variable of interest, $\varphi\times\theta_1$, the interaction term between tax progressivity and tax separateness, is positive and statistically significant at the 1%-level both in the regressions for married women and men. As we will see later, this finding matches the prediction from our model. The intuition is that for married couples, higher tax progressivity together with individual taxation of the two spouses means lower average tax rate for the secondary earner, which gives higher incentives to the secondary earner to enter the labor market. There is also an income effect. The primary earner will bring home less net income with separate progressive taxation, which increases the benefit of having two earners.

Table 1: Summary of Main Regression Results for Married Women and Men

	FE (W)	FE+T (W)	FE (M)	FE+T (M)
$(1-\theta_0)$	0.014	-0.036	-0.547^{***}	-0.602^{***}
	(0.117)	(0.09)	(0.099)	(0.1)
θ_1	-0.169	-0.378^{***}	-0.721^{***}	-0.782^{***}
	(0.129)	(0.098)	(0.108)	(0.108)
$\varphi\times\theta_1$	0.292^{***}	0.232^{***}	0.414^{***}	0.457^{***}
	(0.101)	(0.076)	(0.085)	(0.083)
Const	0.638^{***}	0.704^{***}	1.053^{***}	1.073^{***}
	(0.032)	(0.025)	(0.027)	(0.027)
R^2 (within)	0.079	0.068	0.226	0.259
R^2	0.931	0.965	0.81	0.837

The table displays the results from regressing the labor force participation rate of married women (W) and men (M) on our tax measures. In the columns labeled "Pooled" we include no additional controls. In the columns labeled "FE" we include country fixed effects and in the columns labeled "FE+T" we include country and time fixed effects.

The coefficient on θ_1, our measure of tax progressivity, is statistically significant and negative in three of our four regressions. This is as expected because progressive joint

[8]Fixed effects panel regression estimates are obtained by first subtracting the appropriate group means (using the `linearmodels` library in `Python`).

taxation would have the opposite effect of progressive separate taxation on employment. It encourages one earner in the family by increasing the tax rate on the secondary earner.

One can use our estimates to compute the effect of moving from joint $\varphi = 0$ to individual $\varphi = 1$ taxation, by using the country-specific value of tax progressivity, θ_1. This effect is larger with more progressive taxation.[9] Notice that this effect disappears with proportional taxes (which corresponds to $\theta_1 = 0$), a result which our model replicates.

In line with economic intuition, the coefficient on the level of taxes, $(1 - \theta_0)$, is negative in five out of six regressions and statistically significant in four. This implies that higher average taxes lead to lower labor force participation.[10]

The regression results for single men and women are below. Our theory predicts that, controlling for the tax level, tax progressivity should have a positive effect on the labor force participation of singles, and in particular single women because they have lower average wages. In all four regressions for single women and men, the θ_1 coefficients are positive. However, this coefficient is either insignificant or only marginally statistically significant. The coefficients on tax level, $(1 - \theta_0)$, are negative as expected.

Table 2: Regression Results for Single Women and Men

	FE (W)	FE+T (W)	FE (M)	FE+T (M)
$(1-\theta_0)$	-0.166^{**}	-0.176^{**}	-0.405^{***}	-0.291^{***}
	(0.074)	(0.074)	(0.113)	(0.097)
θ_1	0.095^{**}	0.085^{*}	0.127^{*}	0.024
	(0.047)	(0.046)	(0.072)	(0.061)
Const	0.616^{***}	0.622^{***}	0.721^{***}	0.715^{***}
	(0.02)	(0.02)	(0.031)	(0.026)
R^2 (within)	0.025	0.028	0.049	0.039
R^2	0.952	0.96	0.857	0.909

The table displays the results from regressing the labor force participation rate of single women (W) and men (M) on our tax measures. In the columns labeled "Pooled" we include no additional controls. In the columns labeled "FE" we include country fixed effects and in the columns labeled "FE+T" we include country and time fixed effects.

[9] The average value of the tax progressivity parameter for married couples in our sample is $\bar{\theta}_{1,M} = 0.218$.

[10] See, e.g., Chakraborty, Holter, and Stepanchuk (2015), Bick and Fuchs-Schündeln (2018).

5 The Model

Our model is a life-cycle, heterogeneous agent model with one- and two-person households similar to Holter, Krueger, and Stepanchuk (2019), Chakraborty, Holter, and Stepanchuk (2015). In particular, we extend the model framework in Holter, Krueger, and Stepanchuk (2019) with an extensive margin of labor supply and human capital for men. However, as Chakraborty, Holter, and Stepanchuk (2015), we assume a small open economy where the interest rate is given exogenously.

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 the 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:

$$w_t = \partial Y_t / \partial L_t = (1-\alpha) Z_t^{1-\alpha} \left(\frac{K_t}{L_t}\right)^{\alpha} = (1-\alpha) Z_t \left(\frac{K_t / Z_t}{L_t}\right)^{\alpha} \tag{7}$$

$$r_t = \partial Y_t / \partial K_t - \delta = \alpha Z_t^{1-\alpha} \left(\frac{L_t}{K_t} \right)^{1-\alpha} - \delta = \alpha \left(\frac{L_t}{K_t / Z_t} \right)^{1-\alpha} - \delta \tag{8}$$

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 assume that this is a small open economy where r_t is exogenously given. If r_t remains constant over time, $w_t^z = w_t / Z_t$ is also going to be constant over time, 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.[11] 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 men, single women 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 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

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

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. We model both the extensive and intensive margins of labor supply. Individuals will either work or stay at home, and conditional on working they will choose how much to work. Married households jointly decide on how many hours to work, how much to consume, and how much to save. Individuals who participate in the labor market accumulate one year of labor market experience. 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. Specifically, a single man with ability a^m faces a probability $\phi^w(a|a^m;\psi)$ of marrying a woman of type a, and symmetrically, a woman of type a^w marries a man of ability a with probability $\phi^m(a|a^w;\psi)$. The parameter ψ, calibrated in section 6, captures the degree of sorting in the marriage market, with $\psi = 0$ standing in for perfectly random marriage and $\psi = 1$ representing perfect sorting by permanent ability.[12]

[12] 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 man understands that if he were, by chance, to marry a high ability woman, she would carry higher than average assets into the marriage, since permanent ability and assets are

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:

$$log(w^z(a,e,u,\iota)) = log(w^z) + a + \gamma_0^\iota + \gamma_1^\iota e + \gamma_2^\iota e^2 + \gamma_3^\iota e^3 + u \tag{9}$$

$$u' = \rho^\iota u + \epsilon, \quad \epsilon \sim N(0, \sigma^2_{\epsilon^\iota}) \tag{10}$$

The parameters γ_0^ι encode the average productivity, and γ_1^ι, γ_2^ι as well as γ_3^ι capture returns to experience for women and 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:

$$U^M(c, n^m, n^w) = \log(c) - \frac{1}{2}\chi_M^m \frac{(n^m)^{1+\eta^m}}{1+\eta^m} - \frac{1}{2}\chi_M^w \frac{(n^w)^{1+\eta^w}}{1+\eta^w} - \frac{1}{2}F_M^m \cdot \mathbb{1}_{[n^m>0]} - \frac{1}{2}F_M^w \cdot \mathbb{1}_{[n^w>0]} \tag{11}$$

where F_M^ι is a fixed disutility from working positive hours. The indicator function, $\mathbb{1}_{[n>0]}$, is equal to 0 when $n = 0$ and equal to 1 when $n > 0$. The momentary utility function for singles is given by:

$$U^S(c, n, \iota) = \log(c) - \chi_S^\iota \frac{(n)^{1+\eta^\iota}}{1+\eta^\iota} - F_S^\iota \cdot \mathbb{1}_{[n>0]} \tag{12}$$

We allow the disutility of work and the fixed cost of work to differ by gender and marital status. For married and single men and women, we assume that it takes the following form: $F_X^\iota \sim N(\mu_{F_X^\iota}, \sigma^2_{F_X^\iota})$, $X \in \{M, S\}$. The participation cost of an individual is drawn only once,

positively correlated among single women.

at the beginning of life, and thus is a fixed characteristic of an individual (but is allowed to differ when single and when married).[13]. To capture the fact that the participation cost of married women tends to vary substantially over the life-cycle due to child birth and caring for young children, we let their fixed cost of working be dependent of age. We assume that, similar to the other three demographic groups, the participation cost of married women contains a fixed constant term that is normally distributed. In addition, it has two other terms that are linear and quadratic in age:

$$F_M^w = F_M^{w0} + F_M^{w1} \cdot j + F_M^{w2} \cdot j^2, \tag{13}$$

where $F_M^{w0} \sim N(\mu_{F_M^{w0}}, \sigma^2_{F_M^{w0}})$.

In a model without participation margin, King, Plosser, and Rebelo (2002) show that the above preferences are consistent with balanced growth. Holter, Krueger, and Stepanchuk (2019) demonstrate that this is also true in a 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 (here assumed to be equivalent to wasteful spending), G_t, benefits to people that are not working, ν_t, and lump-sum redistribution, g_t. 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

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

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 proposed by Benabou (2002) and recently used in Heathcote, Storesletten, and Violante (2017), where the average tax rate on labor income y is given by: $\tau(y) = 1 - \theta_0 y^{-\theta_1}$, 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, benefits to individuals that do not work, ν^z, government consumption G^z, and social security benefits Ψ^z, as:

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

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

$$\begin{aligned} g^z \left(45 + \sum_{j \geq 65} \Omega_j \right) + 45\nu^z\zeta + G^z = R^z, \\ \Psi^z \left(\sum_{j \geq 65} \Omega_j \right) = R^{ssz}. \end{aligned}$$

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 lump-sum transfers (times the number of individuals in the economy), per capita transfers to the unemployed (times the number of unemployed) and on government consumption, and has to finance these outlays through tax revenue.

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 fixed costs of working, F_M^ι, as well as the households' age j. Thus the list of state variables of a married household is $(k, e^m, e^w, u^m, u^w, a^m, a^w, F_M^m, F_M^w, j)$. The state space for a single household is $(k, e, u, a, F_S^w, \iota, j)$. 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[14] 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:

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

s.t.:

$$
c^z(1+\tau_c) + (k^z)'(1+\mu) = \begin{cases} \left(k^z + \Gamma^z\right)\left(1 + r(1-\tau_k)\right) + 2g^z + Y^L + \nu^z \left(\mathbb{1}_{[n^m=0]} + \mathbb{1}_{[n^w=0]}\right), & \text{if } j < 65 \\ \left(k^z + \Gamma^z\right)\left(1 + r(1-\tau_k)\right) + 2g^z + 2\Psi^z, & \text{if } j \geq 65 \end{cases}
$$

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

$$
\begin{aligned}
Y^L &= \left(Y^{L,m} + Y^{L,w}\right)\left(1 - \tau_{ss} - \tau_l^M\left(Y^{L,m} + Y^{L,w}\right)\right)\\
Y^{L,\iota} &= \frac{n^\iota w^{z,\iota}\left(a^\iota, e^\iota, u^\iota\right)}{1 + \tilde{\tau}_{ss}},\ \iota = m, w\\
(e^m)' &= e^m + \mathbb{1}_{[n^m>0]}, \quad (e^w)' = e^w + \mathbb{1}_{[n^w>0]},\\
n^m &\in [0,1], \quad n^w \in [0,1], \quad (k^z)' \geq 0, \quad c^z > 0,\\
n^\iota &= 0 \quad \text{if } j \geq 65,\ \iota = m, w.
\end{aligned}
$$

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.:

$$
c^z(1+\tau_c) + (k^z)'(1+\mu) = \begin{cases} \left(k^z + \Gamma^z\right)\left(1 + r(1-\tau_k)\right) + g^z + Y^L + \nu^z \mathbb{1}_{[n^\iota=0]}, & \text{if } j < 65\\ \left(k^z + \Gamma^z\right)\left(1 + r(1-\tau_k)\right) + g^z + \varPsi^z, & \text{if } j \geq 65 \end{cases}
$$

$$
\begin{aligned}
Y^L &= \left(Y^{L,\iota}\right)\left(1 - \tau_{ss} - \tau_l^S\left(Y^{L,\iota}\right)\right)\\
Y^{L,\iota} &= \frac{n^\iota w^{z,\iota}\left(a^\iota, e^\iota, u^\iota\right)}{1 + \tilde{\tau}_{ss}},\ \iota = m, w\\
(e^\iota)' &= e^\iota + \mathbb{1}_{[n^\iota>0]},\\
n^\iota &\in [0,1], \quad (k^z)' \geq 0, \quad c^z > 0,\\
n^\iota &= 0 \quad \text{if } j \geq 65,\ \iota = m, w.
\end{aligned}
$$

$E_{(k^{-\iota})', e^{-\iota}, (u^m)', (u^w)', a^{-\iota}, F^{S-\iota}}$ is here 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 Partial Competitive Equilibrium

We call a partial recursive competitive equilibrium of the growth-adjusted economy a stationary equilibrium in the small open economy.[15] In equilibrium agents optimize, given prices and budget constraints, the government budget constraint balances, and the cross-sectional distribution across household types is stationary. For sake of brevity, the formal equilibrium definition is stated in Appendix A.1. All thought experiments to follow consider stationary partial equilibria, with the exception of Section 8.2 which explicitly considers the transitional dynamics induced by a specific tax reform (but still keeps factor prices constant and insists on period-by-period budget balance of the government).

6 Calibration

This section describes the calibration of the model parameters. We calibrate our model to match selected moments from 2010-2019 U.S. data. Many parameters can be calibrated directly to their empirical counterparts, without solving the model. These are listed (including their values) in Table 3. In contrast, the 11 parameters in Table 4 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 9.77% in U.S. data.

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

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

National Center for Health Statistics.

We assume that there are three family types: (1) single men; (2) single women; (3) married couples. To calculate age-dependent probabilities of transitions between married and single, we use the U.S. data from the CPS March supplement, covering years 2010 to 2019. 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 ψ, which is estimated within the SMM procedure so that the model matches the empirical correlation of hourly wages of 0.287 in the CPS (2010-2019) for married couples.[16]

6.3 Wages

We estimate the experience profiles for male and 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.5 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

[16]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

$$M_n = (1-\psi)\varsigma + \psi a. \tag{14}$$

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 $\psi = 0$, marriage is random, and if $\psi = 1$, marriages are perfectly sorted by spousal ability a. Appendix A.6 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.

the returns to experience for men and women, 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 estimate the mean wage parameters γ_0^w and γ_0^m internally in the model. The associated data moments are the ratio between male and female earnings and the average wage of working individuals, which we normalize to 1 in the model.

6.4 Preferences

The period utility functions for both family types are given in equations (11) and (12). The discount factor, β, the cross-sectional means and variances of the fixed costs of working, $\mu_{F_M^\iota}$, $\mu_{F_S^\iota}$, $\sigma^2_{F_M^\iota}$ and $\sigma^2_{F_S^\iota}$, and the disutility parameters of working more hours, χ_M^ι and χ_S^ι, 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, $\mu_{F_M^\iota}$, $\mu_{F_S^\iota}$, are identified by the employment rates of married and single men and women aged 20-64, taken from the CPS. To pin down the cross-sectional variance of the participation costs, $\sigma^2_{F_M^\iota}$ and $\sigma^2_{F_S^\iota}$, we use the *persistence* of labor force participation of married and single men and women (again aged 20-64) from the PSID. If the cross-sectional dispersion of the participation cost is high, some individuals will work all the time, and some individuals 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 men and 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.[17] We set $1/\eta^m = 0.4$,

[17]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.

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 5.5 we employ the labor income tax function proposed by Benabou (2002). To create a mapping between the tax and income data and our model, we normalize labor income by the average earnings in the economy (AE), both when we estimate our tax functions and in our model. Given gross labor income, y/AE, the after-tax income is denoted as y_{net}/AE, and it is given by: $y_{net}/AE = \theta_0(y/AE)^{-\theta_1}$, with $\theta_0 < 1$, $\theta_1 < 1$. We adjust AE when computing equilibrium so that the tax rate for a person with average income in the model continues to equal the tax rate of a person with average income in the data. Since the OECD tax and Benefit calculator only provides the taxes for incomes up to 200% of Average Earnings we use tax data from the NBER TaxSim to estimate our tax functions for married and single households. Like in Section 4 we obtain the tax data for families with 0-3 children and weight the observations by the shares of these family types in the population.

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

There is an ongoing debate on what share of government spending that resembles transfers to households. Here we take the view that significant share of government spending resembles transfers, in line with Prescott (2004), Oh and Reis (2012). In the calibrated equilibrium we follow Prescott (2004) and assume that two times military spending (obtained from the

Table 3: 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
$\gamma_1^m, \gamma_2^m, \gamma_3^m$	$0.0605,\ 1.06 * 10^{-3},\ 9.30 * 10^{-6}$	$w_t(a_i, e_i, u_i) = w_t e^{a_i+\gamma_0^m+\gamma_1^m e_i+\gamma_2^m e_i^2+\gamma_3^m e_i^3+u_i}$	PSID (1968-1997)
$\gamma_1^w, \gamma_2^w, \gamma_3^w$	$0.0784,\ 2.56 * 10^{-3},\ 2.56 * 10^{-5}$	$w_t(a_i, e_i, u_i) = w_t e^{a_i+\gamma_0^w+\gamma_1^w e_i+\gamma_2^w e_i^2+\gamma_3^w e_i^3+u_i}$	
$\sigma_\epsilon^m, \sigma_\epsilon^w,$	0.322, 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	0.315, 0.385	$a^\iota \sim N(0, \sigma_{a_m}^2)$	
$\theta_0^S, \theta_1^S, \theta_0^M, \theta_1^M$	0.895, 0.140, 0.975, 0.149	$ya = \theta_0 y^{1-\theta_1}$	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)
ν	0.202*AE	Income if not working	CEX 2001-2007
G/Y	0.778	Pure public consumption goods	2X military spending (World Bank)
$\omega(j)$	Varies	Survival probabilities	NCHS
$M(j)$, $D(j)$	Varies	Marriage and divorce probabilities	CPS
μ	0.02	Output growth rate	Trabandt and Uhlig (2011)
δ	0.077	Depreciation rate	$I/K - \mu$ (BEA)
α	1/3	$Y_t(K_t, L_t) = K_t^\alpha \left[Z_t L_t\right]^{1-\alpha}$	Historical capital share

Table 4: Parameters Calibrated Endogenously

Parameter	Value	Description	Moment	Data	Model
γ_0^m	-0.032	$w_t(a_i, e_i, u_i) = w_t e^{a_i+\gamma_0^\iota+\gamma_1^\iota e_i+\gamma_2^\iota e_i^2+\gamma_3^\iota e_i^3+u_i}$	Gender earnings ratio	1.432	1.430
γ_0^f	-0.096		Average Earnings (AE)	1.000	1.000
β	0.992	Discount factor	K/Y	2.683	2.683
$\mu_{F_M^{w0}}$	0.218	$F_M^{w0} \sim N(\mu_{F_M^{w0}}, \sigma^2_{F_M^{w0}})$	Married fem employment	0.668	0.668
$\sigma_{F_M^{w0}}$	0.201		R^2 from $\mathbb{1}_{[n_t>0]} = \rho_0 + \rho_1 \mathbb{1}_{[n_{t-1}>0]}$	0.553	0.553
F_M^{w1}	-0.022	$F_M^w = F_M^{w0} + F_M^{w1} \cdot j + F_M^{w2} \cdot j^2$	Married fem employment, 25-34	0.661	0.663
F_M^{w2}	0.0004		Married fem employment. 55-64	0.597	0.597
χ_M^w	3.97	$\chi_M^w \frac{(n^w)^{1+\eta^w}}{1+\eta^w} - F_M^w \cdot \mathbb{1}_{[n^w>0]}$	Married female hours	0.231 (1260 h/year)	0.229
$\mu_{F_M^m}$	0.209		Married male employment	0.871	0.871
$\sigma_{F_M^m}$	0.092		R^2 from $\mathbb{1}_{[n_t>0]} = \rho_0 + \rho_1 \mathbb{1}_{[n_{t-1}>0]}$	0.457	0.459
χ_M^m	13.10	$\chi_M^m \frac{(n^m)^{1+\eta^m}}{1+\eta^m} - F_M^m \cdot \mathbb{1}_{[n^m>0]}$	Married male hours	0.349 (1905 h/year)	0.349
$\mu_{F_S^w}$	0.065	$F_S^\iota \sim N(\mu_{F_S^\iota}, \sigma^2_{S_M^\iota})$	Single fem. employment	0.694	0.694
$\sigma_{F_S^w}$	0.570		R^2 from $\mathbb{1}_{[n_t>0]} = \rho_0 + \rho_1 \mathbb{1}_{[n_{t-1}>0]}$	0.463	0.463
χ_S^w	9.100	$\chi_S^\iota \frac{(n^\iota)^{1+\eta^\iota}}{1+\eta^\iota} - F_S^\iota \cdot \mathbb{1}_{[n^\iota>0]}$	Single female hours	0.236 (1288 h/year)	0.236
$\mu_{F_S^m}$	1.127		Single male employment	0.727	0.727
$\sigma_{F_S^m}$	0.530		R^2 from $\mathbb{1}_{[n_t>0]} = \rho_0 + \rho_1 \mathbb{1}_{[n_{t-1}>0]}$	0.408	0.403
χ_S^m	43.60		Single male hours	0.260 (1420 h/year)	0.260
ψ	0.081	$M_n = (1-\psi)\varsigma + \psi a$	$corr(\log(w^m), \log(w^w))$	0.287	0.287

World Bank) is spent on a pure public consumption good, G. There is no utility form G in the model it just has to be paid for. People who do not work often have other sources of public income such as unemployment benefits, social aid, disability insurance etc. To approximate the income when not working, ν, we take the average value of non-housing consumption of households with income less than \$5000 per year from the Consumer Expenditure Survey

6.7 *Estimation Method*

Eighteen 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 eighteen data moments in column 5 of Table 4. Let $\Theta = \{\gamma_0^m, \gamma_0^f, \beta, \mu_{F_M^{w0}}, \sigma_{F_M^{w0}}, F_M^{w1}, F_M^{w2}, \chi_M^w, \mu_{F_M^m}, \sigma_{F_M^m}, \chi_M^m, \mu_{F_S^w}, \sigma_{F_S^w}, \chi_S^w, \mu_{F_S^m}, \sigma_{F_S^m}, \chi_S^m, \psi\}$, and let $V(\Theta) = (V_1(\Theta), \ldots, V_{18}(\Theta))'$ 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 4 summarizes the estimated parameter values and the data moments. We get close to matching all the moments. We assume a closed economy when calibrating our model. We get the implied real interest rate which is equal to 4.54%. We keep this interest rate fixed in our experiments in sections 7, 7.3 and 8.2, where we instead assume a small open economy.

7 The Impact of Separate, Progressive Taxation on Government Revenues

In this section, we study the effects of tax progressivity on government revenue under the alternative assumptions that married couples are taxed either separately or jointly. In a nutshell, we find that a relatively progressive, individual-based tax system maximizes government tax revenue.

To arrive at this conclusion we first describe the reform from a system that taxes couples jointly to one where individuals are the basic tax unit. We then study the relationship between the average tax rate and tax revenues (i.e., the Laffer curve) for different degrees of tax progressivity, both under joint and individual-based taxation, and then explore the main mechanism underlying our findings. We conduct a normative analysis of the optimal tax system in Section 8.

7.1 Changing to a Separate Tax System

In the benchmark model described in Section 5 married couples are taxed jointly according to the tax function in Equation 1 and thus their after tax income is given by $y_{\text{net}} = \theta_0^M (y_m + y_f)^{1-\theta_1^M}$. We now consider an alternative specification where both individuals within a couple are taxed separately, and thus household net income is given by:

$$y_{\text{net}} = \theta_0^M y_m^{1-\theta_1^M} + \theta_0^M y_f^{1-\theta_1^M} \tag{15}$$

Note that this tax system imposes the restriction that both members of a couple face the same tax progressivity.

7.2 Laffer Curves, Tax Progressivity and Tax Jointness

We now address the main question in this paper, namely how tax progressivity impacts the government's capacity to generate additional tax revenue, depending on the jointness of the tax code. To do so, we trace out simulated Laffer curves, i.e. graphs with the average tax rate on the x-axis and tax revenue on the y-axis. We do this for different levels of tax progressivity, first with a tax system where married couples are taxed jointly and second with a tax system where they are taxed individually. For each of the two tax systems we change the average labor income tax rate and generate Laffer curves by multiplying the tax function parameters θ_0^M and θ_0^S by a constant. This changes the level of tax rates but keeps tax progressivity constant. We vary tax progressivity (and thus generate a new Laffer curve) by scaling the tax parameters θ_1^M and θ_1^S by a constant, $\varpi \in \{0, 1, 2, 3\}$. We keep the other taxes in the economy constant, and in the benchmark we assume that the government spends the additional revenues on government purchases (that are, equivalently, either wasteful or separable in the household utility function). As sensitivity analysis we also display Laffer curves when the extra revenues are returned to households in a lump-sum fashion.

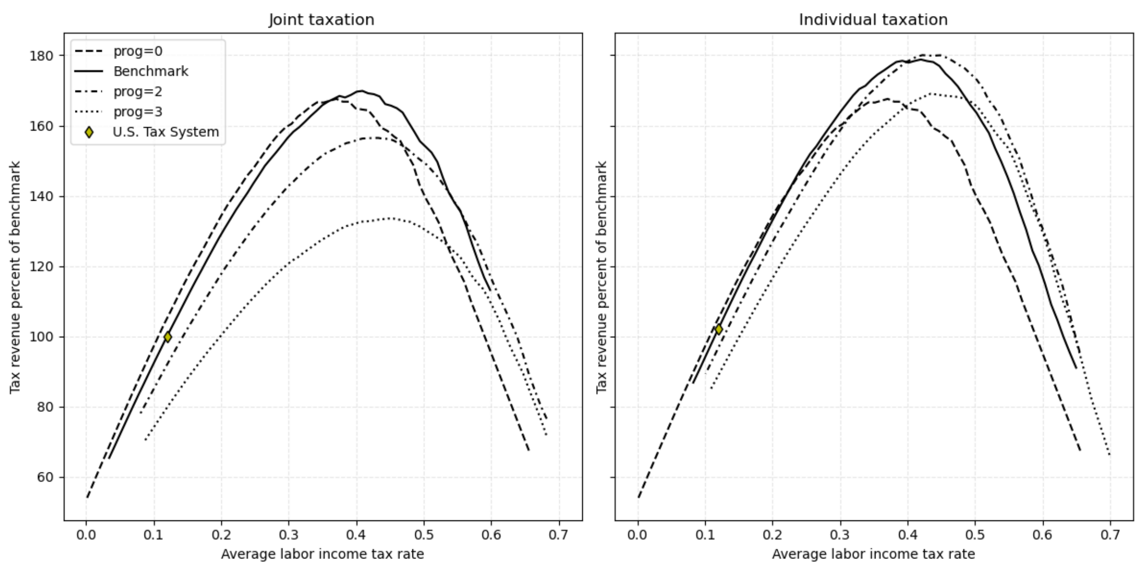

Figure 1: The Impact of Tax Progressivity on Laffer Curves (Assuming New Revenue is Spent on G)

Figure 1 displays Laffer curves for different levels of tax progressivity. We display the average labor income tax rate on the x-axis and total tax revenue, i.e. the sum of labor income taxes, capital taxes and consumption taxes, on the y-axis, and the diamond at a 12% tax rate with benchmark progressivity represents the current U.S. status quo. The left panel represents a tax system where married couples are taxed jointly (as in the current U.S.

system) and the right panel shows the Laffer curves for a tax system where married couples are taxed individually. As can be seen from the figure, the government can raise significantly more revenue with individual taxation, for a given level of tax progressivity.

Furthermore, under joint taxation of married couples an increase in tax progressivity typically leads to less revenue (the exception is for a flat tax at high tax rates). The maximum revenue is attained with a progressivity level of 70% of that of the current U.S. status quo (see Table 5 below), and although the difference is not that large between a flat tax and the current U.S. progressivity level, once progressivity is doubled or tripled revenue falls rather quickly, for a given average tax rate.

With individual-based taxation, in contrast, there is a clearer "progressivity Laffer curve". The revenue maximizing progressivity is 1.6 (see Table 5). We observe that compared to a flat tax, the peak of the Laffer curve is significantly higher with a progressivity equal to the current U.S. tax system and also with a tax system that is twice as progressive as the current U.S. system, and it occurs at an average tax rate that is at least five percentage points larger as well.

Table 5: Maximizing Revenue with Joint and Individual Taxation and Different use of Revenue

Tax System	Progressivity (U.S.=1)	$\bar{\tau}(y)$	Revenue (% of benchmark)
Benchmark (G)	1.0	41.0%	169.9
Joint (G)	0.7	40.0%	171.0
Individual (G)	1.6	41.4%	181.9
Benchmark (lump-sum)	1.0	36.6%	145.9
Joint (lump-sum)	0.0	38.0%	149.2
Individual (lump-sum)	0.7	36.0%	151.4

The table displays the revenue maximizing levels of tax progressivity, the associated average tax rate and tax revenue in % of benchmark tax revenue for joint and individual taxation of married couples, assuming that excess revenue is redistributed lump-sum and assuming it is spent on wasteful government spending (G). For reference, the rows labeled "benchmark" shows the maximum revenue and associated average tax rate for a tax system with the current U.S. system (joint taxation and progressivity equal to 1).

The maximum revenue that can be raised is with individual taxation of married couples and a significantly larger progressivity than the current U.S. tax system ($\varpi = 1.6$) and with an average tax rate of 41%. This maximum revenue equals 182% of the benchmark tax revenue and is 12 percentage points higher than the peak of the Laffer curve under the current U.S. tax structure, see again Table 5. Contrast this with a joint taxation system where maximal revenues are attained at about the same average tax rate of 40%, but it requires a lower tax progressivity $\varpi = 0.7$) and it only raises 71% (rather than 82%) of additional revenues. This demonstrates the main point of the paper, that a *combination* of individual-based and progressive taxation is beneficial for the government's ability to generate additional tax revenues.

That the peak of the labor income tax Laffer curve is located at an average tax rate of 41% may at first seem a bit low, compared to other papers in the literature. For example, Holter, Krueger, and Stepanchuk (2019) find that the peak of the Laffer curve is at about 58%. There are two reasons for why the peak is located at this lower level. First, we model an extensive margin of labor supply and human capital accumulation for both women and men.[18] Second, we keep other tax rates as well as the social security system constant when increasing the labor income tax. Because these other taxes are already relatively high, there is more limited room for generating more revenue through the labor income tax system alone.

Figure 2 displays Laffer curves for different levels of tax progressivity, under the assumption that new tax revenue is distributed lump-sum to households. Again, the left panel is for a tax system where married couples are taxed jointly (like in the current U.S. system) and the right panel is for a tax system where married couples are taxed individually. As can be seen from the figure, our broad conclusions are qualitatively unaltered from the case where government spending adjusts to a change in tax revenue. Again, the government raises more revenue with individual taxation, for a given level of tax progressivity. With joint taxation of married couples an increase in tax progressivity leads to less revenue. With individual-based

[18] Several papers have considered this channel only for women, see e.g. Guner, Kaygusuz, and Ventura (2012) and Holter, Krueger, and Stepanchuk (2019). The finding that the peak of the Laffer curve is not the highest with a flat tax reverses a finding in Holter, Krueger, and Stepanchuk (2019), and also stems from the fact that this paper did not consider the endogenous accumulation of experience and the extensive margin of labor supply for *men* who were assumed to always work.

taxation there still is somewhat of a “progressivity Laffer curve”, at least for higher average tax levels, but a flat tax is not too far from revenue maximizing. Overall, the maximum revenue that can be raised with lump-sum redistribution of revenue is with separate taxation of married couples, a level of progressivity that is about 30% lower than in the current U.S. tax system ($\varpi = 0.7$), and an average tax rate of 36%. This maximum revenue equals 151% of the benchmark tax revenue and is six percentage points higher than the peak of the Laffer curve with the current U.S. tax structure (see again Table 5).

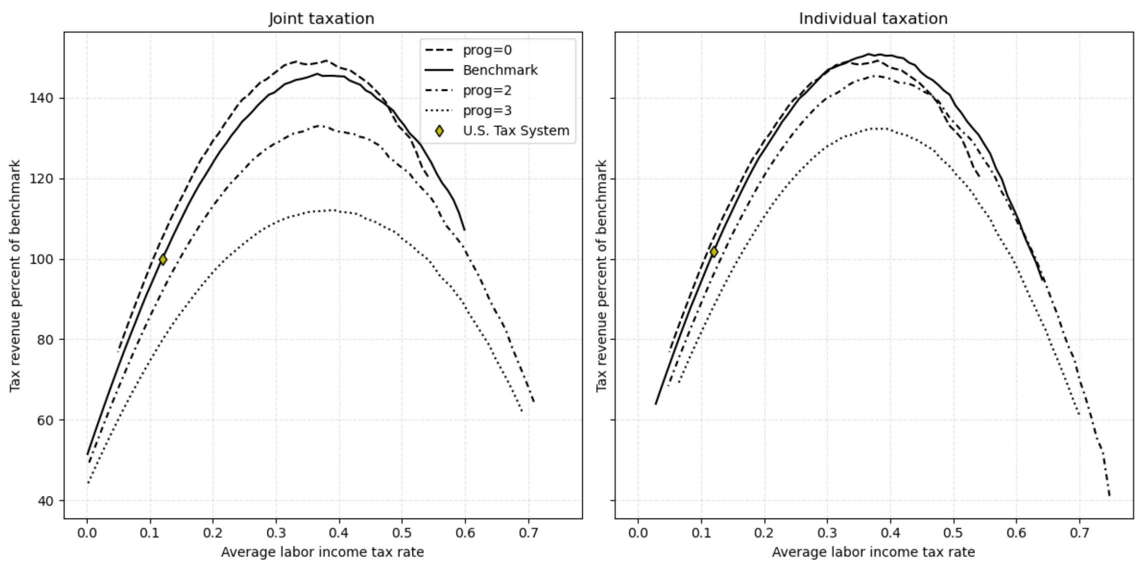

Figure 2: The Impact of Tax Progressivity on Laffer Curves (Assuming New Revenue is Redistributed as a Lump-sum)

7.3 Tax Jointness, Tax Progressivity and Labor Supply: Exploring the Mechanism

Why are progressive taxes good for government revenue when the tax unit is the individual, but not when it is the household? To shed light on the key mechanism we fix the level of taxes and vary its progressivity. Concretely, we perform the following experiment. We first multiply the tax progressivity parameters, θ_1^M and θ_1^S by a constant, $\varpi \in 0, 1, 2$. We then multiply the parameters governing the *level* of taxes, θ_0^M and θ_0^S, by a constant to obtain the same average tax rate (measured as labor income tax revenue divided by labor income) of 12% as in the benchmark tax system. To balance the government budget, in we focus in Table 6 on the case where government spending adjust, but also document results for the case in which lump-sum transfers change to achieve budget balance in Table 13 of the Appendix.

Table 6: Selected Statistics for Joint and Separate Taxation and Different Tax Progressivity

	Joint Taxation			Individual Taxation		
	Flat tax	US Prog.	2×US Prog.	Flat Tax	US Prog.	2×US Prog.
Tax Revenue	104.97	100.00	91.98	104.97	102.16	96.81
Aggregate Labor Supply	101.53	100.00	93.54	101.53	105.79	105.04
Single Male Labor Supply	93.19	100.00	101.52	93.19	98.06	96.80
Married Male Labor Supply	103.69	100.00	87.49	103.69	106.09	102.62
Single Female Labor Supply	91.70	100.00	104.53	91.70	98.34	102.08
Married Female Labor Supply	112.44	100.00	87.99	112.44	117.24	117.72
Single Male LFP	91.43	100.00	104.28	91.43	99.53	102.87
Married Male LFP	99.20	100.00	92.87	99.20	107.12	110.97
Single Female LFP	85.97	100.00	113.68	85.97	98.91	112.26
Married Female LFP	103.93	100.00	95.00	103.93	116.85	127.71
Single Male Intensive Margin	101.93	100.00	97.36	101.93	98.52	94.10
Married Male Intensive Margin	104.52	100.00	94.20	104.52	99.03	92.48
Single Female Intensive Margin	106.66	100.00	91.94	106.66	99.42	90.93
Married Female Intensive Margin	108.18	100.00	92.62	108.18	100.33	92.17

The table displays selected model statistics with individual and joint taxation at the benchmark average tax rate of 12%. All numbers are in % of the U.S. benchmark. Additional tax revenues are used for government spending, G.

We observe that at this relatively low average tax rate, a flat tax is revenue maximizing both for joint and individual taxation[19]. In section 7.2 we saw that at higher tax rates this is typically not the case when individuals are the tax unit. What is clear from Table 6 is that the output and revenue cost of increasing tax progressivity is much smaller for individual taxation. For a joint tax system, a flat tax generates 5 percentage points more revenues than the benchmark and a tax system that is twice as progressive as the current U.S. system generates 8 percentage points less than the benchmark. With individual taxation a flat tax also generates 5 percentage points more revenue of benchmark revenue but now with a tax system that is twice as progressive as the current U.S. system only 3.2 percentage points of benchmark revenue is lost, at an average tax rate of 12%.

Both with joint and with individual taxation higher tax progressivity reduces the labor supply of those who already work (the intensive margin). This is due to higher marginal

[19] With a flat tax it does not matter whether couples are taxed jointly or individually.

tax rates distorting the labor choice in the agents' first order conditions (see e.g., Holter, Krueger, and Stepanchuk (2019), and many other papers in the literature that quantify this point). The lower cost of progressive taxation with an individual-based tax system is due to the very different effects on the labor force participation (LFP) of married couples. With joint taxation the LFP of married women and men falls with increasing tax progressivity. With individual-based taxation the LFP of these couples, in contrast, is strongly increasing in tax progressivity. With a flat tax the LFP of married women is 103.9% of benchmark LFP and this increases to 127.7% of benchmark LFP when the tax system is twice as progressive as the current U.S. system. The pattern for married men is similar, although the elasticity of LFP with respect to θ_1 is smaller.

The elasticity of labor force participation of married women and men with respect to tax progressivity in the model is large and of the same magnitudes as those we estimated empirically in Table 1. Making the tax code more progressive lowers the average tax rate on low-income individuals, and this encourages participation. At the same time there is a positive income effect on the LFP of the secondary earner in a couple from a higher average tax rate on the primary earner. Since more women are secondary earners (since they have on average lower earnings potential), it is natural that the effect is stronger for married women than for married men.

Table 6 also shows that LFP is increasing in tax progressivity for single individuals. For these agents the effect of a more progressive tax system is to also lower the average tax rate on low-earners, those who are often close to the participation margin. There is no income effect from a higher tax on the primary earner in the family, though. However, there is a lifetime income effect from progressive taxation on labor supply due to the idiosyncratic productivity shocks. An individual will optimally choose to work and save when enjoying high labor productivity. With larger tax progressivity, take-home pay in these states of the world declines, reducing lifetime earnings and potentially encouraging participation also in low(er) productivity states in which, with lower progressivity of the tax code, the individual

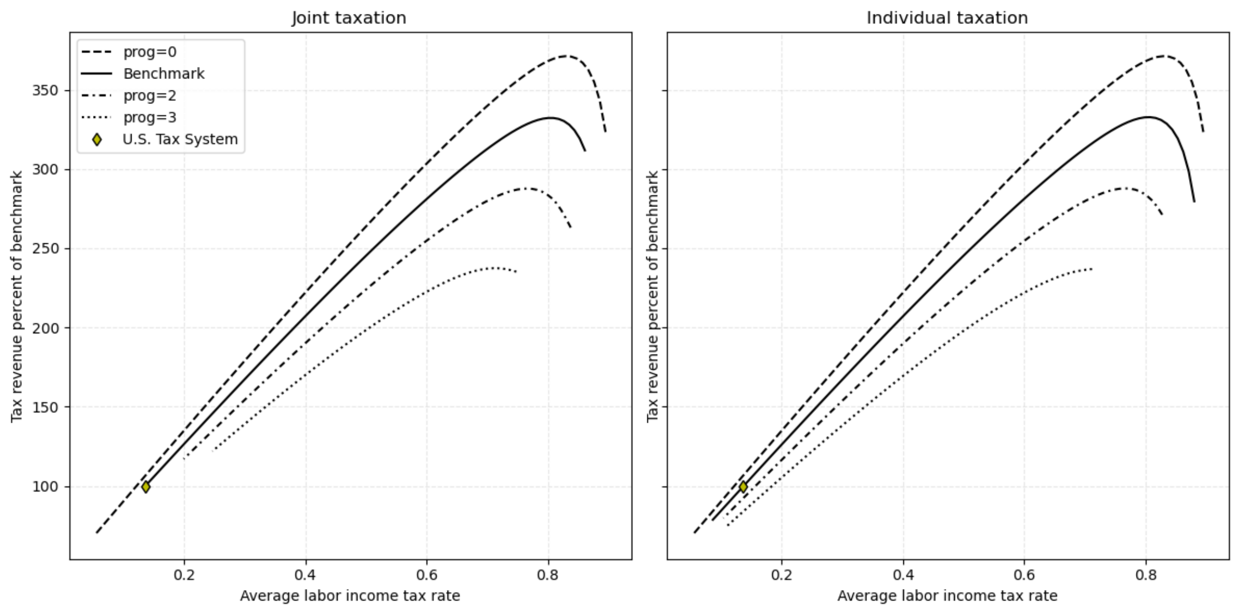

Figure 3: Laffer Curves in a Model with Only Intensive Margin (Assuming Extra Tax Revenue is Spent on G)

would have decided to stay at home.

To demonstrate the importance of the extensive margin for our results for the Laffer curve, Figure 3 displays this curve obtained in a version of the model where the participation margin of labor supply is removed, so that all individuals work, but can still choose their hours of work along the intensive margin (again under the assumption that the additional tax revenues are spent on the government-supplied good G). The key observation is that in this version of our model there is little difference between the Laffer curves that we obtain for joint and individual taxation of married couples. Higher tax progressivity unambiguously lowers the Laffer curves with both types of taxation.[20]

Figure 4, in contrast, plots the Laffer curves for a version of the model with only an extensive margin of labor supply. We assume that those who choose to work supply hours equal to the corresponding average values for their demographic group in the benchmark model (where we differentiate between married and single men and women). In this case, in contrast to our results with only intensive margin of labor supply, the Laffer curves

[20]Figure 12 in the Appendix shows that similar results are obtained when all additional tax revenues are redistributed lump-sum. The Laffer curves are essentially the same with joint and individual-based taxation of families, and they are uniformly lower with higher tax progressivity.

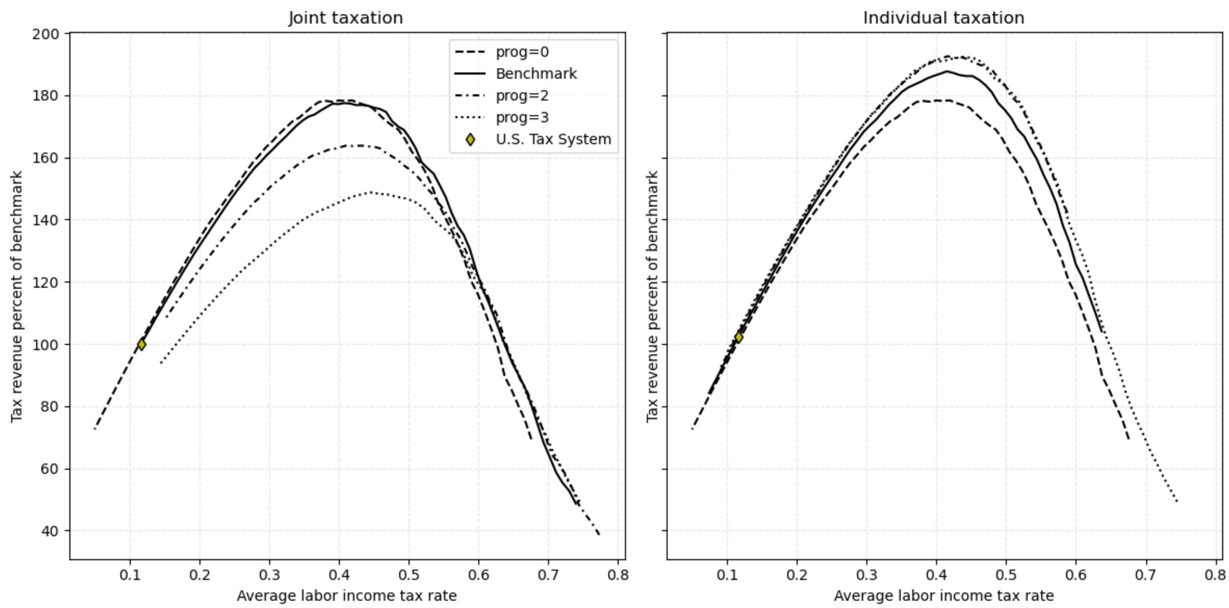

Figure 4: Laffer Curves in a Model with Only Extensive Margin (Assuming Extra Tax Revenue is Spent on G)

with individual-based family taxes differ drastically from those that we obtain with joint taxation of families. When individuals make only participation choices, the Laffer curves are no longer uniformly decreasing in tax progressivity if families are taxed individually. The highest Laffer curve is obtained for a level of progressivity that is three times as high as in the U.S. benchmark calibration.

With joint taxation, it tends to be the case that Laffer curves are decreasing in tax progressivity. In addition, all Laffer curves with individual taxation of families lie noticeably above those with joint family taxation. This clearly demonstrates that the extensive margin of labor supply is a key component in our model that leads to the results we documented in section 7.

8 Optimal Taxation of Families: A Separate, Progressive Tax System

We now search for the optimal tax system in the same way as we draw the Laffer curves. We keep the relative progressivity and tax level of married and singles at the benchmark level. We then change the level and progressivity of the tax system by multiplying θ_0^M and θ_0^S by the same constant and θ_1^M and θ_1^S by the same constant. We do this under the assumption that the extra tax revenue is used for enlarging the lump-sum transfer, to avoid having to take a stance on the extent to which government spending yields utility enhancing public goods or services. We first explore the tax system that maximizes steady state welfare, and then, in Subsection 8.2 argue that the welfare gains are robust to an explicit modeling of the economic transition induced by an unanticipated reform of the tax code towards the steady state optimum.

8.1 *The Optimal Steady State Tax System*

Table 7: Maximizing Welfare with Joint and Individual Taxation

Tax System	Optimal Progressivity (U.S.=1)	Optimal $\bar{\tau}(y)$	Welfare Gain (% of benchmark c)
Joint	0.0	9.7%	2.2%
Individual	0.8	6.8%	4.9%

The table displays the optimal levels of tax progressivity, the optimal average tax rate and the average welfare gain in % of benchmark consumption with joint and individual taxation of married couples. Government spending adjusts to guarantee budget balance of the government.

We search for maximum steady state welfare, both for a tax system where married couples are taxed jointly and for a tax system where married couples are taxed separately. Individual taxation in general gives higher welfare for similar average tax rates. The optimal tax system is about 20% less progressive than the current U.S. system with an average tax rate of about 6.8%. The welfare gain in consumption equivalents, assuming a utilitarian social welfare function, can be calculated according to Appendix A.4. The welfare gain with the optimal tax system is about 4.9%. This is a substantial welfare gain given that we are only reforming

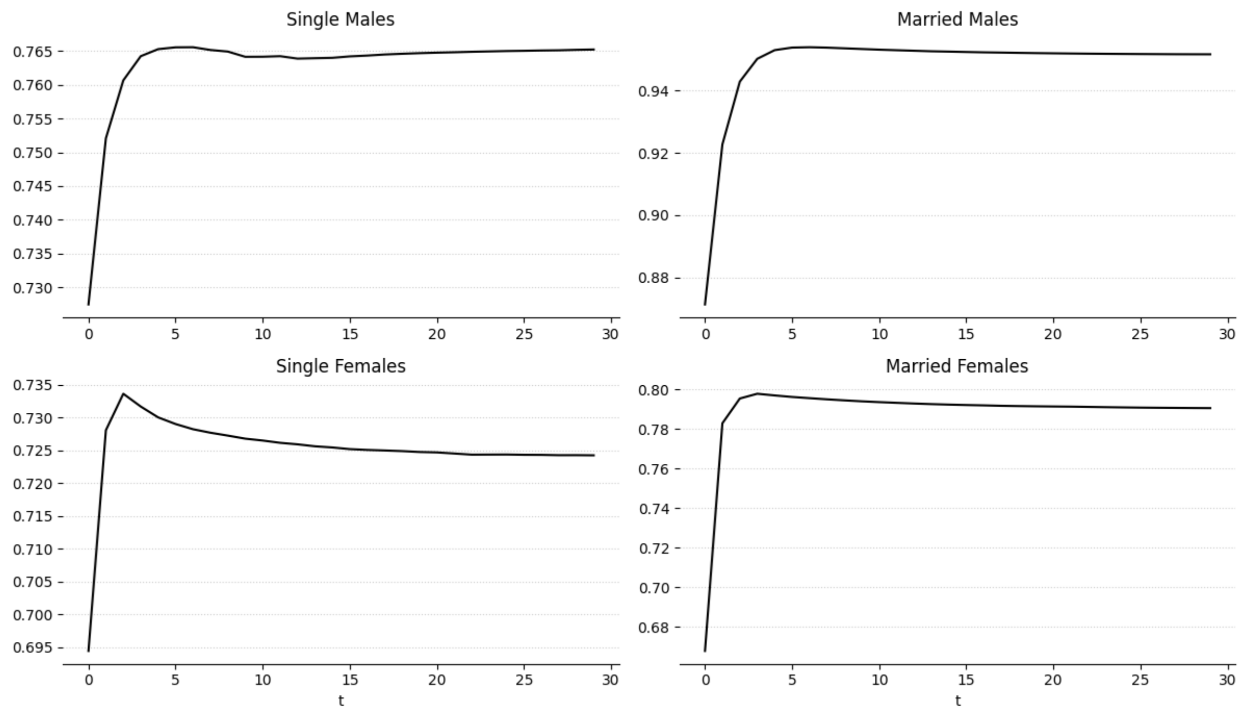

Figure 5: Labor Force Participation Along the Transition Path

the labor tax system while keeping other taxes as well as the social security system fixed. With joint taxation of married couples, a flat tax is socially optimal. A flat tax of about 9.7% leads to a welfare gain of 2.2%.

8.2 Transition to the Optimal Steady State

In this section we study the transition path induced by a one-time policy reform that implements an unexpected change from the U.S. benchmark with joint taxation of families to the optimal tax system with individual-based taxation of families. Starting from the calibrated benchmark steady state at $t = 0$, at $t = 1$ the government permanently changes tax progressivity and the tax level to those that maximize steady-state welfare, as reported in table 7. In every period along the transition government transfers adjust so that the government balances its budget.

Figure 5 displays the labor force participation rates of single as well as married women and men along the transition path, whereas Figure 6 shows how aggregate hours, output, consumption and assets held by the private sector evolve over time. Finally Figure 7 depicts

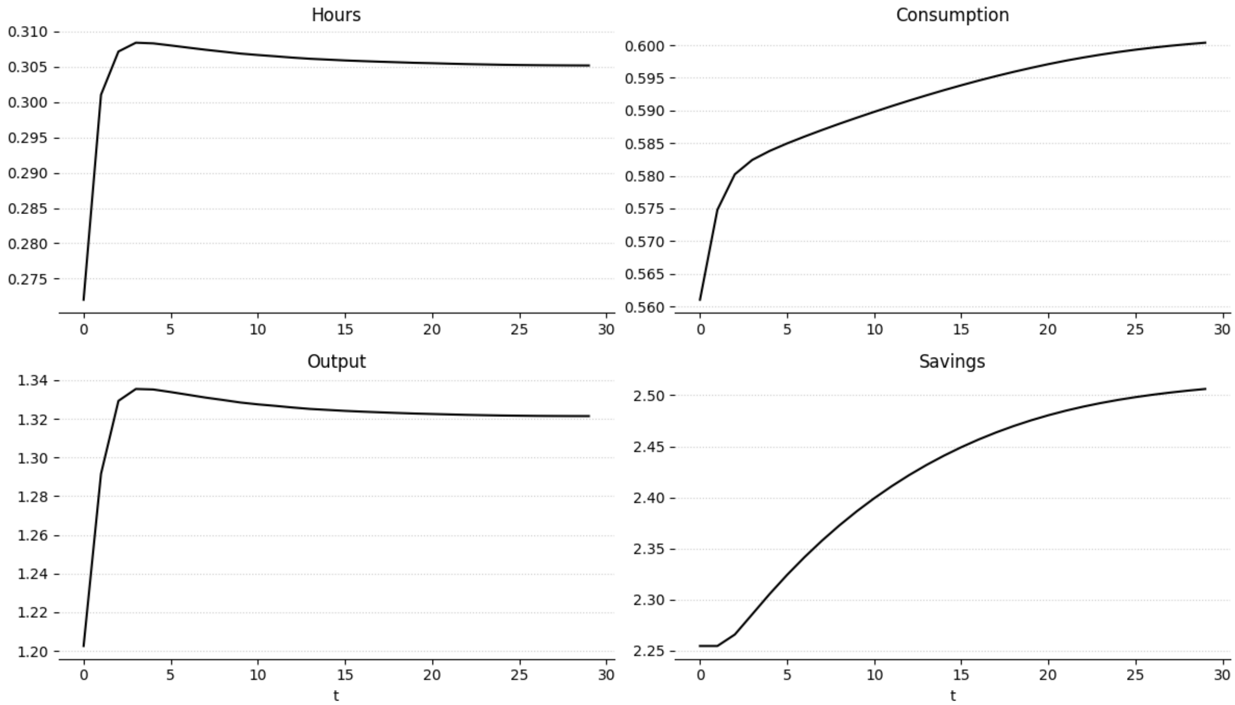

Figure 6: Hours Worked, Consumption, Output and Savings Along the Transition Path

the welfare consequences (measured in terms of consumption equivalent variation) from the reform for different generations and time periods, both for newborn individuals (based on expected lifetime utility) as well as for a utilitarian aggregate of lifetime utilities of all individuals currently alive.

Both participation rates as well as aggregate hours and output jump up upon impact of the tax reform, and show a hump-shaped evolution along the transition. Initially, the tax reform leads to a significant decline in government transfers, and the associated wealth effect encourages labor supply, both along the extensive and the extensive margin, boosting output in return. As the economy accumulates more experience, and collects higher taxes, transfers recover and this effect subsides along the transition, with participation and hours falling off their peaks, but still remaining at a higher level than before the tax reform. Private asset accumulation and consumption rises throughout the transition towards the new steady state.

Finally, we observe that most of the welfare gains for a newborn individual are realized almost immediately after the change in tax policy. There is also an initial jump in the

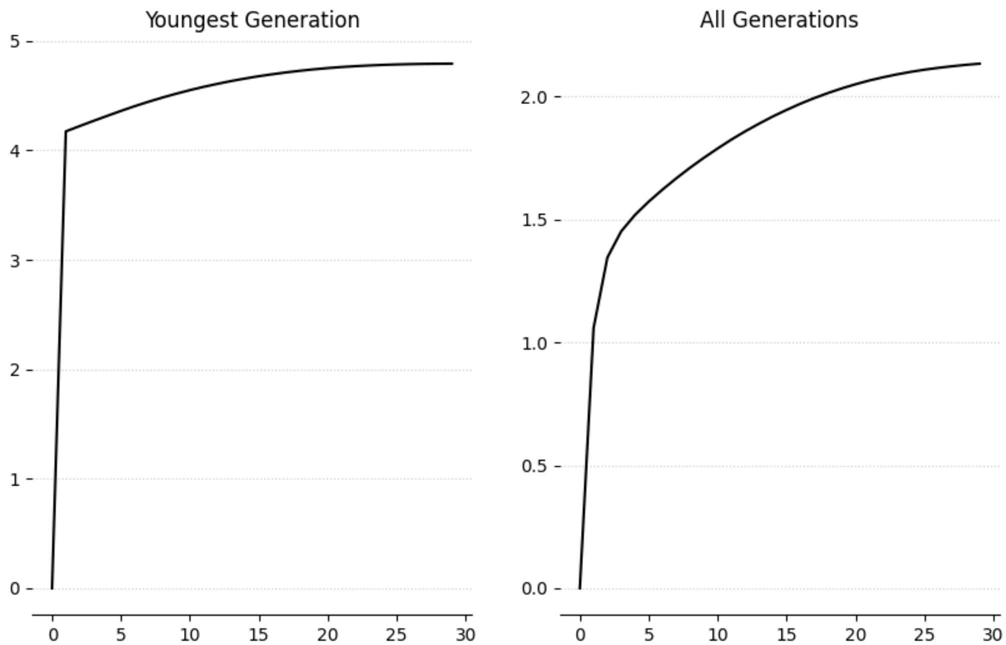

Figure 7: Welfare in Consumption Equivalent Units Along the Transition Path

average welfare of everyone in the population of about 1.1%. This means that a majority of the population will likely support the reform to a policy that maximizes steady state welfare. The optimal policy with individual taxation and a relatively low average tax rate is good for currently working generations and leads to an immediate jump in labor force participation. And because of the PAYGO social security system this reform is also welfare improving for older generations that receive a higher pension.

9 Conclusion

In this paper we show that the U.S. could gain, both in terms of revenue and welfare, by changing to a relatively progressive tax system where married couples are taxed separately. We demonstrate, in cross-country micro data and in a heterogeneous agent dynamic macro model, that a separate, progressive tax system encourages labor force participation. Thus, it leads to a higher level of human capital in the economy, more fiscal space and higher welfare.

Our paper seeks to inform recent policy reform debates concerning the taxation of couples, such as the discussion of the "Ehegattensplitting" in Germany. We argue that reforms towards separate taxation do not only encourage female labor force participation and thus a more equal distribution of incomes within couples, but when combined with more tax progressivity, also more participation of single women towards the bottom of the (potential) earnings distribution. These distributional benefits from increased participation are combined, especially in the long run, with a higher aggregate distribution of human capital and bigger capacity of the government to raise tax revenue. Thus, up to a point, there need not be a trade-off between aggregate efficiency and redistributional concerns when raising the progressivity of the tax code, as long as the tax unit is the individual rather than the household.

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A Appendix

A.1 Definition of a Recursive Competitive Equilibrium

We model a small open economy where the factor prices are given exogenously. We call an equilibrium of the growth-adjusted small open economy a stationary equilibrium.[21] Let $\sigma^M = (k^z, e^m, e^w, u^m, u^w, a^m, a^w, F^{Mm}, F^{Mw}, j)$ be a vector of state variables for a married household, and similarly let $\sigma^S = (k^z, e, u, a, \iota, F_S^\iota, j)$ be a vector of state variables for a single household. Let $\Phi^M(\sigma^M)$ be the measure of married households with the corresponding characteristics, and let $\Phi^S(\sigma^S)$ be the measure of single households. We now define such a stationary recursive competitive equilibrium as follows:

Definition:

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

2. Given the factor prices, firms choose capital and labor input so that the following optimality conditions are satisfied:

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

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

3. The government budget balances:

$$g^z\left(2\int d\Phi^M + \int d\Phi^S\right) + G^z + \nu^z\left(\int_{j<65}\left(\mathbb{1}_{[n^m=0]} + \mathbb{1}_{[n^w=0]}\right)d\Phi^M + \int_{j<65}\mathbb{1}_{[n^\iota=0]}d\Phi^S\right)$$
$$= \int\left(\tau_k r(k^z+\Gamma^z) + \tau_c c^z + \tau_l^M\left(\frac{n^m w^{mz} + n^w w^{wz}}{1+\tilde{\tau}_{ss}}\right)\right)d\Phi^M$$
$$+ \int\left(\tau_k r(k^z+\Gamma^z) + \tau_c c^z + \tau_l^S\left(\frac{nw^z}{1+\tilde{\tau}_{ss}}\right)\right)d\Phi^S$$

4. The social security system balances:

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

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

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

6. The labor market clears:

$$L^z = \frac{1}{w^z}\int\left(n^m\widetilde{w}^{zm} + n^w\widetilde{w}^{zf}\right)d\Phi^M + \int\left(n\widetilde{w}^z\right)d\Phi^S$$

   where $\widetilde{w^z} = w(a,e,u,\iota)$ are the individual wages that depend both on individual's characteristics and the market wages per efficiency units of labor, as described in section 5.3.

Note that because we assume a small open economy, the capital market does not have to clear.

A.2 Recursive Formulation of the Household Problem

Married households of age j_0 in period t maximize

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

subject to the sequence of budget constraints:

$$c_{t,j}(1+\tau_c)+k_{t+1,j+1} = \begin{cases} (k_{t,j}+\Gamma_t)\left(1+r_t(1-\tau_k)\right)+g_t+W_{t,j}^L+\nu_t\left(\mathbb{1}_{[n^m=0]}+\mathbb{1}_{[n^w=0]}\right), & \text{if } j<65 \\ (k_{t,j}+\Gamma_t)\left(1+r_t(1-\tau_k)\right)/\omega(j-1)+g_t+\Psi_t, & \text{if } j\geq 65 \end{cases}$$

where W^L is the household labor income:

$$W_{t,j}^L = \left(W_{t,j}^{L,m}+W_{t,j}^{L,w}\right)\left(1-\tau_{ss}-\tau_l\left(W_{t,j}^{L,m}+W_{t,j}^{L,w}\right)\right),$$

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

$$W_{t,j}^{L,\iota} = \frac{n_{t,j}^{\iota} w_t e^{a^{\iota}+\gamma_0^{\iota}+\gamma_1^{\iota}e_{t,j}^{\iota}+\gamma_2^{\iota}(e_{t,j}^{\iota})^2+\gamma_3^{\iota}(e_{t,j}^{\iota})^3+u_{t,j}^{\iota}}}{1+\tilde{\tau}_{ss}}, \quad \iota = m, w$$

which depend on the individual's fixed type a^{ι}, experience $e_{t,j}^{\iota}$ and productivity shock $u_{t,j}^{i}$.

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, $g^z = g_t/Z_t$, $\Psi^z = \Psi_t/Z_t$, $w^z = w_t/Z_t$ and r_t must remain constant. We define $c_j^z = c_{t,j}/Z_t$ and $k_j^z = k_{t,j}/Z_t$ and conjecture that they do not depend on the calendar time t either. This allows us to rewrite the budget constraints as:

$$c_j^z(1+\tau_c)+k_{j+1}^z(1+\mu) = \begin{cases} k_j^z\left(1+r(1-\tau_k)\right)+g^z+W_j^L+\nu^z\left(\mathbb{1}_{[n^m=0]}+\mathbb{1}_{[n^w=0]}\right), & \text{if } j<65 \\ k_j^z\left(1+r(1-\tau_k)\right)/\omega(j-1)+g^z+\Psi^z, & \text{if } j\geq 65 \end{cases}$$

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. A similar transformation can be applied for the single households.

A.3 Tax Function

Given the tax function

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

we employ, the after tax income 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

$$1 - \frac{1 - T'(y_2)}{1 - T'(y_1)} = 1 - \left(\frac{y_2}{y_1}\right)^{-\theta_1} = 1 - \frac{1 - \tau(y_2)}{1 - \tau(y_1)} \tag{16}$$

and therefore independent of the scaling parameter θ_0 [22]. 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[23] 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.4 Cardinal Measure of Welfare Gains from Policy Reform

Consider a household with discount factor β that has unconditional probability, at birth (i.e. age 1 in our model) of survival until age j of $\Omega_j \in [0, 1]$ which is weakly decreasing in age j. The household has period utility function that is logarithmic in consumption and separable in everything else. Let $v(s)$ denote expected lifetime utility of a household at economic age 0 born with idiosyncratic state s and by

$$W = \int v(s) d\Phi(s) \tag{17}$$

utilitarian social welfare (or expected lifetime utility before one's type is realized). Note that $\int d\Phi(s) = 1$, that is, the initial distribution over types integrates to 1.

Claim A.1. *Fix an initial state s and an allocation of consumption and labor. Denote by $v(s)$ the associated expected lifetime utility. Now scale consumption up by a factor $1 + g(s)$ in each period of life, in all states of the world, leaving the labor allocation unchanged, and denote the resulting expected lifetime utility from that allocation by $v(s; g)$. Then*

$$v(s; g) = v(s) + \left(\sum_{j=0}^{J} \beta^j \Omega_j \right) \log(1 + g(s)) \tag{18}$$

[22]It should be noted that the last inequality only holds in the absence of additional lump-sum transfers.

[23]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.

Similarly, since Φ integrates to 1 and all individuals have the same discount factor and survival probabilities, utilitarian social welfare satisfies

$$W(g) = W + \left(\sum_{j=0}^{J} \beta^j \Omega_j\right) \log(1+g) \tag{19}$$

Finally, denote by $v(s;\tau)$ lifetime utility under an alternative tax system, with $W(\tau)$ being defined accordingly. Finally, let $g(s;\tau)$ and $g(\tau)$ denote the CEV (permanent percentage increase in consumption) needed to make an individual s indifferent between the benchmark tax system and the alternative tax system τ.

Corollary A.2. *The numbers $g(s;\tau)$ and $g(\tau)$ satisfy*

$$v(s;g(s;\tau)) = v(s;\tau) \tag{20}$$

$$W(g(\tau)) = W(\tau) \tag{21}$$

Thus, given knowledge of the value functions we can compute them (expressed in terms of percents)

$$g(s;\tau) = 100 * \left[\exp\left(\frac{v(s;\tau)-v(s)}{\sum_{j=0}^{J}\beta^j\Omega_j}\right) - 1\right] \tag{22}$$

$$g(\tau) = 100 * \left[\exp\left(\frac{W(\tau)-W}{\sum_{j=0}^{J}\beta^j\Omega_j}\right) - 1\right] \tag{23}$$

Obviously, since $g(\tau)$ is a monotonically increasing function of $W(\tau)$, maximizing $W(\tau)$ is equivalent to maximizing $g(\tau)$ but the latter gives a cardinal measure of the welfare gains. The way it is expressed, the units are "percent of permanent consumption". The number $g(s;\tau)$ is interpreted analogously, but conditions on s and thus takes an ex interim perspective. Note that since the value function is not linear, $g(\tau)$ is not the population-weighted sum of the $g(s;\tau)$.

A.5 Estimation of Returns to Experience and Shock Processes From the PSID

We take the log of equation 9 and estimate a log(wage) equation using data from the non-poverty sample of the PSID 1968-1997. Equation 10 is estimated using the residuals from 9.

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 years of labor market experience, e, as well as dummies for the year of observation, D:

$$log(w_{it}) = \phi_i(constant + D_t'\zeta + \gamma_1 e_{it} + \gamma_2 e_{it}^2 + \gamma_3 e_{it}^3 + u_{it}) \tag{24}$$

Labor market experience is the only observable determinants of wages in the model apart from gender. The probability of participation (or selection equation) depends on various demographic characteristics, Z:

$$\Phi(participation) = \Phi(Z_{it}'\xi + \upsilon_{it}) \tag{25}$$

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 σ_{α^ι} we obtain the residuals $u_i t$ and use them to estimate the below equation by fixed effects estimation:

$$u_{it} = \alpha_i + \rho u_{it-1} + \epsilon_{it} \tag{26}$$

The parameters can be found in Table 3.

A.6 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:

$$M_n = (1-\psi)\varsigma + \psi a \tag{27}$$

where $\psi \in [0,1]$. 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, ψ, thus determines the degree of assortative matching, based on ability. If $\psi = 0$, then matching is random and if $\psi = 1$ spouses will have identical ability.

Singles have rational expectations with respect to potential partners. The matching function in Equation 27 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:

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

A.7 Data Description

Below we describe the data used in the empirical exercise in Section 3.

A.7.1 Tax Data from the OECD Tax-Benefit Web Calculator

As explained in section 3, we obtain the data on personal income taxation from the OECD Tax-Benefit web calculator available at https://taxben.oecd.org/index.htm[24]. We use the online tax-benefit calculator to compute the tax liabilities and benefits "by Earnings levels" in each country and each year in our sample. For singles, we collect the data for gross earnings between 0 and 200 percent of the average earnings in a given year and country, in equal steps of 2 percent, while for married couples, we collect the data for all possible combinations of the earnings of the two spouses between 0 and 200 percent of the average earnings in the corresponding year and country. Net after-tax earnings are computed as:

$$Y_{\text{net}} = Y_{\text{gross}} + SA + HB + FB + IW - IT - SC$$

where SA is "social assistance", HB is "housing benefits", FB is "family benefits", IW is "in-work benefits", IT is the "income tax" and SC is "social security contributions"[25]. Central, state and local government income taxes are included[26]. The annual housing costs

[24] The methodology used by OECD Tax-Benefit calculator is described in detail at https://www.oecd.org/els/soc/OECD-Tax-Benefit-model-Methodology.pdf

[25] Differently from when we obtain tax data from the OECD, when we obtain U.S. tax data from the NBER TAX SIM, to be used in the calibrated benchmark model, we do not include payroll taxes because the model contains a balanced social security system that is separate from the tax system and the government budget.

[26] The rates applying in the state of Michigan for the United States

are assumed to be equal to 20 percent of the average wage income.

For married couples, we collect the data for the families with 0, 1, 2 and 3 children. In the families with one child, the age of the child is assumed to be 4. In the families with two children, they are assumed to be of 4 and 6 years of age. Finally, in the families with three children, they are assumed to be of 4, 6 and 8 years of age.

A.7.2 The European Labor Force Survey

To compute employment rates in European countries in our sample, we use the EU Labour Force Survey Database. Restricting our data to the individuals between 16 and 64 years of age, and excluding those in compulsory military service, we compute the employment rate as the share of individuals for whom the variable `ILOSTAT` takes on the value of 1 ("employed"). To compute the employment rates in the US, we use the CPS data. For the individuals between 16 and 64 years of age who are not in the armed forces, we classify them as employed if the value of `empstat` variable is equal to either "at work" or "has job, not at work last week".

A.8 Estimating Tax Functions

To obtain the estimates for the parameters in our tax functions, we minimize the distance between the net (after-tax) income for each type of household in the data and the one implied by our estimated tax function (expressed in terms of the average income in a given country and year), for each value of the earnings between 20 percent and 200 percent of the average earnings for the single households, and each combination of the earnings of the two spouses in this range for the married households with 0, 1, 2 and 3 children. We perform the minimization using a combination of the global grid search and local search (using the `scipy` library). Our estimates of the tax functions for married couples are a weighted average of the estimates for the families with 0, 1, 2 and 3 children, using the shares of these families in the US as the weights.

Table 8: Average Tax Function Parameters by Country

Country	φ	$(1-\theta_0^M)$	θ_1^M	$(1-\theta_0^S)$	θ_1^S
Austria	0.803	0.260	0.231	0.307	0.285
Belgium	0.633	0.305	0.334	0.404	0.332
Switzerland	0.000	0.224	0.104	0.259	0.201
Germany	0.000	0.252	0.228	0.387	0.288
Denmark	1.179	0.383	0.273	0.344	0.397
Spain	1.133	0.202	0.151	0.200	0.143
Finland	1.137	0.304	0.254	0.281	0.363
France	0.076	0.163	0.174	0.262	0.257
UK	1.075	0.256	0.219	0.226	0.270
Greece	1.285	0.274	0.157	0.243	0.186
Ireland	0.282	0.069	0.282	0.206	0.331
Iceland	0.672	0.266	0.216	0.290	0.273
Italy	1.378	0.366	0.269	0.314	0.244
Netherlands	1.217	0.370	0.240	0.332	0.369
Portugal	0.011	0.119	0.189	0.246	0.158
Sweden	1.414	0.337	0.217	0.285	0.288
US	0.028	0.142	0.163	0.251	0.156

To illustrate how the tax functions that we estimate fit the data, figures 8 and 9 show the average tax rates faced by married households with no children in the US and Finland in 2001, defined as:

$$\tau(x_1 + x_2) = \frac{T(x_1, x_2)}{x_1 + x_2}$$

The dashed lines show the ones that we compute from data that we have obtained from the OECD Tax-benefit calculator, while the solid lines show the ones implied by our estimated tax functions. Notice that we did not aim to minimize the distance in terms of these average tax rates when estimating our parametric tax functions (instead, we minimized the distance in terms of the net after-tax income). Nevertheless, our parametric tax functions appear to fit the data along this dimension reasonably well.

Important for a family's choice of having one or two earners is the net added income from the second earner. Figures 10 and 11 show the average tax rate *on the second earner* in a married family with no children, in the US and Finland in 2001, implied by our estimated tax function (as a function of the earnings of both earners). We define the average tax rate

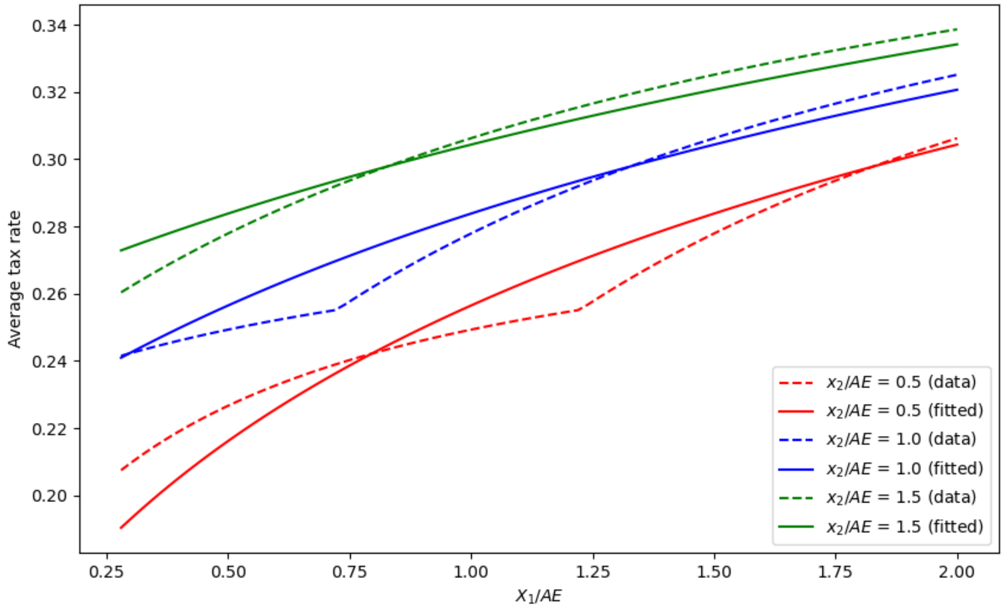

Figure 8: Household average tax rate, US 2001, families without children

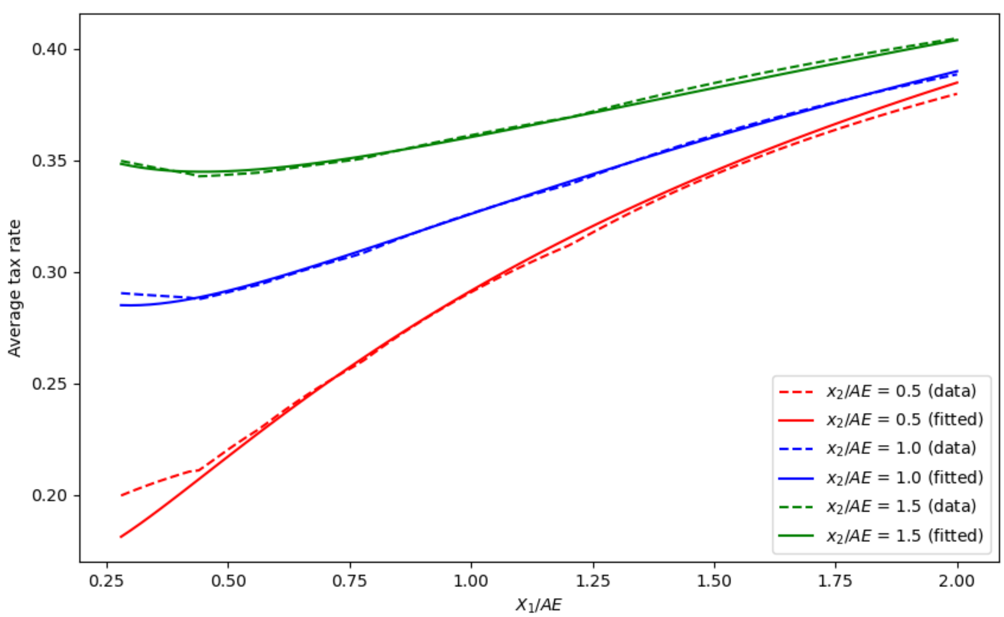

Figure 9: Household average tax rate, Finland 2001, families without children

on the second earner's income, keeping the first earner's income constant, as follows:

$$\begin{aligned}\tau(y_2 \mid y_1) &= 1 - \frac{y_{net}(y_1, y_2) - y_{net}(y_1, 0)}{y_1} \\ &= 1 - \frac{\theta_0 \left((y_1)^\rho + (y_2)^\rho\right)^{\frac{1-\theta_1}{\rho}}}{y_2} - \frac{\theta_0 y_1^{1-\theta_1}}{y_2}\end{aligned}$$

Figure 10 shows that in the US, where our estimates suggest that families are taxed jointly, this average tax rate on the earnings of the secondary earner depends positively on the earnings of both spouses. In contrast to that, in Finland, where our estimates suggest that families are taxed individually (φ is close to 1), this average tax rate essentially does not change with the earnings of the first earner (y_1).

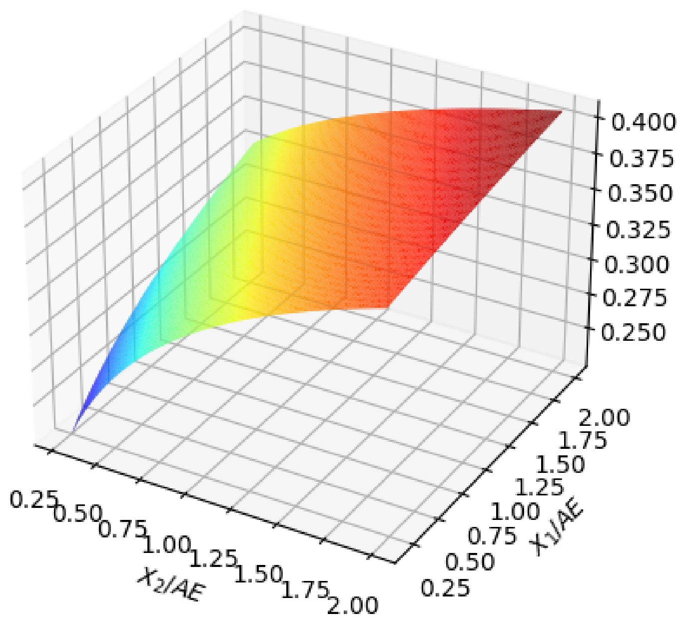

Figure 10: Average tax rate on the second earner, US 2001, families without children

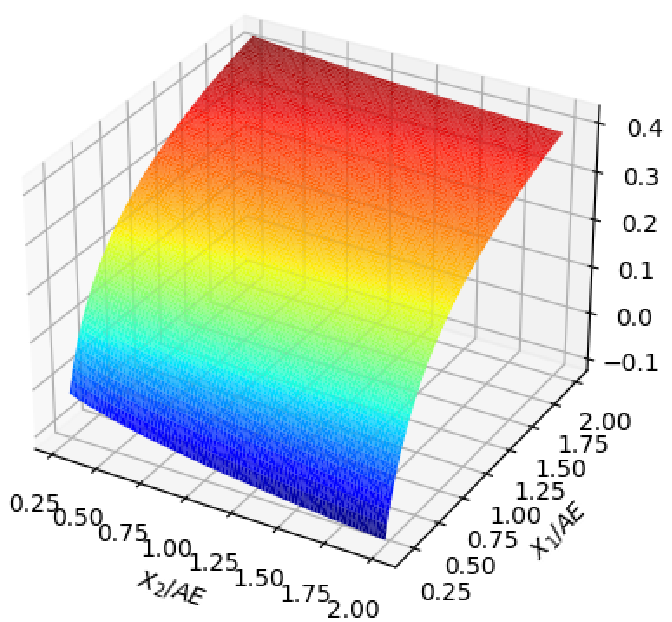

Figure 11: Average tax rate on the second earner, Finland 2001, families without children

A.9 Additional Empirical Results for Married Women and Men

In each of our 3 regression groups for married couples, we start with 3 regression specifications where we include only one of our various tax measures ($(1-\theta_0)$, θ_1 or φ) separately. These correspond to regression results in columns (1), (2) and (3) in the Tables **??**, 9, 10, **??**, 11, and 12.

In the pooled OLS group for married women (see Table **??**), only the $(1-\theta_0)$ coefficient is statistically significant in the first 3 regressions, but it has the counter-intuitive positive sign. In the fixed-effects regressions with country-fixed effects group (see table 9), only the θ_1 coefficient is statistically significant, and it also has the positive sign. In the fixed-effects regressions with both country- and year-fixed effects group (see table 10), we again find that only the θ_1 coefficient is marginally statistically significant, but now it has the negative sign.

In the pooled OLS group for married men (see Table **??**), only the θ_1 coefficient is statistically significant in the first 3 regressions. It has the negative sign. In the fixed-effects regressions with country-fixed effects group (see table 11), still only the θ_1 coefficient is statistically significant, and it still has the negative sign. In the fixed-effects regressions with both country- and year-fixed effects group (see table 12), we find that both the θ_1 and $(1-\theta_0)$ coefficients are marginally statistically significant and have the negative sign.

Next, we consider 2 regressions where we include 2 of our 3 tax measures ($(1-\theta_0)$ and θ_1, or $(1-\theta_0)$ and φ) but do not include the $\varphi\times\theta_1$ interaction term. They correspond to regressions (4) and (5) in each table. For married women, the pooled OLS group, $(1-\theta_0)$ coefficients remain positive and statistically significant. Unexpectedly, the φ coefficient is negative and statistically significant in regression (5). In our fixed-effects regression with country-effects only, only the θ_1 coefficient is statistically significant and positive in regression (4). Finally, in the fixed-effects with both country- and year-effects group, the θ_1 coefficient is the only one that is marginally statistically significant but now has the negative sign.

For married men, the pooled OLS group, $(1-\theta_0)$ coefficients remain positive and insignificant in column (4), weakly significant in column (5). The φ coefficient is positive and statistically significant in regression (5). The θ_1 coefficient is negative and statistically significant in column (4). In our fixed-effects regressions both with country-effects only and when year effects are included, the θ_1 coefficient is statistically significant and positive in regression (5). The $(1 - \theta_0)$ is negative but only statistically significant in column (5), and the φ coefficient is positive and statistically significant in column (5).

Finally, in all 3 groups, we consider the regression with all our 3 tax measures and the $\varphi \times \theta_1$ interaction term (regression (6) in all 3 tables). In all these regression specifications, this interaction term is positive and statistically significant both in the regressions for married women and men. As we will see later, this finding matches the prediction from our model. The intuition is that for the married couples, higher tax progressivity together with separate taxation of the two spouses means lower average tax rate on the secondary earner, which gives higher incentives to the secondary earner to enter the labor market. There is also an income effect. The primary earner will be able to bring home less net income with separate progressive taxation, which increases the benefit of having two earners.

Interestingly, many other coefficients become statistically significant in this final specification. For instance, the θ_1 coefficient is statistically significant and negative in all 6 tables. This is as expected because progressive joint taxation would have the opposite effect of progressive separate taxation on employment. It encourages one earner in the family by increasing the tax rate on the secondary earner. Perhaps somewhat counter-intuitively, the φ is also statistically significant and negative in all 6 tables (or perhaps not because separate taxation only matters when taxes are progressive, so it may be that this coefficient just correlates with some other country features).

Table 9: Fixed Effects Regression with Country Effects, Married Women

	(1)	(2)	(3)	(4)	(5)	(6)
Tax Level	–	–	0.244^{***}	0.218^{**}	0.014	0.015
			(0.088)	(0.109)	(0.117)	(0.114)
Tax Progressivity	0.195^{**}	–	0.086	–	-0.169	-0.611^{***}
	(0.088)		(0.095)		(0.129)	(0.174)
Tax Sep	–	0.052^{***}	–	0.019	–	-0.169^{***}
		(0.018)		(0.024)		(0.046)
Tax Sep×TaxProgressivity	–	–	–	–	0.292^{***}	0.906^{***}
					(0.101)	(0.194)
Const	0.608^{***}	0.615^{***}	0.572^{***}	0.584^{***}	0.638^{***}	0.753^{***}
	(0.019)	(0.012)	(0.023)	(0.02)	(0.032)	(0.044)
$R^2(within)$	0.019	0.032	0.048	0.047	0.079	0.125
R^2	0.927	0.928	0.929	0.929	0.931	0.935

Table 10: Fixed Effects Regression with Country and Time Effects, Married Women

	(1)	(2)	(3)	(4)	(5)	(6)
Tax Level	–	–	0.146^{**}	0.009	-0.036	-0.033
			(0.069)	(0.086)	(0.09)	(0.09)
Tax Progressivity	-0.118^{*}	–	-0.175^{**}	–	-0.378^{***}	-0.537^{***}
	(0.069)		(0.074)		(0.098)	(0.133)
Tax Sep	–	0.026^{*}	–	0.024	–	-0.063^{*}
		(0.014)		(0.018)		(0.036)
Tax Sep×TaxProgressivity	–	–	–	–	0.232^{***}	0.46^{***}
					(0.076)	(0.15)
Const	0.675^{***}	0.632^{***}	0.652^{***}	0.631^{***}	0.704^{***}	0.745^{***}
	(0.015)	(0.009)	(0.018)	(0.016)	(0.025)	(0.034)
$R^2(within)$	0.012	0.015	0.031	0.015	0.068	0.08
R^2	0.963	0.963	0.964	0.963	0.965	0.966

Table 11: Fixed Effects Regression with Country Effects, Married Men

	(1)	(2)	(3)	(4)	(5)	(6)
Tax Level	–	–	-0.222^{***}	-0.472^{***}	-0.547^{***}	-0.547^{***}
			(0.076)	(0.097)	(0.099)	(0.097)
Tax Progressivity	-0.458^{***}	–	-0.359^{***}	–	-0.721^{***}	-1.066^{***}
	(0.076)		(0.082)		(0.108)	(0.147)
Tax Sep	–	-0.034^{**}	–	0.037^{*}	–	-0.132^{***}
		(0.016)		(0.021)		(0.039)
Tax Sep×TaxProgressivity	–	–	–	–	0.414^{***}	0.893^{***}
					(0.085)	(0.164)
Const	0.927^{***}	0.852^{***}	0.96^{***}	0.919^{***}	1.053^{***}	1.143^{***}
	(0.016)	(0.011)	(0.02)	(0.018)	(0.027)	(0.037)
$R^2(within)$	0.124	0.016	0.153	0.1	0.226	0.26
R^2	0.785	0.759	0.792	0.779	0.81	0.818

Table 12: Fixed Effects Regression with Country and Time Effects, Married Men

	(1)	(2)	(3)	(4)	(5)	(6)
TaxLevel	–	–	-0.242^{***}	-0.509^{***}	-0.602^{***}	-0.595^{***}
			(0.079)	(0.102)	(0.1)	(0.097)
TaxProgressivity	-0.477^{***}	–	-0.383^{***}	–	-0.782^{***}	-1.132^{***}
	(0.08)		(0.084)		(0.108)	(0.144)
TaxSep	–	-0.028^{*}	–	0.043^{**}	–	-0.138^{***}
		(0.017)		(0.022)		(0.039)
TaxSep×TaxProgressivity	–	–	–	–	0.457^{***}	0.958^{***}
					(0.083)	(0.162)
Const	0.931^{***}	0.848^{***}	0.97^{***}	0.924^{***}	1.073^{***}	1.163^{***}
	(0.017)	(0.012)	(0.021)	(0.019)	(0.027)	(0.037)
$R^2(within)$	0.131	0.011	0.164	0.106	0.259	0.297
R^2	0.809	0.783	0.816	0.803	0.837	0.845

A.10 Additional Figures and Tables

Table 13: Selected Statistics for Joint and Separate Taxation and Different Tax Progressivity (assuming government spending clears the budget)

	Joint Taxation			Separate Taxation		
	Flat tax	US Prog.	2×US Prog.	Flat Tax	US Prog.	2×US Prog.
Tax Revenue	105.29	100.00	91.94	105.29	101.81	96.16
Labor Tax Revenue	105.14	100.00	90.65	105.14	101.06	97.91
Aggregate Labor Supply	102.04	100.00	93.44	102.04	104.95	103.50
Single Male Labor Supply	94.35	100.00	101.41	94.35	96.87	94.92
Married Male Labor Supply	104.25	100.00	87.39	104.25	105.42	101.58
Single Female Labor Supply	92.00	100.00	104.36	92.00	97.39	100.06
Married Female Labor Supply	112.49	100.00	87.94	112.49	116.50	116.03
Single Male LFP	92.58	100.00	104.17	92.58	98.61	101.42
Married Male LFP	99.66	100.00	92.80	99.66	106.75	110.45
Single Female LFP	86.04	100.00	113.59	86.04	98.57	111.27
Married Female LFP	103.92	100.00	95.01	103.92	116.58	126.92
Single Male Intensive Margin	101.92	100.00	97.35	101.92	98.23	93.59
Married Male Intensive Margin	104.61	100.00	94.17	104.61	98.76	91.97
Single Female Intensive Margin	106.92	100.00	91.88	106.92	98.80	89.92
Married Female Intensive Margin	108.24	100.00	92.56	108.24	99.94	91.42
Savings	105.36	100.00	95.58	105.36	98.00	91.57

The table displays selected model statistics with separate and joint taxation and different model statistics at the benchmark average tax rate of 12%. All numbers are in % of the U.S. Benchmark. Additional tax revenues are redistributed lump-sum back to households.

Table 14: Percent Change in Married Women's Employment to Tax Changes by Ability and Age

	Change to Individual Taxation					**Change to Ind. Tax (2X U.S. Prog.)**				
Ability	20-28	29-37	38-46	47-55	56-64	20-28	29-37	38-46	47-55	56-64
1.0	35.1	32.6	25.1	25.5	23.6	85.4	55.3	41.9	48.2	50.1
2.0	33.4	19.7	17.5	17.3	22.5	55.8	40.0	33.7	35.8	47.3
3.0	24.7	21.6	16.8	20.8	20.4	36.9	27.7	24.0	27.9	37.8
4.0	18.7	11.6	8.5	11.0	19.4	21.1	15.9	15.9	18.7	27.6
5.0	9.2	6.5	7.0	6.5	14.0	9.6	8.5	9.3	12.1	20.0

The table displays the percent change in married women's employment rate when the tax system is changed from the benchmark system with joint taxation to a system with individual taxation or a system with individual taxation and two times U.S. tax progressivity. In both experiments the average tax rate is kept at the benchmark level.

Table 15: Percent Change in Married Men's Employment to Tax Changes by Ability and Age

	Change to Individual Taxation					Change to Ind. Tax (2X U.S. Prog.)				
Ability	20-28	29-37	38-46	47-55	56-64	20-28	29-37	38-46	47-55	56-64
1.0	24.5	28.1	27.8	27.9	25.6	47.8	54.6	55.5	58.0	57.6
2.0	11.0	12.7	13.2	13.3	12.7	13.5	16.2	17.6	19.2	20.0
3.0	3.0	4.3	5.3	5.9	5.8	3.1	4.7	6.1	7.6	9.1
4.0	0.4	1.1	2.3	3.1	3.5	0.4	1.1	2.4	3.6	5.0
5.0	0.0	0.0	0.6	1.3	2.3	0.0	0.0	0.5	1.5	3.0

The table displays the percent change in married men's employment rate when the tax system is changed from the benchmark system with joint taxation to a system with individual taxation or a system with individual taxation and two times U.S. tax progressivity. In both experiments the average tax rate is kept at the benchmark level.

Table 16: Percent Change in Single Women's and Men's Employment After a Change to a Tax System With Double Progressivity

	Women					Men				
Ability	20-28	29-37	38-46	47-55	56-64	20-28	29-37	38-46	47-55	56-64
1.0	41.2	26.1	16.3	24.1	24.6	43.6	36.8	16.9	24.6	34.4
2.0	19.6	22.3	22.7	16.7	15.6	2.8	2.0	5.4	5.0	4.6
3.0	19.1	8.4	9.6	10.7	15.0	-0.7	-1.9	-2.0	2.9	2.7
4.0	1.8	7.6	6.9	10.0	7.0	-0.4	-2.6	-3.4	-4.7	-1.4
5.0	0.7	1.5	5.2	5.4	2.1	-0.1	-2.0	-3.7	-2.7	-0.6

The table displays the percent change in single women's and men's employment rate when the tax system is changed from the benchmark system to a system with two times U.S. tax progressivity. The average tax rate is kept at the benchmark level.

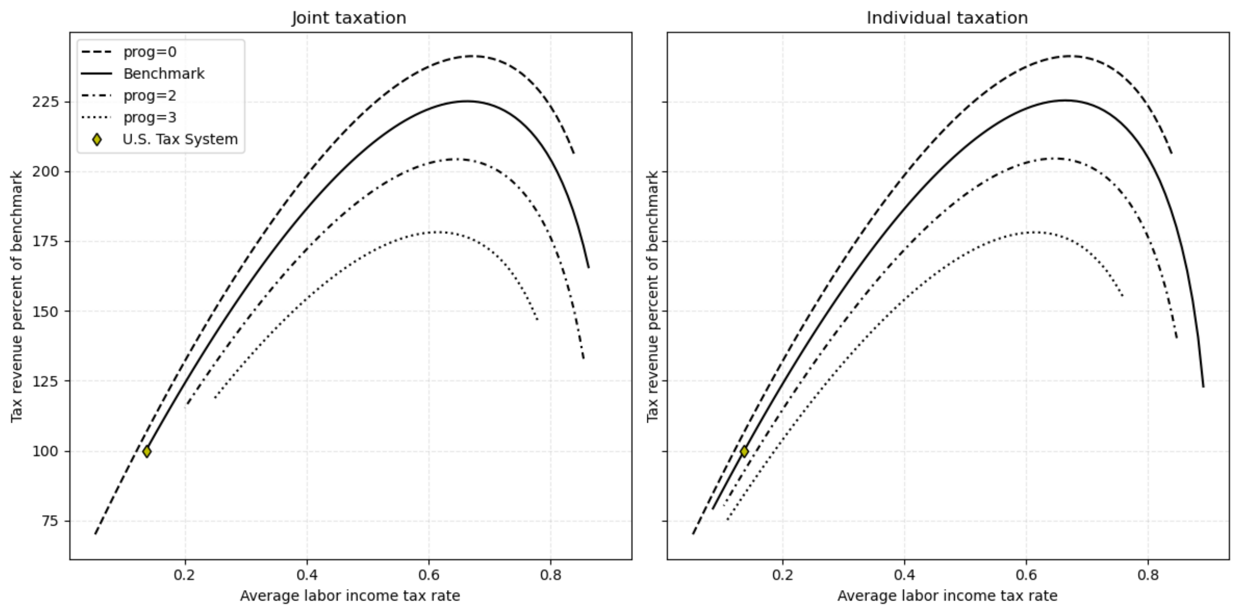

Figure 12: Laffer Curves in a Model with Only Intensive Margin (Assuming Extra Tax Revenue is Redistributed Lump Sum)

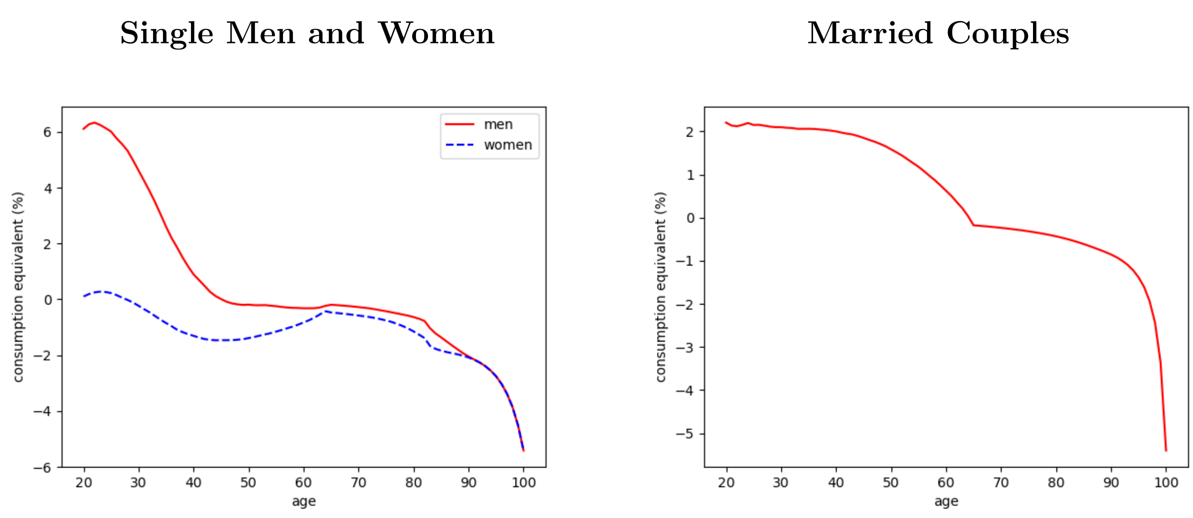

Figure 13: Comparison of Welfare in Consumption Equivalent Units by Age

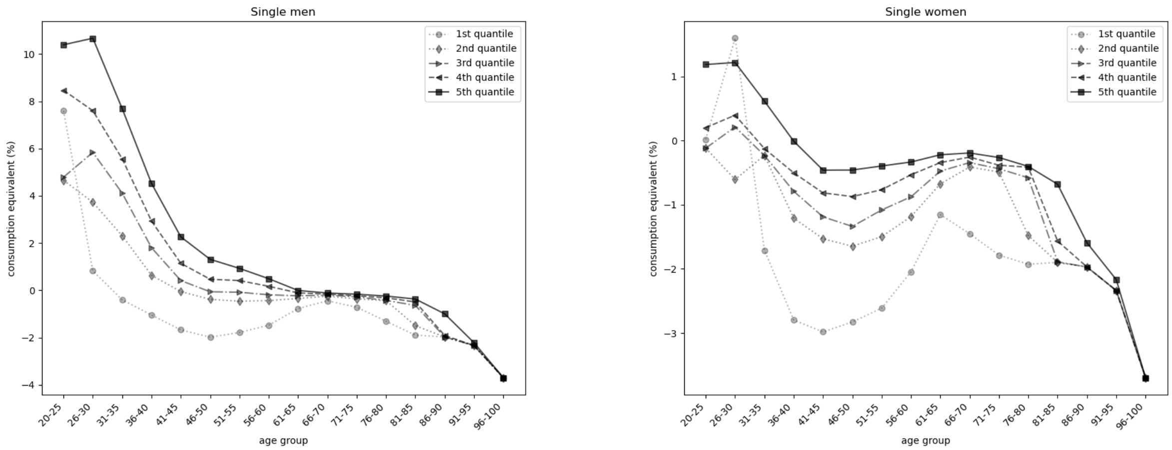

Figure 14: Comparison of Welfare in Consumption Equivalent Units by Age and Wealth Quantile, Single Men and Women

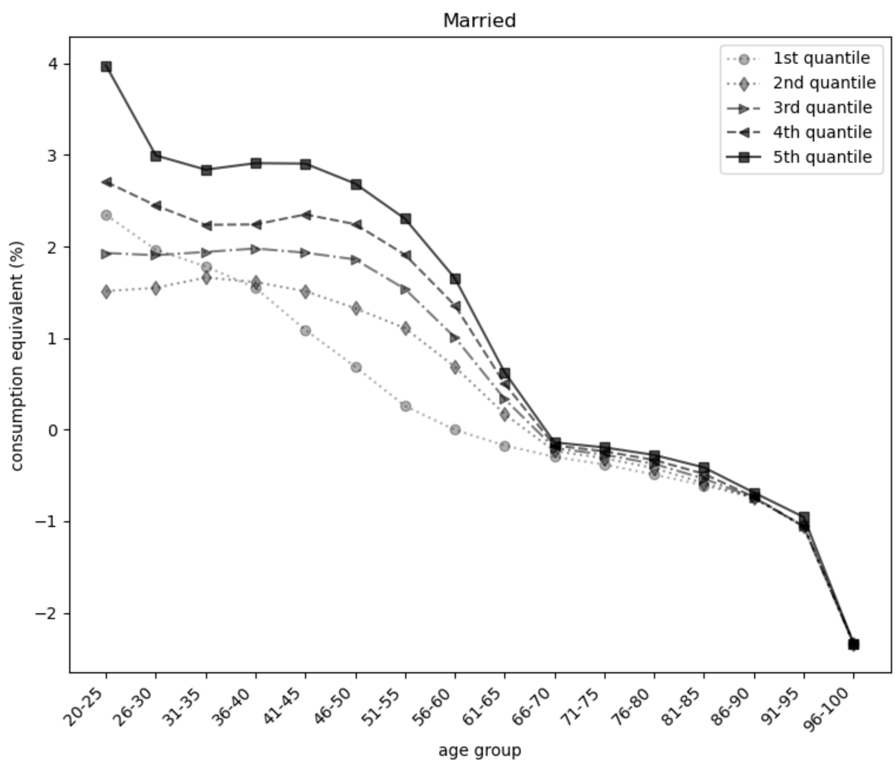

Figure 15: Comparison of Welfare in Consumption Equivalent Units by Age and Wealth Quantile, Married Couples

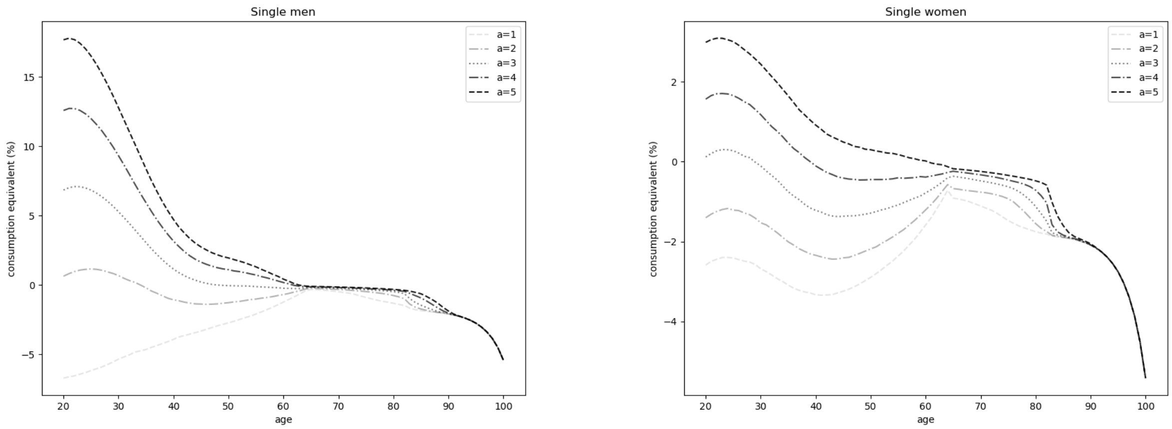

Figure 16: Comparison of Welfare in Consumption Equivalent Units by Age and Ability, Single Men and Women

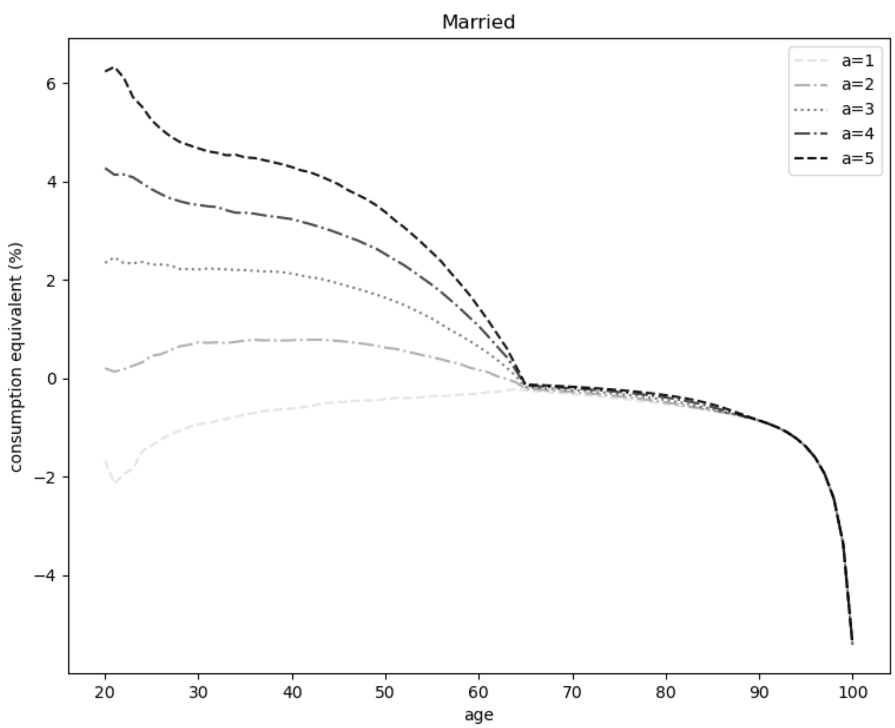

Figure 17: Comparison of Welfare in Consumption Equivalent Units by Age and Ability, Married Couples