Optimal Income Taxation of Singles and Couples

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How different should income taxation be across singles and couples? I answer this question using a general equilibrium overlapping generations model that incorporates single and married households, intensive and extensive margins of labor supply, human capital accumulation, and uninsurable idiosyncratic labor productivity risk. The degree of tax progressivity is allowed to vary with marital status. I parameterize the model to match the U.S. economy and find that couples should be taxed less progressively than singles. Relative to the actual U.S. tax system, the optimal reform reduces progressivity for couples and increases it for singles. The key determinants of optimal policy for couples relative to singles include the detrimental effects of joint taxation and progressivity on labor supply and human capital accumulation of married secondary earners, the degree of assortative mating, and within-household insurance through responses of spousal labor supply. I conclude that explicitly modeling couples and accounting for the extensive margin of labor supply and human capital accumulation is qualitatively and quantitatively important for the optimal policy design.

JEL: C63, D15, D52, E21, E62, H21, J24.

Keywords: Optimal Taxation, Taxation of Couples, Labor Supply, Human Capital, Tax Progressivity.

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1 Introduction

How different should income taxation be across singles and couples? The answer to this question is of crucial importance for both academic economists and policymakers. In this paper, I focus on a particular aspect of income taxation, that is progressivity, which I define as 1 minus the average elasticity of post-tax/transfer income to pre-tax/transfer income. For example, in the Unites States, progressivity for single individuals is around 12%, meaning that, on average across the income distribution, a 10% increase in pre-tax/transfer income results in a 8.8% increase in post-tax/transfer income. In Figure 1, I report tax progressivity for singles and couples in a number of developed countries. The key takeaway from the figure is that there is considerable variation in progressivity of the tax code for singles and couples.[1] In the United States (and in some other countries), progressivity for singles and couples is roughly equal; however, for a majority of countries progressivity for couples is lower than for singles. This evidence raises, first, the question of what is the rationale for taxing couples differently from singles, and, second, whether any given country can improve welfare of its citizens by changing how it taxes couples relative to singles.

This paper focuses on three determinants of taxation of couples relative to singles. First, it considers the well-documented feature that the combination of joint taxation of couples and high progressivity can have a detrimental effect on labor supply and human capital accumulation of the secondary earner in a dual-earner couple (Eissa and Hoynes, 2004; Bick and Fuchs-Schündeln, 2017b; Borella et al., 2021). This feature, ceteris paribus, will favor lower progressivity for couples. Second, it considers the possibility of within-household insurance through responses of spousal labor supply in couples (Attanasio et al., 2005; Blundell et al., 2016b; Wu and Krueger, 2021). The presence of this private insurance device reduces the desired degree of public insurance in the form of tax progressivity. This feature also calls for lower progressivity for couples. Finally, it considers the possibility of positive assortative mating, that is that similarly educated people are more likely to marry each other, which has been highlighted as one of the driving forces of between-household inequality (Fernandez et al., 2005; Eika et al., 2019). This feature will call for higher progressivity for couples.

To consider all these features in a unified framework, this paper develops a general equilibrium overlapping generations model that incorporates single and positively assorted married households facing uninsurable idiosyncratic labor productivity risk, intensive and extensive margins of labor supply, and human capital accumulation. I parameterize the model using the Method of Simulated Moments and data for the United States from the Current Population Survey (CPS) and the Panel Study of Income Dynamics (PSID). The model matches the patterns from the data

[1] In Figure E.1, I also compare average personal income tax rates for singles and married couples in OECD countries. A sizable fraction of observations is located off the 45-degree line.

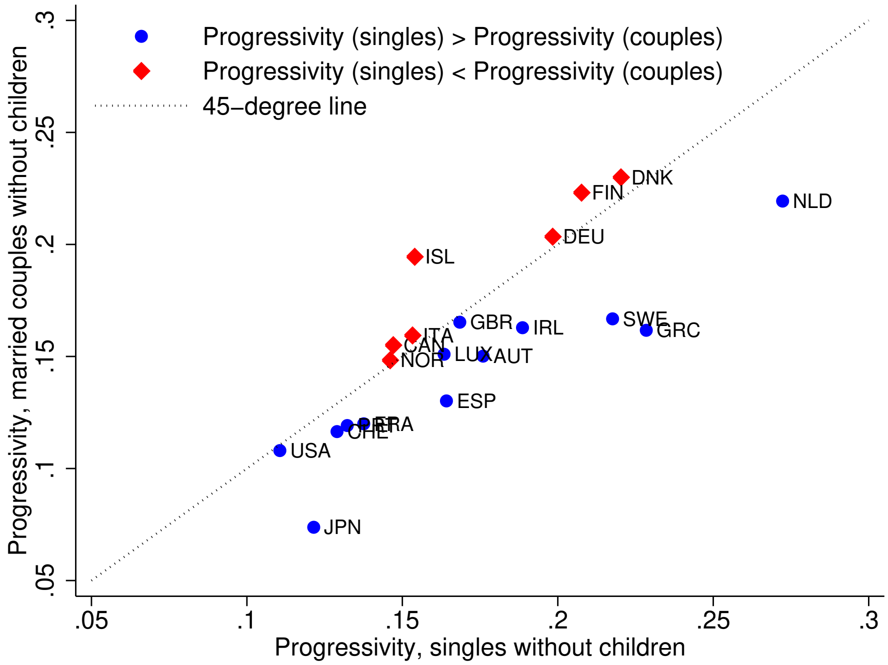


Figure 1: Tax progressivity for singles and married couples by country

Notes: Progressivity is defined as 1 minus the average elasticity of post-tax/transfer income to pre-tax/transfer income. The dotted line is a 45-degree line. The estimates are from Holter et al. (2019) who use the OECD Tax-Benefit calculator for the period of 2000-2007. For consistency, I consider childless singles and married couples.

remarkably well. In particular, it generates the compensated labor supply elasticities that are consistent with empirical studies. Having checked the validity of the model, I quantitatively characterize the optimal tax progressivity, separately for single and married households. To find the optimal tax schedule, I maximize the welfare of a newborn household at the new steady state.

My first finding is that tax progressivity in the United States should be lower for married couples than for singles. Under the optimal tax schedule, the average elasticity of post-tax/transfer income to pre-tax/transfer income for couples is 4.3 p.p. higher than one for singles. Furthermore, the optimal tax reform increases this elasticity by 3.9 p.p. for married couples and reduces it by 2.6 p.p. for singles relative to the actual U.S. tax system. Under the optimal policy, married women's employment goes up by 2.6 p.p. (from 69.2% to 71.8%). Replacing the actual tax system with the optimal one would generate an aggregate welfare gain of about 1.3% in consumption-equivalent terms.

The model also suggests that there exist welfare improving reforms that replace the actual U.S. income tax schedule in a revenue-neutral fashion, so that the schedule for one group (e.g., singles) remains at the U.S. benchmark level while the schedule for the other group (e.g., couples) is changed. To separate the effects of changes in tax progressivity and average tax rates, I also consider a reform when the government varies the degree of progressivity but keeps the average tax rates at the status-quo level. I find that my main results still hold under this policy rule.

I consider several extensions of the baseline model and show that my main findings carry over into the other environments. First, I lay out a version of the model where the government uses part of the revenue to service the outstanding government debt. Second, I relax the assumption that individuals do not change their marital status over the life cycle. Third, I allow the idiosyncratic labor productivity shocks of spouses to be correlated. Finally, I consider a version of the model where married couples can choose between joint and separate filing.

To the best of my knowledge, this paper is the first one that addresses the question of optimal taxation of singles and married couples in a unified general equilibrium framework with rich heterogeneity and human capital. I conclude that explicitly modeling couples and accounting for the extensive margin of labor supply and human capital accumulation is qualitatively as well as quantitatively important for the optimal policy design.

This paper contributes to several strands of literature. First, it is related to the Ramsey-style papers that study the optimal income taxation in heterogeneous-agent models with incomplete markets (Conesa and Krueger, 2006; Conesa et al., 2009).[2] While most of the papers in this literature abstract from heterogeneity in marital status and gender, Keane (2011) emphasizes the importance of accounting for both of them in studying the relationship between tax and transfer policy and labor supply responses.[3] In this vein, my work is related to the papers that study income taxation of couples. Influential existing studies include Bar and Leukhina (2009), Kleven et al. (2009), Immervoll et al. (2011), Guner et al. (2012a), Frankel (2014), Gayle and Shephard (2019), and Bronson and Mazzocco (2021). Kleven et al. (2009) consider a static unitary model of couples where the primary earners choose labor supply at the intensive margin and the secondary earners choose whether to work or not. Gayle and Shephard (2019), using a static model, study the role of marriage market in shaping the optimal income tax schedule. These two papers suggest that the optimal tax schedule is characterized by negative jointness, i.e. marginal tax rates should be lower for individuals with high-earning spouses. In Bar and Leukhina (2009) and Immervoll et al. (2011), spouses choose labor supply at the extensive margin, but not hours.

My paper also adds to the literature on tagging pioneered by Akerlof (1978), who suggests that conditioning taxes on personal characteristics can improve redistributive taxation (Cremer et al., 2010). More recently, this idea was discussed in the context of age-dependent taxation (Weinzierl,

[2] Stantcheva (2020) provides an excellent discussion of widespread approaches in the dynamic taxation literature. These include the parametric Ramsey, the Mirrlees, and the sufficient statistics approaches.

[3] Borella et al. (2018) claim that even macroeconomists not interested in heterogeneity in marital status and gender per se should start taking them into account in the context of quantitative structural models because it would yield better results in terms of matching the aggregates. In this paper, I carefully account for these features in my quantitative work and go one step further by evaluating the optimal tax reforms.

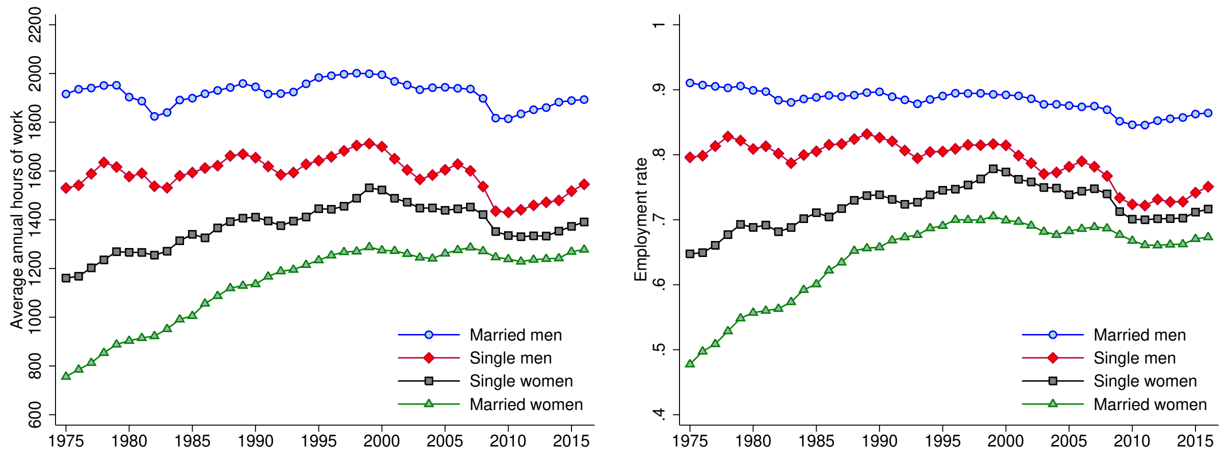
2011; Heathcote et al., 2020), gender-based taxation (Alesina et al., 2011; Guner et al., 2012b), and asset-based taxation (Karabarbounis, 2016).

Next, this paper belongs to studies that emphasize the role of females and their labor supply as well as families in studying inequality and macroeconomic policies (Doepke and Tertilt, 2016). Eissa and Liebman (1996) and Eissa and Hoynes (2004) find that the Earned Income Tax Credit (EITC) expansions between 1984 and 1996, on the one hand, reduced total family labor supply of couples mainly through lowering labor force participation of married women, and, on the other hand, increased participation of single women with children relative to single women without children. Borella et al. (2021) show that eliminating marriage-related taxes and old age Social Security benefits in the United States would significantly enhance married women's labor force participation over the life cycle. Kaygusuz (2010) claims that around a quarter of a 13-p.p. rise in labor force participation of married women in the United States between 1980 to 1990 can be attributed to the tax reforms of 1981 and 1986. Through the lens of a cross-country perspective, Bick and Fuchs-Schündeln (2017b) conclude that non-linear labor income taxation combined with the tax treatment of married couples accounts for a sizable share of variation in married women's hours of work across European countries.

Female labor supply is often considered in the context of the so-called "added worker effect," i.e. a temporary increase in the labor supply of married women whose husbands have become unemployed (Lundberg, 1985). The evidence on this effect is mixed. On the one hand, using the PSID data, Blundell et al. (2016b) document that a sizable share of smoothing of men's and women's permanent shocks to wages operates through changes in spousal labor supply. Furthermore, Park and Shin (2020) also find the empirical support for the added worker effect by showing that wives significantly increase their labor supply—mainly through adjustments along the extensive margin—in response to an increase in the variance of permanent wage shocks of their husbands. On the other hand, Birinci (2019) and Busch et al. (2021) find that the magnitude of this effect is small.

Finally, human capital accumulation plays an important role in the model. Therefore, my work is also related to the literature that studies the interaction between human capital accumulation and income tax policy (Erosa and Koreshkova, 2007; Guvenen et al., 2014; Stantcheva, 2017).

The rest of the paper is organized as follows. In Section 2, I document the empirical facts about labor supply and income taxation of single and married individuals in the United States. To build the intuition and explain the various channels through which tax progressivity affects singles and couples, in Section 3, I consider a simple static model. Section 4 lays out the full-fledged quantitative model. In Section 5, I discuss the parameterization and model fit. Section 6 describes the tax reforms and contains the quantitative results. In Section 7, I discuss the extensions of the baseline model and prospects for future research. Section 8 concludes.



(a) Average annual hours of work

(b) Employment rate

Figure 2: Labor supply trends by gender and marital status in the United States

NOTES: I use the CPS data for individuals aged 25-65. Annual hours of work are constructed by multiplying the usual number of hours worked per week last year by the number of weeks worked last year. An individual is defined as employed if he/she worked a positive number of hours. I drop those who are employed but who report working less than 260 hours, those who report working more than 4160 hours, and those who earn less than half of the federal minimum wage.

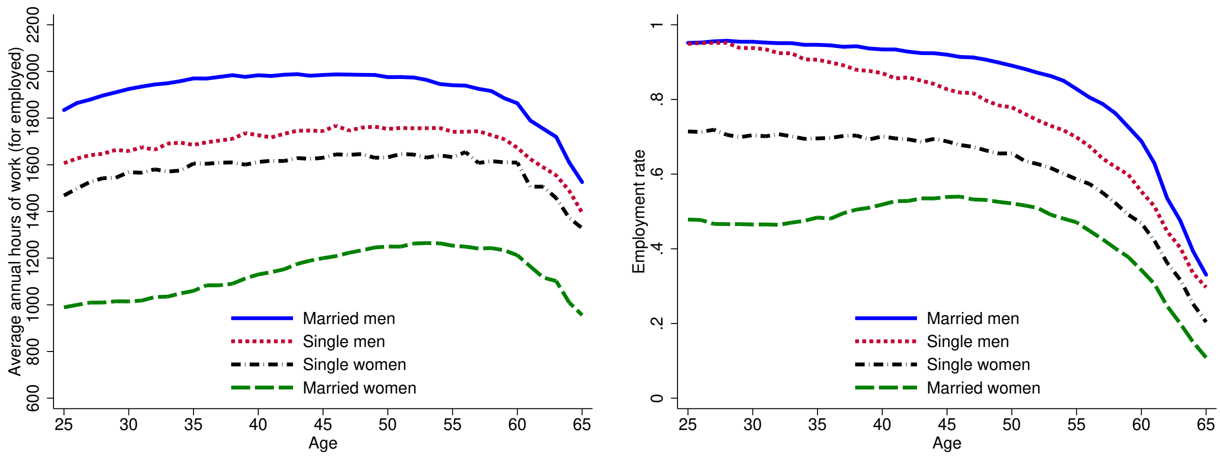
2 Labor Supply and Income Taxation: Empirical Facts

In this section, I document the patterns of labor supply over time and over the life cycle for U.S. individuals that differ by gender and marital status. Next, I demonstrate that in the United States married secondary earners typically face higher participation tax rates relative to otherwise identical single individuals. In the subsequent sections, I will show that my quantitative model successfully matches the features described below.

I use the data from the CPS for the survey years 1976-2017.[4] The sample consists of single and married individuals aged 25-65. Annual hours of work are calculated by multiplying the usual number of hours worked per week last year (variable *uhrsworkly*) by the number of weeks worked last year (variable *wkswork1*). An individual is defined as employed if he/she worked a positive number of hours last year. I drop those who are employed but who report working less than 260 hours, those who earn less than half of the federal minimum wage, and those who report working more than 4160 hours, i.e. more than 80 hours per week for the entire year.[5] Finally, to ensure consistency, I drop individuals who report zero hours but positive earnings or zero earnings but positive hours.

[4] The data is extracted from IPUMS at https://cps.ipums.org/cps. See Flood et al. (2020).

[5] In Figures E.2-E.3, I also report the time series and lifecycle profiles that are constructed using the information on the hours worked during the previous week (variable *ahrsworkt*). In this case, I drop those individuals who are employed and who report working less than 5 hours or more than 80 hours.



(a) Average annual hours of work (for employed)

(b) Employment rate

Figure 3: Lifecycle profiles of labor supply by gender and marital status in the United States

NOTES: I use the CPS data for individuals aged 25-65. Annual hours of work are constructed by multiplying the usual number of hours worked per week last year by the number of weeks worked last year. An individual is defined as employed if he/she worked a positive number of hours. I drop those who are employed but who report working less than 260 hours, those who report working more than 4160 hours, and those who earn less than half of the federal minimum wage. The profiles are constructed by cleaning cohort effects following the usual procedure in the literature.

2.1 Labor Supply over Time

I start my analysis by looking at the time series of labor supply between 1975 and 2016. In Figure 2, I report the average annual hours of work (left panel) and the employment rate (right panel) for single and married men and women. Consistent with the previous studies, the striking feature of the last several decades is the substantial increase in married women's labor supply (Knowles, 2013; Jones et al., 2015). Nowadays, their average hours of work and employment rate are very close to those of single men and women. The other observation from Figure 2 is that single men's labor supply has not significantly changed over time while it has gone up for single women. As a result, the gap between them has narrowed down. Finally, the employment of married men has declined from 91.0% in 1975 to 86.4% in 2016. Motivated by the evidence from this section, in my model, I allow both men and women to make labor supply decisions at the intensive and extensive margins.

2.2 Labor Supply over the Life Cycle

Next, I look at the labor supply lifecycle profiles of men and women that differ by marital status. I follow the usual procedure in the literature, and construct them by cleaning cohort effects (Deaton and Paxson, 1994). The left panel of Figure 3 reports the average annual hours of work conditional

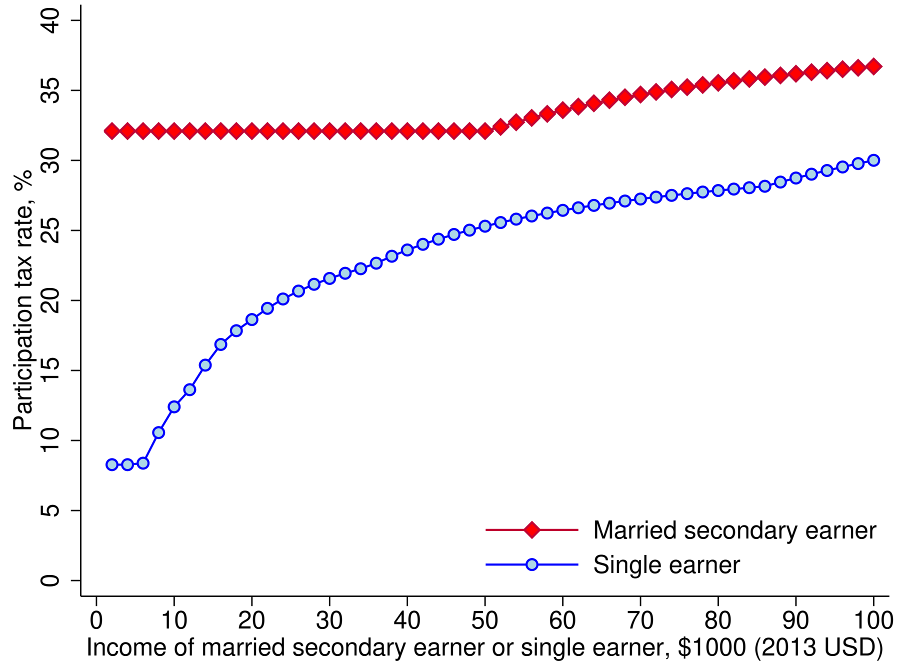


Figure 4: Participation tax rates of single and married secondary earners in the United States

NOTES: For the married secondary earner, the participation tax rate is defined as the additional tax burden that the couple faces if he/she goes from not working to working divided by his/her income. For the single earner, it is equal to the effective average tax rate. The tax rates are calculated using the NBER TAXSIM and include federal, state, and FICA tax rates. Both individuals aged 40, live in Michigan, and have two children under age 17. A secondary earner spouse's annual income is fixed at $35603 (2013 USD) which is the U.S. median level for 2013 (Song et al., 2019). Individuals do not have any non-labor income. Married couple is assumed to file jointly.

on being employed. The right panel reports the employment rates. Consistent with the literature, employment and hours of employed men and women are hump-shaped, however, there is not much variation in hours over the life cycle (Attanasio et al., 2008; Erosa et al., 2016). Women have lower employment rates than men and work less hours conditional on being employed. Among four groups, married women has the lowest employment rate and hours of work.

2.3 Participation Tax Rates for Single and Married Secondary Earners

The fact that the combination of joint taxation of couples and tax progressivity creates substantial disincentive effects for married women's employment (Bick and Fuchs-Schündeln, 2017a) underscores the importance of accounting for the extensive margin of labor supply and human capital accumulation in my analysis.[6] Under this policy, the marginal tax rate on the first dollar earned by the secondary (lower-income) earner is equal to the marginal tax rate on the last dollar earned by

[6] In the data, married women are more likely to be secondary earners.

the primary (higher-income) earner. As a result, married secondary earners typically face higher tax rates than otherwise identical single earners. Figure 4 illustrates this point by showing the participation tax rates for single and married secondary earners in the United States. Intuitively, I calculate their average marginal tax rates if they go from not working to working. For the married secondary earner, I define his/her participation tax rate as the additional tax burden that the couple faces divided by his/her income:

$$\text{PTR} = \frac{\text{Taxes (dual-earner couple)} - \text{Taxes (single-earner couple)}}{\text{Secondary earner's income}}$$

For singles, it is simply equal to the effective average tax rate. Except for the marital status, two individuals in the figure are identical. I assume that the married person's spouse earns the median income. Furthermore, both households do not have any non-labor income. The key takeaway from this illustration is that the married secondary earner faces a significantly higher tax rate, when he/she starts working, than the single one.

3 Simple Example

To provide some intuition behind the different channels through which tax progressivity interacts with labor supply of singles and couples, I consider an analytically tractable static model. I demonstrate that the presence of private within-household insurance through spousal labor supply in couples reduces the desired degree of public insurance in the form of tax progressivity. Furthermore, I show that an increase in tax progressivity can lead to the opposite employment decisions of single individuals and secondary earners in couples. In Section 4, I enrich this environment by extending it to a general equilibrium setting and adding empirically relevant features (such as human capital accumulation and wage heterogeneity) that are necessary for a comprehensive quantitative analysis.

Consider two types of households—singles and married couples—making consumption and labor supply decisions. In particular, each individual decides whether to work or not and if work, then how much. If he/she works, then there is additional fixed time cost of work q. I interpret it as time spent on getting ready to work or the commuting costs. Modeling the participation margin with the fixed cost of work allows generating the distribution of hours that is consistent with the data (Cogan, 1981; French, 2005). Specifically, as Figure E.4 reports, the empirical distribution of weekly hours of work has a little mass at low positive numbers of hours. Instead, they are clustered around 0 and 40 hours. This is true for both men and women irrespective of their marital status. In the model, each person is endowed with one unit of time which is allocated between leisure, work, and fixed cost of work. Denote by w_m and w_f the labor market productivities (wage rates) of males and females, respectively. Households face the tax and transfer function that is given by

$$T\left(y\right)=y-\lambda y^{1-\tau} \tag{1}$$

where parameters λ and τ are allowed to vary by marital status. Parameter τ stands for the degree of tax progressivity. Given τ, parameter λ determines the average level of taxes in the economy. Single households pay taxes on their individual income, while married couples are taxed jointly, i.e. on the total income of spouses.[7] This functional form is widely used in the quantitative macroeconomics and public finance literature (Benabou, 2002; Heathcote et al., 2017). I discuss its properties in Appendix B.1.

First, consider the problem of a single individual with gender $i=m,f$:

$$\max_{c,n}\log\left(c\right)-\psi\frac{\left(n+q\cdot\mathbb{1}\{n>0\}\right)^{1+\eta}}{1+\eta} \tag{2}$$

$$\text{s.t.}\quad c=\lambda_s\left(w_i n\right)^{1-\tau_s}+\tilde{T}$$

where c denotes consumption, n denotes hours of work, $\mathbb{1}\{n>0\}$ is an indicator for working positive number of hours (it equals to 1 if an individual works), and $\tilde{T}$ is a lump-sum government transfer. Parameters λ_s and τ_s characterize the tax schedule for single households.

Next, consider the problem of a married couple:

$$\max_{c,n_m,n_f}\ 2\log\left(c\right)-\psi\frac{\left(n_m+q\cdot\mathbb{1}\{n_m>0\}\right)^{1+\eta}}{1+\eta}-\psi\frac{\left(n_f+q\cdot\mathbb{1}\{n_f>0\}\right)^{1+\eta}}{1+\eta} \tag{3}$$

$$\text{s.t.}\quad c=\lambda_j\left(w_m n_m+w_f n_f\right)^{1-\tau_j}+2\tilde{T}$$

where parameters λ_j and τ_j characterize the tax schedule for married couples.

First, consider the following comparative-static exercise. Suppose that an individual with gender i is hit by a productivity (wage) shock. In Proposition 1, I characterize the extent to which this shock translates into consumption movement.

Proposition 1 (Passthrough of Wage Shocks to Consumption). *Assume $q=0$ and $\tilde{T}=0$. For singles, the elasticity of consumption to wage shock is given by*

$$\frac{d\log(c)}{d\log\left(w_i\right)}=1-\tau_s \tag{4}$$

[7] While in the United States married couples can choose between separate and joint filing, most of them choose the latter option. For example, in tax year 2018, 94.3% of married couples filed joint tax returns (see Table 1.6 "All Returns: Number of Returns, by Age, Marital Status, and Size of Adjusted Gross Income" in the Statistics of Income (SOI) data). Therefore, in the baseline version of my model, I assume that spouses are taxed on their joint income. In Section 7.4, I relax this assumption and allow married couples to choose between separate and joint filing.

For couples, the elasticity of household consumption to wage shock of individual i is given by

$$\frac{d\log(c)}{d\log\left(w_i\right)}=\frac{w_i^{\frac{1+\eta}{\eta}}}{w_i^{\frac{1+\eta}{\eta}}+w_{-i}^{\frac{1+\eta}{\eta}}}\left(1-\tau_j\right) \tag{5}$$

Proof. *See Appendix A.1.*

Proposition 1 shows how consumption of singles and couples responds to wage shocks, and how public insurance in the form of tax progressivity (τ_s and τ_j) affects these responses.[8] In particular, $(1-\tau_s)$% of the shock passes through to single household consumption. For couples, the transmission coefficient is smaller than $(1-\tau_j)$. It is mitigated because individual i's spouse adjusts his/her hours of work. Spousal labor supply serves as a private insurance against wage shocks, and it limits the role of tax progressivity as a social insurance device. Summing it up, Proposition 1 suggests that, ceteris paribus, this feature favors lower progressivity for couples. In Appendix A.1, I show that this result also holds in the environment where married couples are taxed separately rather than jointly.

I now discuss the effects of changes in tax progressivity on labor force participation of single individuals and married secondary earners in couples. The next two propositions show that an increase in tax progressivity can lead to the opposite results for these groups of people.

Proposition 2 (Tax Progressivity and Extensive Margin of Singles). *Define the threshold on fixed working cost $\bar{q}_s$ through the following equation:*

$$\underbrace{V_1^s\left(c_1^*,n^*;\bar{q}_s\right)}_{\textit{work}}=\underbrace{V_0^s\left(c_0^*,0\right)}_{\textit{does not work}}$$

For singles whose income is below average, $w_i n_i<1$, the fixed cost threshold is strictly increasing in progressivity, $\partial\bar{q}_s/\partial\tau_s>0$, i.e. their labor force participation is increasing in progressivity.
Proof. *See Appendix A.2.*

Proposition 3 (Tax Progressivity and Extensive Margin of Married Secondary Earners). *Assume that the primary earners (males) do not face fixed working costs. Assume $\tilde{T}=0$. Define the threshold on fixed working cost for married females $\bar{q}_c$ through the following equation:*

$$\underbrace{V_2^c\left(c_2^*,n_{m,2}^*,n_f^*;\bar{q}_c\right)}_{\textit{dual-earner couple}}=\underbrace{V_1^c\left(c_1^*,n_{m,1}^*,0\right)}_{\textit{single-earner couple}}$$

[8] Using the terminology from Blundell et al. (2008), I call the elasticities from Proposition 1 as transmission coefficients.

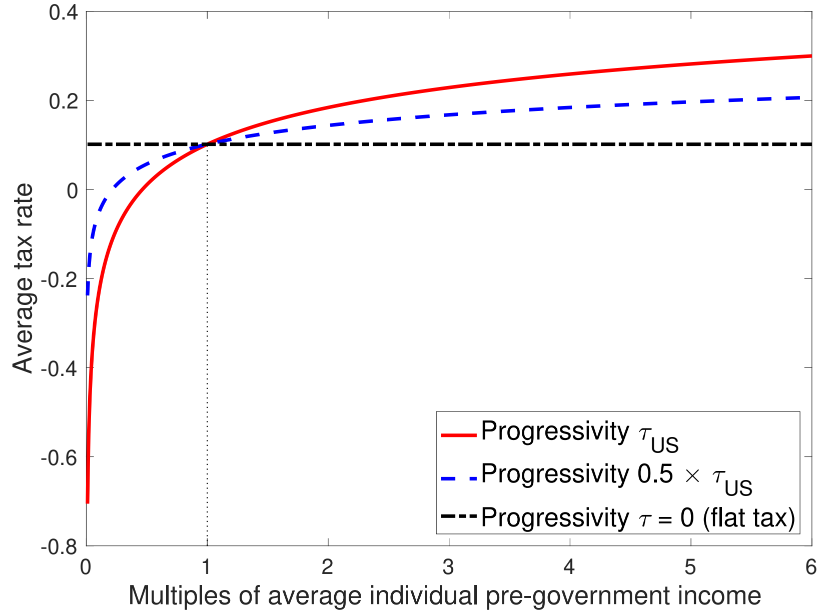


Figure 5: Average tax rate under different degrees of tax progressivity

NOTES: Parameters of the tax function for the United States are estimated using the data on single and married households from the Panel Study of Income Dynamics (PSID) for survey years 2013, 2015, and 2017, combined with the NBER TAXSIM (Feenberg and Coutts, 1993). See Appendix B.2 for the details.

Under joint taxation, if the primary earner's income is high enough, then the fixed cost threshold is strictly decreasing in progressivity, $\partial \bar{q}_c / \partial \tau_j < 0$, i.e. labor force participation of secondary earners is decreasing in progressivity.

Proof. *See Appendix A.3.*

I define a threshold value $\bar{q}_s$ for singles ($\bar{q}_c$ for secondary earners in couples) such that for singles with $q < \bar{q}_s$ (secondary earners with $q < \bar{q}_c$) it is optimal to work. In turn, with high enough values of q, singles and secondary earners choose not to work. Propositions 2 and 3 characterize the way these thresholds change with the degree of tax progressivity. On the one hand, higher tax progressivity encourages labor force participation of single individuals at the low end of the income distribution. Hence, a more progressive tax system creates a negative income effect on the labor supply of individuals whose income is below average. On the other hand, an increase in tax progressivity under joint taxation of spousal income discourages the labor force participation of the secondary earners. Joint taxation is often considered as one of the main factors that limits female labor force participation in the United States and some European countries (Bick and Fuchs-Schündeln, 2017a). These disincentive effects can have long-run consequences because of human capital depreciation, a feature that I account for in my quantitative model.

To provide more intuition, in Figure 5, I plot the average tax rates against income relative to average income for different degrees of tax progressivity τ. The red solid line corresponds to the U.S. tax schedule.[9] Furthermore, the blue dashed line represents the less progressive tax schedule with the progressivity parameter that is equal to $0.5\tau_{US}$, and black dash-dotted line represents the flat tax system, i.e. $\tau = 0$. An increase in tax progressivity (e.g., moving from the blue dotted line to the red solid line) decreases the average tax rate for households whose income is below average and increases it for those whose income is above average.

Taking stock, the simple model studied here highlights the different implications of tax progressivity for singles and couples. The presence of private within-household insurance through responses of spousal labor supply in couples reduces the demand for public insurance in the form of tax progressivity. Furthermore, higher tax progressivity may result in the opposite effects for employment of single and married secondary earners.

4 Quantitative Model

In this section, I present an overlapping generations model that incorporates single and married households facing uninsurable idiosyncratic labor productivity shocks, intensive and extensive margins of labor supply, and human capital accumulation. It provides a natural framework to analyze the tax reforms. I focus on a balanced growth equilibrium where long-run growth is generated by exogenous technological progress and thus drop time subscripts.

Economic Environment. Consider a closed overlapping generations economy populated by a continuum of individuals that are either males (m) or females (f). I index gender by i, so that $i \in \{m, f\}$. Time is discrete. There are no aggregate shocks. The production side is described by a constant returns to scale technology. The government levies taxes, spends money, and runs a balanced budget social security system.

Demographics. The economy is populated by A overlapping generations. Households are finitely lived, and their age is indexed by $a \in \{1, ..., A\}$. I assume that the population is constant. In each period, a unit measure of new agents is born. Each household is either a single (s) or a married couple (c). I index marital status by ι, so that $\iota \in \{s, c\}$. There are three types of households: single men, single women, and married couples. In the baseline model, I assume that agents are born as either single or married, and do not change the marital status over time. The life cycle of each individual is comprised of the working stage and retirement. During the working stage that runs from $a = 1$ to exogenous retirement age a_R, the agents have zero probability of dying. They choose how much to consume, work, and save. During the retirement stage, the

[9] Note that I use Figure 5 for illustrative purposes only. In the quantitative part of this paper, I estimate the tax and transfer function separately for single and married households.

agents do not work and face age-dependent survival probability ζ_a, and certainly die at age A, i.e. $\zeta_A = 0$. For tractability, I assume that spouses within each married couple have the same age and die at the same age.

Households. Household have preferences over consumption (c) and leisure (l). They discount the future at rate β. The momentary utility function for single household is given by

$$U^s(c,l) = \log(c) + \psi \frac{l^{1-\eta}}{1-\eta} \tag{6}$$

Married couples have joint utility function over (public) consumption and spousal leisure:

$$U^c\left(c, l^m, l^f\right) = \log\left(\frac{c}{\xi}\right) + \psi \frac{\left(l^m\right)^{1-\eta}}{1-\eta} + \psi \frac{\left(l^f\right)^{1-\eta}}{1-\eta} \tag{7}$$

where ξ denotes the consumption equivalence scale. Parameter ψ defines the utility weight attached to leisure and parameter η is the curvature of leisure that affects the Frisch elasticity of labor supply.

Each individual with gender i and marital status ι is endowed with $\bar{L}^i_\iota$ units of time that he/she splits between leisure and work. I interpret this time endowment to be net of home production, child care, and elderly care. Despite I do not explicitly model children, one can interpret lower $\bar{L}^i_\iota$ (and, therefore, less available time for leisure and work) as time costs associated with children. Furthermore, if an individual works, then he/she has to pay the fixed time cost of work. Therefore,

$$l^i_\iota = \bar{L}^i_\iota - n^i - q^i_\iota(a) \cdot \mathbb{1}\{n^i > 0\} \tag{8}$$

where n^i denotes hours of work, $\mathbb{1}\{n > 0\}$ is an indicator for working positive number of hours. The net time endowment is given by

$$\bar{L}^i_\iota = \frac{112}{1 + \exp\left(\varphi^i_\iota\right)} \tag{9}$$

where the gross time endowment is calculated as 168 hours (24×7 hours) minus 56 hours (8×7 hours) for sleep. I estimate φ^i_ι using the model.

I allow the fixed cost of work $q_\iota^i(a)$ to depend on gender, marital status, and age. Following Borella et al. (2021), I assume that it is described by a quadratic function of age[10]

$$q_\iota^i(a) = \frac{\exp\left(\alpha_0^{i,\iota} + \alpha_1^{i,\iota} a + \alpha_2^{i,\iota} a^2\right)}{1 + \exp\left(\alpha_0^{i,\iota} + \alpha_1^{i,\iota} a + \alpha_2^{i,\iota} a^2\right)} \tag{10}$$

and estimate parameters $\left(\alpha_0^{i,\iota}, \alpha_1^{i,\iota}, \alpha_2^{i,\iota}\right)$ using the model.

Human Capital. Women endogenously accumulate human capital through the labor market experience. In particular, following Attanasio et al. (2008), I assume that women's human capital evolves according to

$$h_{a+1} = h_a + (\varsigma_0 + \varsigma_1 a) \cdot \mathbb{1}\{n_a^f > 0\} - \delta_h \cdot \mathbb{1}\{n_a^f = 0\} \tag{11}$$

where ς_0 and ς_1 denote the returns to human capital, δ_h denotes human capital depreciation. Each period, if a woman works, her human capital increases by $\varsigma_0 + \varsigma_1$ units. I assume that the returns to human capital depend on age. Following Olivetti (2006) and Attanasio et al. (2008), if $\varsigma_1 < 0$, then I interpret it as the diminishing with age returns to human capital. In turn, if a woman does not work, it depreciates by δ_h units.[11]

Labor Productivity and Wages. During the working period, labor productivity of individuals depends on their human capital h (for women) or age a (for men), permanent ability υ, and persistent idiosyncratic shock u. I assume that retired individuals aged $a \geq a_R$ have zero labor productivity. Denote the experience efficiency profile for women by $g^f(h)$ and the age-efficiency profile for men by $g^m(a)$. Permanent ability $\upsilon^i \sim \mathcal{N}\left(0, \sigma_{\upsilon^i}^2\right)$ is drawn once at birth and accounts for differences in education and innate abilities. I allow the draws for spouses to be correlated (ρ_υ). This correlation measures the degree of assortative mating in the economy. Rich existing literature documents positive assortative mating by education in many countries, i.e. people with similar levels of education are more likely to marry each other (Pencavel, 1998; Greenwood et al., 2014; Eika et al., 2019). The idiosyncratic productivity shock u follows an AR(1) process:

$$u_a^i = \rho^i u_{a-1}^i + \varepsilon_a^i, \qquad \varepsilon_a^i \sim \mathcal{N}\left(0, \sigma_{\varepsilon^i}^2\right) \tag{12}$$

[10] For example, this functional form allows to capture the role of child rearing for married women's labor force participation in a simple way.

[11] This formulation of human capital accumulation process is also close to the one described in Blundell et al. (2016a). They allow the returns to human capital to depend on whether a woman works full-time or part-time.

In each period, the log wage of a female characterized by age a, human capital h, permanent ability υ, and stochastic labor productivity u is given by

$$\log\left(\tilde{\omega}^{f}\left(a,h,\upsilon,u\right)\right)=\log\left(\tilde{w}\right)+\underbrace{\gamma_{0}^{f}+\gamma_{1}^{f}h+\gamma_{2}^{f}h^{2}+\gamma_{3}^{f}h^{3}}_{\text{experience-efficiency profile, } g^{f}(h)}+\upsilon^{f}+u^{f} \tag{13}$$

where $\tilde{w}$ is the aggregate wage per efficiency unit of labor.[12] Thus, a female with $\left(a,h,\upsilon^{f},u^{f}\right)$ has $\exp\left(g^{f}(h)\upsilon^{f}u^{f}\right)$ efficiency units of labor.

Similarly, the log wage of a male characterized by age a, permanent ability υ, and stochastic labor productivity u is given by

$$\log\left(\tilde{\omega}^{m}\left(a,\upsilon,u\right)\right)=\log\left(\tilde{w}\right)+\underbrace{\gamma_{0}^{m}+\gamma_{1}^{m}a+\gamma_{2}^{m}a^{2}+\gamma_{3}^{m}a^{3}}_{\text{age-efficiency profile, } g^{m}(a)}+\upsilon^{m}+u^{m} \tag{14}$$

Thus, a male with (a,υ^{m},u^{m}) has $\exp\left(g^{m}(a)\upsilon^{m}u^{m}\right)$ efficiency units of labor. I estimate the returns to age and experience using the PSID data.

Production. The production side of the economy is given by a representative firm that operates a constant returns to scale technology described by a Cobb-Douglas production function:

$$F_{t}\left(K_{t},N_{t}\right)=K_{t}^{\alpha}\left(Z_{t}N_{t}\right)^{1-\alpha} \tag{15}$$

where K_t is capital input, N_t is labor input measured in efficiency units, and $Z_t=(1+\mu)^{t}Z_0$ is labor-augmenting technological progress. I normalize $Z_0=1$. Capital accumulation is standard and given by

$$K_{t+1}=\left(1-\delta\right)K_{t}+I_{t} \tag{16}$$

where I_t is gross investment and δ is the capital depreciation rate.

The aggregate resource constraint is given by

$$C_{t}+K_{t+1}-(1-\delta)K_{t}+G_{t}\leq K_{t}^{\alpha}\left(Z_{t}N_{t}\right)^{1-\alpha} \tag{17}$$

In each period, the firm rents labor efficiency units at rate w and capital at rate r, and maximizes its profit

$$\pi_{t}=Y_{t}-\left(r_{t}+\delta\right)K_{t}-w_{t}N_{t} \tag{18}$$

[12] As I explain later, I transform the growing economy into a stationary one, and therefore the wage per efficiency unit of labor $\tilde{w}$ is equal to the wage per efficiency unit of labor in a growing economy w_t divided by labor-augmenting technological progress Z_t.

Government. The government levies consumption and income taxes, spends collected revenues, and runs a balanced budget pay-as-you-go Social Security system. Retired individuals receive Social Security benefits ss that are independent of their earnings history. These benefits are financed by proportional payroll taxes at exogenous rate τ_{ss}.[13] There are no annuity markets, and the assets of households that die are collected by the government and uniformly redistributed among households that are currently alive as accidental bequests ($\tilde{\Omega}$).

The government needs to finance an exogenously given level of government consumption G. It collects revenue from the following sources. First, there is a proportional consumption tax (t_c). Second, the government taxes household income of singles, $y^m = \tilde{\omega}^m (a, \upsilon, u)\, n^m$ and $y^f = \tilde{\omega}^f (h, \upsilon, u)\, n^f$, and couples $y^c = \tilde{\omega}^m (a, \upsilon, u)\, n^m + \tilde{\omega}^f (h, \upsilon, u)\, n^f$, where $\tilde{\omega}^f$ and $\tilde{\omega}^m$ are given in (13) and (14) correspondingly. I use the tax and transfer function of the form (1) and allow its parameters to vary by marital status of taxpayers. For singles, it is given by

$$T^s (y; \lambda_s, \tau_s) = y - \lambda_s y^{1-\tau_s} \tag{19}$$

Couples are taxed on the basis of joint spousal income,

$$T^j (y_m, y_f; \lambda_j, \tau_j) = y^m + y^f - \lambda_j \left(y^m + y^f\right)^{1-\tau_j} \tag{20}$$

Market Structure. I assume that the asset market is incomplete, so that individuals cannot insure against idiosyncratic labor productivity risk by trading explicit insurance contracts. Furthermore, annuity markets are missing. Individuals can trade one-period risk-free bonds but cannot borrow.

4.1 Recursive Formulation

At any period of time, a single household is characterized by gender (i), asset holdings (b), human capital (h), permanent ability (υ^i), and idiosyncratic labor productivity (u^i), and age (a).[14] Hence the individual state space for single males is $(m, b, \upsilon^m, u^m, a)$. The individual state space for single females is $\left(f, b, h, \upsilon^f, u^f, a\right)$. The individual state space for married couples is $(b, h, \boldsymbol{\upsilon}, \boldsymbol{u}, a)$, where $\boldsymbol{\upsilon} = \left(\upsilon^m, \upsilon^f\right)$ and $\boldsymbol{u} = \left(u^m, u^f\right)$. I transform the growing economy into a stationary one by deflating all appropriate variables by the growth factor Z_t.[15] I denote by $\tilde{x}$ the deflated variable x_t, i.e. x_t/Z_t. In what follows, I describe the problems of single and married households during the working and retirement stages of life.

[13] I assume that Social Security benefits do not depend on the earnings history to reduce the computational burden, so that I do not need to keep track of Social Security contributions.

[14] Recall that human capital is a relevant state variable only for females.

[15] See King et al. (2002) for the discussion.

Single Males (Working Stage). The recursive problem for a single male during the working stage is given by

$$V^m\left(\tilde{b}, \upsilon, u, a\right) = \max_{\tilde{c}, \tilde{b}', n}\left[U^m\left(\tilde{c}, l\right) + \beta \mathbb{E} V^m\left(\tilde{b}', u', \upsilon, a+1\right)\right] \tag{21}$$

subject to

$$(1+t_c)\,\tilde{c} + (1+\mu)\tilde{b}' = (1-\tau_{ss})\underbrace{\tilde{\omega}^m\left(a, \upsilon, u\right) n^m}_{\text{labor income}} + \underbrace{(1+r)\left(\tilde{b}+\tilde{\Omega}\right)}_{\text{savings + accidental bequests}} + \underbrace{\tilde{T}}_{\text{lump-sum transfers}} - T^s\underbrace{\left(\left(1-0.5\tau_{ss}\right)\tilde{\omega}^m\left(a, \upsilon, u\right) n^m + r\left(\tilde{b}+\tilde{\Omega}\right)\right)}_{\text{taxable income}} \tag{22}$$

$$l^m = \bar{L}^m_s - n^m - q^m_s(a)\cdot \mathbb{1}\{n^m > 0\} \tag{23}$$

$$\tilde{b}' \geq 0, \quad \tilde{c} > 0, \quad n^m \geq 0, \quad a < a_R \tag{24}$$

The expectation in (21) is taken over the next period's labor productivity shock.

Single Females (Working Stage). The recursive problem for a single female during the working stage is given by

$$V^f\left(\tilde{b}, h, \upsilon, u, a\right) = \max_{\tilde{c}, \tilde{b}', n}\left[U^f\left(\tilde{c}, l\right) + \beta \mathbb{E} V^f\left(\tilde{b}', h', u', \upsilon, a+1\right)\right] \tag{25}$$

subject to

$$(1+t_c)\,\tilde{c} + (1+\mu)\tilde{b}' = (1-\tau_{ss})\,\tilde{\omega}^f\left(h, \upsilon, u\right) n^f + (1+r)\left(\tilde{b}+\tilde{\Omega}\right) + \tilde{T} - T^s\left(\left(1-0.5\tau_{ss}\right)\tilde{\omega}^f\left(h, \upsilon, u\right) n^f + r\left(\tilde{b}+\tilde{\Omega}\right)\right) \tag{26}$$

$$l^f = \bar{L}^f_s - n^f - q^f_s(a)\cdot \mathbb{1}\{n^f > 0\} \tag{27}$$

$$h' = h + (\varsigma_0 + \varsigma_1 a)\cdot \mathbb{1}\{n^f > 0\} - \delta_h \cdot \mathbb{1}\{n^f = 0\} \tag{28}$$

$$\tilde{b}' \geq 0, \quad \tilde{c} > 0, \quad n^f \geq 0, \quad a < a_R \tag{29}$$

The expectation in (25) is taken over the next period's labor productivity shock.

Married Couples (Working Stage). The recursive problem for a married couple during the working stage is given by

$$V^c\left(\tilde{b}, h, \boldsymbol{\upsilon}, \boldsymbol{u}, a\right) = \max_{\tilde{c}, \tilde{b}', n^m, n^f}\left[U^c\left(\tilde{c}, l^m, l^f\right) + \beta \mathbb{E} V^c\left(\tilde{b}', h', \boldsymbol{\upsilon}, \boldsymbol{u}', a+1\right)\right] \tag{30}$$

subject to

$$(1+t_c)\,\tilde{c}+(1+\mu)\tilde{b}' = (1-\tau_{ss})\left[\tilde{\omega}^m(a,\upsilon,u)\,n^m+\tilde{\omega}^f(h,\upsilon,u)\,n^f\right]+(1+r)\left(\tilde{b}+2\tilde{\Omega}\right)+ \\ 2\tilde{T}-T^c\left(\sum_{i=m,f}(1-0.5\tau_{ss})\,\tilde{\omega}^i(h,a,\upsilon,u)\,n^i+r\left(\tilde{b}+2\tilde{\Omega}\right)\right) \quad (31)$$

$$l^m = \bar{L}^m_c - n^m - q^m_c(a)\cdot\mathbb{1}\{n^m>0\} \quad (32)$$

$$l^f = \bar{L}^f_c - n^f - q^f_c(a)\cdot\mathbb{1}\{n^f>0\} \quad (33)$$

$$h' = h+(\varsigma_0+\varsigma_1 a)\cdot\mathbb{1}\{n^f>0\}-\delta_h\cdot\mathbb{1}\{n^f=0\} \quad (34)$$

$$\tilde{b}'\geq 0,\quad \tilde{c}>0,\quad ,n^m\geq 0,\quad n^f\geq 0,\quad a<a_R \quad (35)$$

The expectation in (30) is taken over the next period's labor productivity shocks for each of the spouses.[16]

Single Households (Retirement Stage). The recursive problem for a single individual with gender $i\in\{m,f\}$ during the retirement stage is given by

$$V^i\left(\tilde{b},a,\upsilon\right)=\max_{\tilde{c},\tilde{b}'}\left[U^i\left(\tilde{c},\bar{L}^i_s\right)+\zeta_a\beta V^i\left(\tilde{b}',a+1,\upsilon\right)\right] \quad (36)$$

subject to

$$(1+t_c)\,\tilde{c}+(1+\mu)\tilde{b}' = \underbrace{ss}_{\text{retirement benefits}}+(1+r)\left(\tilde{b}+\tilde{\Omega}\right)-T^s\left(ss+r\left(\tilde{b}+\tilde{\Omega}\right)\right) \quad (37)$$

$$\tilde{b}'\geq 0,\quad \tilde{c}>0,\quad a\geq a_R \quad (38)$$

Married Couples (Retirement Stage). Finally, the recursive problem for a married couple during the retirement stage is given by

$$V^c\left(\tilde{b},a,\upsilon\right)=\max_{\tilde{c},\tilde{b}'}\left[U^c\left(\tilde{c},\bar{L}^m_c,\bar{L}^f_c\right)+\zeta_a\beta V^c\left(\tilde{b}',a+1,\upsilon\right)\right] \quad (39)$$

subject to

$$(1+t_c)\,\tilde{c}+(1+\mu)\tilde{b}' = 2ss+(1+r)\left(\tilde{b}+2\tilde{\Omega}\right)-T^c\left(2ss+r\left(\tilde{b}+2\tilde{\Omega}\right)\right) \quad (40)$$

[16] In the baseline version of the model, they are assumed to be independent. I relax this assumption in Section 7.3.

$$\tilde{b}' \geq 0, \quad \tilde{c} > 0, \quad a \geq a_R \tag{41}$$

4.2 Recursive Competitive Equilibrium

Let $\Pi^m\left(\tilde{b}, \upsilon, u, a\right)$ be the measure of single males, $\Pi^f\left(\tilde{b}, h, \upsilon, u, a\right)$ be the measure of single females, and $\Pi^c\left(\tilde{b}, h, \boldsymbol{\upsilon}, \boldsymbol{u}, a\right)$ be the measure of married couples. A stationary recursive competitive equilibrium is defined by

1. Given initial conditions, prices, transfers, and social security benefits, the value functions $V^m\left(\Pi^m\right)$, $V^f\left(\Pi^f\right)$, and $V^c\left(\Pi^c\right)$, and associated policy functions for consumption, hours, and savings, $\tilde{c}\left(\Pi^m\right)$, $n^m\left(\Pi^m\right)$, $\tilde{b}\left(\Pi^m\right)$, $\tilde{c}\left(\Pi^f\right)$, $n^f\left(\Pi^f\right)$, $\tilde{b}\left(\Pi^f\right)$, $\tilde{c}\left(\Pi^c\right)$, $n^m\left(\Pi^c\right)$, $n^f\left(\Pi^c\right)$, and $\tilde{b}\left(\Pi^c\right)$ solve the households' optimization problems.

2. Markets for labor, capital, and final output are clear:

$$\begin{aligned}\tilde{N} = \int \exp\left(g^m(a)\upsilon^m u^m\right) n^m d\Pi^m + \int \exp\left(g^f(h)\upsilon^f u^f\right) n^f d\Pi^f + \\ \int \left(\exp\left(g^m(a)\upsilon^m u^m\right) n^m + \exp\left(g^f(h)\upsilon^f u^f\right) n^f\right) d\Pi^c\end{aligned} \tag{42}$$

$$\tilde{K} = \int \tilde{b} d\Pi^m + \int \tilde{b} d\Pi^f + \int \tilde{b} d\Pi^c \tag{43}$$

$$\int \tilde{c} d\Pi^m + \int \tilde{c} d\Pi^f + \int \tilde{c} d\Pi^c + (\mu + \delta)\tilde{K} + \tilde{G} = \tilde{K}^\alpha \tilde{N}^{1-\alpha} \tag{44}$$

3. The factor prices satisfy:

$$\tilde{w} = (1-\alpha)\left(\frac{\tilde{K}}{\tilde{N}}\right)^\alpha \tag{45}$$

$$r = \alpha\left(\frac{\tilde{K}}{\tilde{N}}\right)^{\alpha-1} - \delta \tag{46}$$

4. The assets of dead households are uniformly redistributed among households that are currently alive:

$$\begin{aligned}\tilde{\Omega}\left(\int \zeta_a d\Pi^m + \int \zeta_a d\Pi^f + \int \zeta_a d\Pi^c\right) = \\ \int (1-\zeta_a)\tilde{b} d\Pi^m + \int (1-\zeta_a)\tilde{b} d\Pi^f + \int (1-\zeta_a)\tilde{b} d\Pi^c\end{aligned} \tag{47}$$

5. The social security system is budget balanced:

$$\tau_{ss}\tilde{w}\tilde{N} = ss\left(\int_{a\geq a_R} d\Pi^m + \int_{a\geq a_R} d\Pi^f + \int_{a\geq a_R} d\Pi^c\right) \tag{48}$$

6. The government budget is balanced:

$$\begin{aligned}\tilde{G} = t_c\left(\int \tilde{c}d\Pi^m + \int \tilde{c}d\Pi^f + \int \tilde{c}d\Pi^c\right) + \\ \int T^s\left(\left(1-0.5\tau_{ss}\right)\tilde{w}\exp\left(g^m(a)\upsilon^m u^m\right)n^m + r\left(\tilde{b}+\tilde{\Omega}\right)\right)d\Pi^m + \\ \int T^s\left(\left(1-0.5\tau_{ss}\right)\tilde{w}\exp\left(g^f(h)\upsilon^f u^f\right)n^f + r\left(\tilde{b}+\tilde{\Omega}\right)\right)d\Pi^f + \\ T^c\left(\left(1-0.5\tau_{ss}\right)\left(\tilde{w}\exp\left(g^m(a)\upsilon^m u^m\right)n^m + \tilde{w}\exp\left(g^f(h)\upsilon^f u^f\right)n^f\right) + r\left(\tilde{b}+2\tilde{\Omega}\right)\right)\end{aligned} \tag{49}$$

5 Parameterization

I now discuss the parameter choices for the model. I parameterize the model using a two-stage procedure (Gourinchas and Parker, 2002). In the first stage, I calibrate the parameters that can be set directly to their empirical counterparts without using the model. I take some parameter values from the literature, and estimate the remaining parameters directly from the data. In the second stage, I use the Method of Simulated Moments (MSM) (Pakes and Pollard, 1989; Duffie and Singleton, 1993). In Appendix C.2, I described the estimation procedure in detail.

5.1 First-Stage Parameterization

Demographics. A model period is one year. The individuals enter the economy at age 25 (model age 1), retire at age 65 (model age 41) and live up to a maximum age of 100 (model age 76). I take the survival probabilities from “Life table for the total population: United States, 2014” provided by the National Center for Health Statistics. Table F.1 reports the survival probabilities for the ages 65-100. I take an adult equivalence scale from OECD, $\xi = 1.7$. Following Guner et al. (2012a), I set the share of married couples to be 77% of all households.

Preferences. Following Erosa et al. (2016), I set parameter η that governs the Frisch elasticity of labor supply to 2. Discount factor β, the utility weight attached to leisure ψ, and parameters that govern net time endowment and fixed cost of work are estimated in the second stage.

Human Capital. Following Attanasio et al. (2008), I set $\varsigma_0 = 0.0266$ and $\varsigma_1 = -0.00038$. Negative ς_1 implies that the returns to human capital diminish with age. Furthermore, I set human

Table 1: Parameters calibrated at the first stage

Parameter	Description	Value	Source
a_R	Retirement age: 65 years	41	Standard
A	Maximum age: 100 years	76	Standard
ζ_a	Survival probability	Table F.1	NCHS
ξ	Adult equivalence scale	1.7	OECD
ϖ	Share of married couples	0.77	Guner et al. (2012a)
η	Leisure curvature	2	Erosa et al. (2016)
ς_0, ς_1	Returns to human capital	0.0266, -0.00038	Attanasio et al. (2008)
δ_h	Human capital depreciation	0.074	Attanasio et al. (2008)
γ_1^m, γ_2^m, γ_3^m	Age-efficiency profile, males	Text	PSID
γ_1^f, γ_2^f, γ_3^f	Experience-efficiency profile, females	Text	PSID
ρ^m, ρ^f	Productivity shock, persistence	0.937, 0.939	PSID
σ_{ε^m}, σ_{ε^f}	Productivity shock, st.dev.	0.187, 0.145	PSID
σ_{υ^m}, σ_{υ^f}	Permanent ability. st.dev.	0.332	PSID
α	Technology	0.36	Capital share
δ	Capital depreciation rate	0.0799	BEA, $I/K = 9.74\%$
μ	Growth rate	0.0175	U.S. data
τ_{ss}	Social security tax	0.106	Kitao (2010)
t_c	Consumption tax	0.052	Mendoza et al. (1994)
τ_s, τ_j	Tax progressivity	0.125, 0.147	PSID, NBER TAXSIM
G/Y	Government consumption	0.17	U.S. data

capital depreciation rate to $\delta_h = 0.074$.

Labor Productivity. I estimate the age-efficiency profile for the wages of males (γ_1^m, γ_2^m, and γ_3^m) and experience-efficiency profile for the wages of females (γ_1^f, γ_2^f, and γ_3^f) using the PSID data. To control for selection into the labor market, I use a two-step Heckman approach. Having estimated the returns to age and experience, I use the residuals from regressions together with the panel structure of the PSID data to estimate the parameters of the productivity shock processes (ρ^m, $\sigma^2_{\varepsilon^m}$, ρ^f, and $\sigma^2_{\varepsilon^f}$) and the variance of permanent ability ($\sigma^2_{\upsilon^m}$ and $\sigma^2_{\upsilon^f}$), following the identification strategy by Storesletten et al. (2004). I normalize $\gamma_0^f = 1$ and estimate γ_0^m in the second stage.[17]

Production. I set $\alpha = 0.36$ to match the capital share. Furthermore, I set the capital depreciation rate $\delta = 0.0799$ to match the average U.S. investment-capital ratio of 9.74% reported by the U.S. Bureau of Economic Analysis (BEA) for 2012-2016. To match the long-run growth rate of the U.S. GDP per capita, I set $\mu = 0.0175$ (Conesa and Krueger, 2006).

Government. Following Kitao (2010), I set the payroll tax rate to $\tau_{ss} = 10.6\%$. The retirement

[17] Note that γ_0^m should not be interpreted as the gender wage gap between 25-year-old males and females. This is due to the fact that the age-efficiency profile for men starts at 25 years, while the experience-efficiency profile for women starts at 0 years.

Table 2: Parameters estimated by the Method of Simulated Moments

	Description	Value	Moment
β	Discount factor	0.996	Capital-output ratio
ψ	Taste for leisure	7.31	Working hours
γ_0^m	Male wage parameter	-1.092	Average gender wage gap
$\bar{L}_c^m$	Time endowment, married men	0.91	Working hours, married men
$\bar{L}_s^f$	Time endowment, single women	0.99	Working hours, single women
$\bar{L}_c^f$	Time endowment, married women	0.80	Working hours, married women
$\alpha_0^{i,\iota}, \alpha_1^{i,\iota}, \alpha_2^{i,\iota}$	Fixed costs of work	Text	Labor participation rates

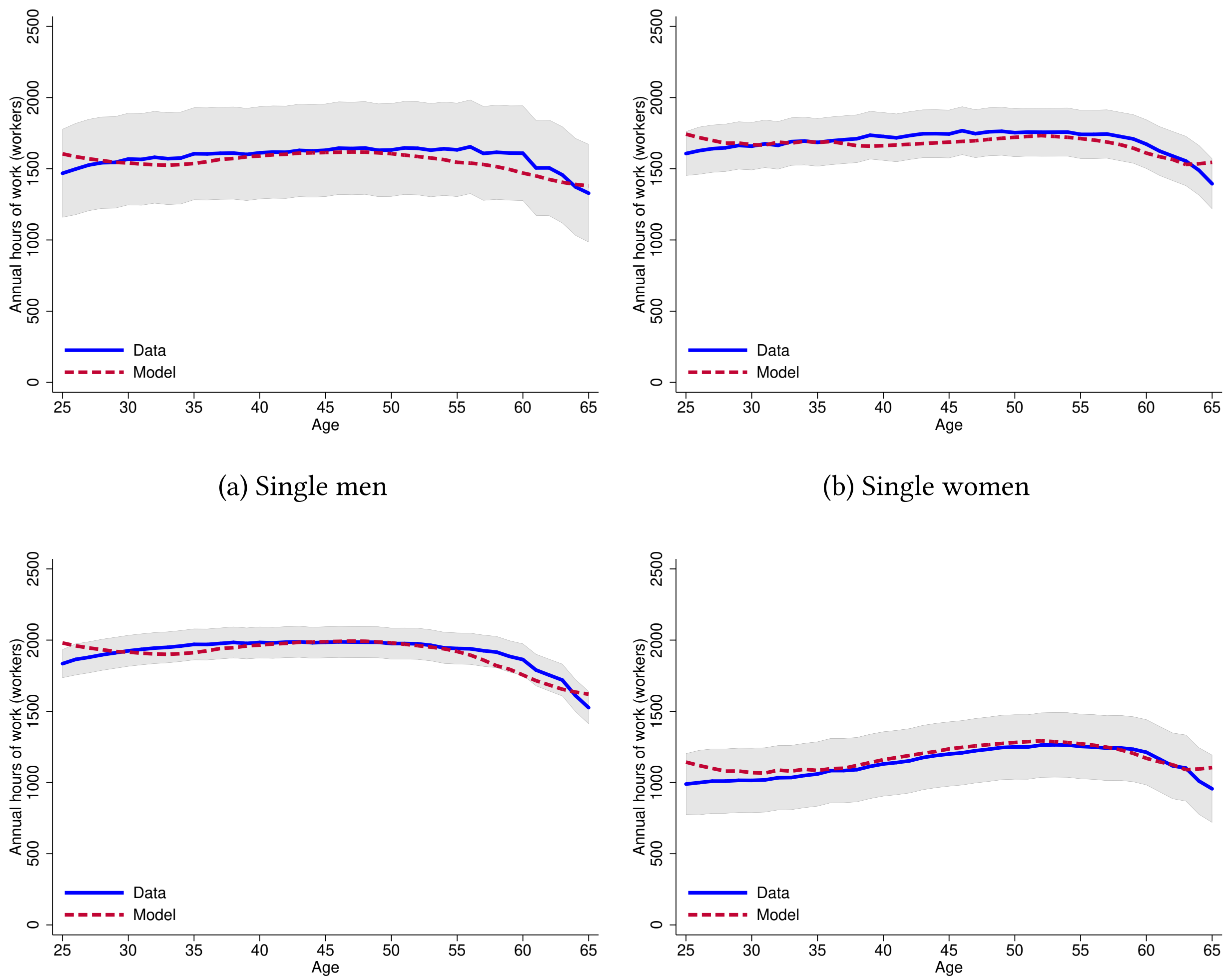
benefit ss is determined endogenously from the Social Security system budget constraint (48), and the resulting replacement rate is about 45%. Next, using the estimate from Mendoza et al. (1994), I set consumption tax rate to $t_c = 5.2\%$. Finally, I estimate the parameters of the tax and transfer functions (19) and (20) using the PSID data for waves 2013, 2015, and 2017 combined with the NBER TAXSIM (Feenberg and Coutts, 1993). The resulting values for the degree of tax progressivity are $\tau_s = 0.125$ and $\tau_j = 0.147$. My estimates are close to ones from Heathcote et al. (2017), who estimate $\tau = 0.181$ using the PSID and survey years 2000-2006, and Holter et al. (2019), who estimate $\tau_s = 0.111$ and $\tau_j = 0.158$ using the OECD tax and benefit calculator for years 2000-2007. They are higher than ones reported by Guner et al. (2014), who use the data from the Internal Revenue Service (IRS) 2000 Public Use Tax File, and hence do not account for transfers. Appendix B.2 discusses the estimation in detail. I choose the level of government consumption G so that in a balanced growth path its share in GDP is equal to 17%.

Table 1 summarizes the parameter values selected in the first stage.

5.2 Second-Stage Estimation

In the second stage, I estimate parameters $\left(\beta, \psi, \gamma_0^m, \left(\alpha_0^{i,\iota}, \alpha_1^{i,\iota}, \alpha_2^{i,\iota}\right), \bar{L}_\iota^i\right)$. I choose the following moments from the U.S. data to pin down these parameters: capital-output ratio, average female-to-male hourly wage ratio, labor market participation (employment) of single and married men and women between age 25 and age 65, and hours of work (conditional on working) of single and married men and women between age 25 and age 65. Table 2 summarizes the parameter values estimated in the second stage.[18]

[18] Net time endowments are expressed as fractions of the net time endowment for single males that I normalize to 112 hours.



(a) Single men

(b) Single women

(c) Married men

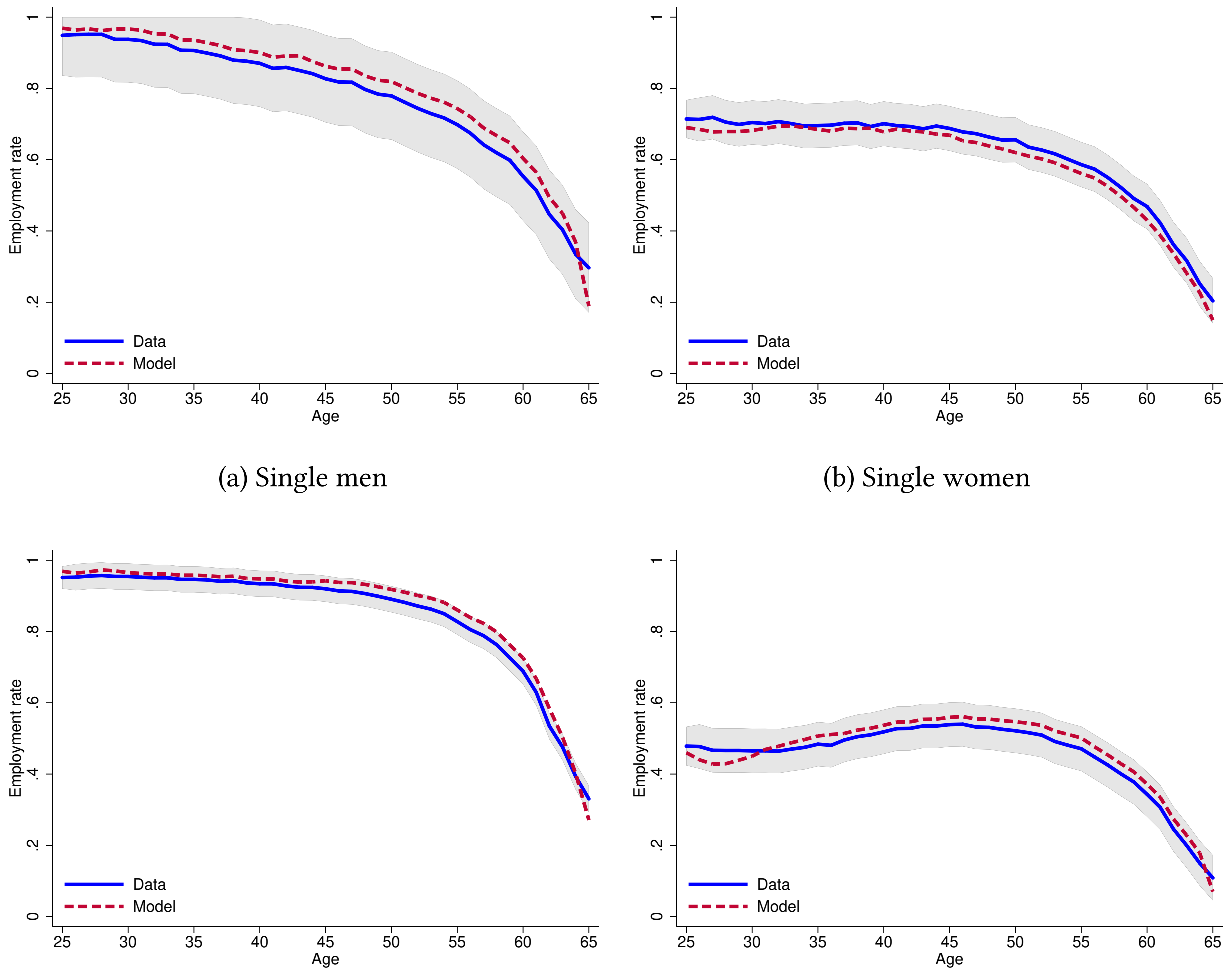
(d) Married women

Figure 6: Hours of work (for workers) over the life cycle, model and data

NOTES: The shaded area represents the 95% confidence interval.

5.3 Model Fit

In this section, I briefly discuss whether the model fits the data well. Figure 6 reports the lifecycle profile of hours of work (conditional on working) for single men and women and married men and women. As in the data, both male and female workers do not significantly vary the hours of work over the life cycle. Figure 7 reports the lifecycle profile of labor participation. As in the data, women (especially married) choose to enter the labor market relatively later than men. Overall, the model fits the targeted data well.



(a) Single men

(b) Single women

(c) Married men

(d) Married women

Figure 7: Participation over the life cycle, model and data

NOTES: The shaded area represents the 95% confidence interval.

Table 3: Model fit

Moment	Data	Model
Capital-output ratio	3.2	3.17
Gender wage gap	0.72	0.729
Working hours	See Figure 6	See Figure 6
Labor participation rates	See Figure 7	See Figure 7

5.4 Model Performance

In this section, I verify how my model performs along the dimensions that are not targeted by calibration. In particular, given the crucial importance of labor supply elasticities in evaluating the effects of tax and transfer reforms, I report the model-implied compensated labor supply elasticities. To obtain them, I temporarily increase the wage for a particular gender-marital status-age group (e.g., single men aged 40) by 1%.

Table 4 reports the intensive margin labor supply elasticities for single men and women and married men and women by age groups. Table 5 reports the extensive margin labor supply elasticities for single men and women and married men and women by age groups. Remarkably, elasticities for men are lower than for women. Moreover, there is a substantial variation in extensive margin elasticities over the life cycle. Notably, participation elasticities are very high around the time of retirement. My estimates are consistent with the results from Attanasio et al. (2018).

Table 4: Intensive margin labor supply elasticities generated by the model

Age	Single men	Single women	Married men	Married women
30	0.32	0.37	0.42	0.54
40	0.43	0.44	0.52	0.63
50	0.41	0.42	0.49	0.61
60	0.29	0.34	0.43	0.56

Table 5: Extensive margin labor supply elasticities generated by the model

Age	Single men	Single women	Married men	Married women
30	0.16	0.57	0.02	0.96
40	0.21	0.42	0.11	0.73
50	0.47	0.45	0.19	0.64
60	1.24	1.92	0.71	1.13

6 Tax Reforms

In this section, I consider the main quantitative exercise. In particular, I take the Social Security system and consumption tax rate t_c as given and optimize the social welfare over income tax schedules that are allowed to be different for single and married households within a parametric class (1).

Table 6: Aggregate effects of tax reforms

Parameter/Variable	U.S. Benchmark	Optimal	Proportional	Fixed (w, r)
Progressivity τ_s	0.125	0.151	0	0.153
Progressivity τ_j	0.147	0.108	0	0.109
Interest rate	2.77%	2.41%	2.12%	2.77%
Wage rate	—	1.72%	2.68%	—
Aggregate hours	—	2.71%	3.72%	2.66%
Married women employment, %	0.692	0.718	0.731	0.717
Aggregate output	—	0.76%	2.04%	0.67%
Aggregate consumption	—	0.91%	1.77%	0.90%
Gini (consumption)	0.314	0.325	0.354	0.325
Welfare gain	—	1.31%	0.51%	1.27%

NOTES: In this table, I report the percentage change in macroeconomic variables for each tax reform. The changes in interest rate and Gini are reported in terms of percentage points. Column "Benchmark" corresponds to the status-quo economy.

6.1 Optimal Policy

To rank tax functions, I use the social welfare function that is defined as the ex-ante steady state expected utility of newborn households. Formally, the problem of the utilitarian government is given by[19]

$$SWF(\tau_s, \tau_j, \lambda_s, \lambda_j) = \int_{\{(\tilde{b}, h, \upsilon, \boldsymbol{u}, a):\tilde{b}=0, a=1\}} V^c\left(\tilde{b}, h, \upsilon, \boldsymbol{u}, a\right) d\Pi^c + \sum_{i=m,f} \int_{\{(\tilde{b}, h, \upsilon, u, a):\tilde{b}=0, a=1\}} V^i\left(\tilde{b}, h, \upsilon, u, a\right) d\Pi^i \quad (50)$$

In my policy experiments, parameter λ_s endogenously adjusts to keep the government budget constraint balanced. By having one budget constraint, I allow for cross-redistribution between singles and couples.[20] The government chooses $(\tau_s, \tau_j, \lambda_j)$ so that

$$\left(\tau_s^*, \tau_j^*, \lambda_j^*\right) = \underset{\tau_s, \tau_j, \lambda_j}{\operatorname{argmax}}\, SWF(\tau_s, \tau_j, \lambda_j; \lambda_s) \quad (51)$$

Table 6 reports the results. The first finding is that singles ($\tau_s^* = 0.151$) should be taxed

[19] Several papers challenge the assumption about utilitarian taste for redistribution (Moser and Olea de Souza e Silva, 2019; Heathcote and Tsujiyama, 2021; Wu, 2021). For example, Heathcote and Tsujiyama (2021), using the inverse-optimum approach, conclude that the current U.S. tax and transfer system is characterized by a weaker than utilitarian taste for redistribution.

[20] Another alternative is to have two separate government budget constraints, one for singles and one for couples. In this case, redistribution occurs within groups but not between them.

Table 7: Welfare decomposition

Total welfare gain	1.31%
Consumption, couples	
Level	
Distribution	
Leisure, married men	
Level	
Distribution	
Leisure, married women	
Level	
Distribution	
Consumption, singles	
Level	
Distribution	
Leisure, singles	
Level	
Distribution	

NOTES: In this table, I report the decomposition of aggregate welfare gain generated by moving from the actual U.S. tax system to the optimal one. The welfare gain is in consumption-equivalent terms.

more progressively than couples ($\tau_j^* = 0.108$). Second, I find that the optimal tax schedule has a higher degree of progressivity for singles and lower progressivity for couples relative to the actual income tax policy ($\tau_s = 0.125$ and $\tau_j = 0.147$). The optimal tax reform increases the couples' average elasticity of post-tax/transfer income to pre-tax/transfer income from 0.853 (under actual U.S. tax system) to 0.892 (under optimal tax system). This gives rise to an increase in married women participation by 2.6 p.p. (from 69.2% to 71.8%). Furthermore, replacing the U.S. tax and transfer system with the optimal schedule is associated with sizable welfare gain of 1.31% in consumption-equivalent terms.

Given that both consumption and labor supply are higher under the optimal tax system, it is instructive to decompose the aggregate welfare gain into corresponding components. To do this, I follow Conesa et al. (2009). Figure 7 reports the results.

In addition, I also consider a reform that replaces the current U.S. tax schedule with a flat tax system. In this case, $\tau_s = \tau_j = 0$. The results are reported in column "Proportional" of Table 6. Despite the aggregate output and aggregate consumption are higher under this reform relative to the optimal reform, it creates smaller welfare gain (0.51%). This reflects that there is a strong social demand for redistribution and insurance that the flat tax system cannot provide.

Finally, to evaluate the potential size of the bias that arises because I do not account for the transition to the optimal steady state, I compute the new steady state under optimal τ_s^* and τ_j^* but fixing the wage rate and interest rate at their benchmark levels. The last column of Table 6 shows that abstracting from changes in the capital stock between two steady states is not associated with significantly different welfare gain.

6.2 Distribution of Welfare Gains

In this section, I provide the decomposition of welfare gains from the optimal reform by permanent ability groups. I divide the population of men and women into four groups corresponding to the quartiles of the permanent ability distribution. Tables 8 and 9 report the results for singles and married couples correspondingly.

Table 8: Distribution of welfare gains for singles

	Q1	Q2	Q3	Q4
Males	1.6%	0.8%	0.2%	-0.4%
Females	1.8%	0.8%	0.2%	-0.4%

NOTES: In this table, I report the distribution of welfare gains by permanent ability groups υ. The groups are defined as the quartiles of permanent ability distribution.

Table 9: Distribution of welfare gains for married couples

	Q1, females	Q2, females	Q3, females	Q4, females
Q1, males	0.4%	0.4%	0.6%	0.9%
Q2, males	0.4%	0.6%	0.8%	1.0%
Q3, males	0.5%	0.7%	1.1%	1.5%
Q4, males	0.9%	1.1%	1.6%	2.1%

NOTES: In this table, I report the distribution of welfare gains by permanent ability groups υ. The groups are defined as the quartiles of permanent ability distribution. "Q1" denotes the bottom 25% of permanent ability distribution. "Q4" denotes the top 25% of permanent ability distribution.

First, the welfare gains are positive for all groups except for the subgroup of singles in the top quartile (Q4) of the permanent ability distribution. Second, the welfare gains are not uniformly distributed. For singles, the gains decrease along the permanent ability distribution, ranging from 1.6-1.8% for the bottom quartile (Q1) to -0.4% for the top quartile. Couples where both spouses belong to the bottom quartile of the permanent ability distribution, gain around 0.4% in consumption-equivalent terms. In turn, couples where both spouses belong to the top quartile of the permanent ability distribution, gain around 2.1% in consumption-equivalent terms.

6.3 Partial Reforms

In the previous section, I consider the reforms that change the tax and transfer schedules for both singles and couples. Now I ask the following question. Is there a welfare-improving reform that replaces the actual U.S. income tax code with a revenue-neutral income tax system so that the schedule for one group (e.g., singles) remains at the benchmark level while the schedule for the other group (e.g., couples) is changed. Table 10 reports the results.

I find that these "partial" reforms deliver aggregate welfare gain. Reforming tax schedule for singles, while keeping the tax schedule for couples fixed, delivers the welfare of 0.71%. On the other hand, reforming the tax schedule only for couples is associated with the welfare gain of 0.52%.

Table 10: Aggregate effects of partial tax reforms

Parameter/Variable	U.S. Benchmark	Optimal	Optimal τ_s	Optimal τ_j
Progressivity τ_s	0.125	0.151	0.178	0.125
Progressivity τ_j	0.147	0.108	0.147	0.091
Welfare gain	—	1.31%	0.71%	0.52%

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy. Column "Optimal τ_s" corresponds to the policy experiment where I keep progressivity for couples τ_j at the benchmark level and optimize over progressivity parameter for singles τ_s. Column "Optimal τ_j" corresponds to the policy experiment where I keep progressivity for singles τ_s at the benchmark level and optimize over progressivity parameter for couples τ_j.

6.4 What if We Abstract from Couples?

In this section, I consider the following exercise. Suppose that the government treat all the households as single individuals, and therefore everyone faces the same tax and transfer schedule. Furthermore, assume that the extensive margin of labor supply is not operative, so that everyone chooses to work positive number of hours (therefore, I also abstract away from human capital accumulation). In this environment, couples are treated as richer singles. What is the optimal tax policy recipe in this environment? Table 11 reports the results.

Table 11: Optimal tax policy in an environment where all households are singles

	U.S. Benchmark	Optimal	U.S. Benchmark (All Singles)	Optimal (All Singles)
Progressivity τ_s	0.125	0.151	—	—
Progressivity τ_j	0.147	0.108	—	—
Progressivity τ	—	—	0.139	0.186
Welfare gain	—	1.31%	—	1.12%

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy. Column "Benchmark (All Singles)" corresponds to the environment where I assume that economy is populated only by singles. Column "Optimal (All Singles)" corresponds to the optimal policy associated with this environment.

In this case, the government finds it optimal to increase the tax progressivity from $\tau = 0.139$ to $\tau^* = 0.186$. This experiment illustrates that explicitly modeling couples and accounting for the extensive margin of labor supply combined with human capital accumulation is qualitatively as well as quantitatively important for the optimal tax policy design.

6.5 Isolating the Changes in Tax Progressivity

In this section, I go one step further and ask how does the optimal tax schedule look like when the government varies the degree of progressivity but keeps the average tax rates at the status-quo level. As I show in Appendix B.1, with tax and transfer function 1, both marginal and average tax rates depend on parameters τ and λ. In particular, $MTR = 1-\lambda(1-\tau)y^{-\tau}$ and $ATR = 1-\lambda y^{-\tau}$. By changing the degree of tax progressivity as measured by parameter τ, the government also changes the parameter λ to balance the government budget. As a result, a new tax system can feature both new progressivity and a new average tax rate.

I follow the idea from Guvenen et al. (2014), and consider the following policy experiment. Suppose that the government chooses the degree of tax progressivity τ and adjust the parameter λ so that the new tax system has the same average tax rates for singles and couples as in the benchmark economy. To balance the government budget, I adjust the lump-sum transfers. Would the result that the couples should be taxed less progressively than singles still remain? Table 12 reports the results.

Table 12: Tax reform with a fixed average tax rate

	U.S. Benchmark	Optimal (Baseline)	Optimal (+ Fixed ATR)
Progressivity τ_s	0.125	0.151	0.144
Progressivity τ_j	0.147	0.108	0.117
Welfare gain	—	1.31%	1.16%

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy.

If the government changes the progressivity of the tax schedule for singles and couples but keeps their average tax rates at the pre-reform levels, the resulting policy again implies that couples should be taxed less progressively than singles.

7 Extensions

I consider several extensions of the model from Section 4. The goal of this section is to explore whether and how the main results from Section 6.1 change in the alternative environments where I relax some assumptions of the baseline model. As before, the government chooses the optimal tax and transfer schedule by maximizing over parameters of tax functions (19) and (20).

7.1 Government Debt

In the baseline version of the model, I assume that the government runs the balanced budget. In this section, I relax this assumption and allow the government to accumulate government debt. In the model, government debt enters the steady state government budget constraint and the market clearing condition for the asset market. As for timing, the government makes interest payments before the remaining tax revenues are redistributed to the households. Table 13 reports the results.

Table 13: Optimal tax policy in an environment with government debt

	U.S. Benchmark	Optimal (Baseline)	Optimal (+ Government Debt)
Progressivity τ_s	0.125	0.151	Pending
Progressivity τ_j	0.147	0.108	Pending
Welfare gain	—	1.31%	Pending

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy with no government debt.

7.2 Marriage and Divorce

In the baseline model, I assume that individuals are born with predetermined marital status and do not change it over the life cycle. Since the labor supply decisions substantially vary by age and marital status, it is desirable to have a plausible distribution of household types by age. In this section, I relax the assumption about fixed marital status, and model marriage and divorce as exogenous shocks in the spirit of Cubeddu and Ríos-Rull (2003), Chakraborty et al. (2015), and Holter et al. (2019). While accounting for the endogenous response of marriage and divorce rates to changes in tax policy is potentially important, the empirical literature finds that in the United States the magnitude of this impact is quite small. In other words, most individuals do not respond to tax incentives in their decisions about marriage and divorce (Alm and Whittington, 1995; Whittington and Alm, 1997; Alm and Whittington, 1999).[21] I assume that married individuals face an age-dependent probability of divorce (d_a). In turn, single individuals face an age-dependent probability of getting married (ϑ_a).

I follow the modeling approach of Holter et al. (2019) and allow for assortative mating by permanent ability (education) in the marriage market. To calculate the age-dependent probabilities of marriage and divorce, I use data from the Annual Social and Economic Supplement (ASEC) of the CPS for years 2013-2017. I assume that these probabilities do not depend on the birth cohort. Denote by m_a and d_a the probability for a single to get married and the probability for a married couple to divorce at age a correspondingly. I compute these objects from the following identities

$$\underbrace{\bar{M}(a+1)}_{\text{married at age } a+1} = \underbrace{m_a\left(1-\bar{M}(a)\right)}_{\text{divorced} \to \text{married}} + \underbrace{(1-d_a)\,\bar{M}(a)}_{\text{married} \to \text{married}} \tag{52}$$

$$\underbrace{\bar{D}(a+1)}_{\text{divorced at age } a+1} = \underbrace{(1-m_a)\,\bar{D}(a)}_{\text{divorced} \to \text{divorced}} + \underbrace{d_a\bar{M}(a)}_{\text{married} \to \text{divorced}} \tag{53}$$

where $\bar{M}(a)$ and $\bar{D}(a)$ denote the shares of married and divorced individuals at age a.

Parameter ϱ affects the probability of matching and hence captures the degree of assortative mating. When I parameterize the model, I estimate it using the Method of Simulated Moments by matching the correlation of hourly wages for married couples calculated from the CPS. Table 14 reports the results.

[21] Using the U.S. data, Fisher (2013) estimates that a \$1000 change in the marriage bonus or penalty is associated with a 1.7 p.p. (or 1.9%) change in the probability of marriage. This effect is substantially higher than in the other papers. For comparison, Persson (2020) finds that elimination of survivors insurance in Sweden raised the divorce rate by 10%.

Table 14: Optimal tax policy in an environment with marriage and divorce

	U.S. Benchmark	Optimal (Baseline)	Optimal (+ Marriage & Divorce)
Progressivity τ_s	0.125	0.151	0.148
Progressivity τ_j	0.147	0.108	0.111
Welfare gain	—	1.31%	1.34%

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy without marriage and divorce shocks.

In an environment with marriage and divorce, the results are very close to those from the baseline optimal reform. Intuitively, in an economy characterized by positive assortative mating, the government should increase the extent of public insurance against ex-post heterogeneity by taxing couples more progressively. However, since I already allow the spousal permanent abilities to be correlated, introduction of marriage and divorce shocks does not significantly change the distribution of households with different marital status by permanent ability. The resulting welfare gain is equal to 1.34% which is almost the same as under the baseline optimal policy. Overall, the conclusions from Section 6.1 continue to hold.

7.3 Correlated Productivity Shocks of Spouses

In the baseline version of the model, I assume that the draws of idiosyncratic productivity shocks are independent between spouses. In this section, I relax this assumption and allow them to be potentially correlated. In particular, $\left(u^m, u^f\right)$ follow

$$u_a^m = \rho^m u_{a-1}^m + \varepsilon_a^m$$

$$u_a^f = \rho^f u_{a-1}^f + \varepsilon_a^f$$

where $\left(\varepsilon^m, \varepsilon^f\right) \sim \mathcal{N}\left(\mathbf{0}, \mathbf{\Sigma}_{\boldsymbol{\varepsilon}}\right)$ and

$$\mathbf{\Sigma}_{\boldsymbol{\varepsilon}} = \begin{pmatrix} \sigma_{\varepsilon^m}^2 & \rho^\varepsilon \sigma_{\varepsilon^m} \sigma_{\varepsilon^f} \\ \rho^\varepsilon \sigma_{\varepsilon^m} \sigma_{\varepsilon^f} & \sigma_{\varepsilon^f}^2 \end{pmatrix}$$

Using the estimate from Hyslop (2001), I set the correlation between spousal shocks to be $\rho^\varepsilon = 0.25$. Table 15 reports the results.

Table 15: Optimal tax policy in an environment with correlated spousal productivity shocks

	U.S. Benchmark	Optimal (Baseline)	Optimal (+ Correlated Shocks)
Progressivity τ_s	0.125	0.151	0.149
Progressivity τ_j	0.147	0.108	0.115
Welfare gain	—	1.31%	1.43%

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy with idiosyncratic productivity shocks that are independent between spouses.

In an environment with positively correlated spousal labor productivity shocks, couples are taxed more progressively relative to the baseline optimal policy. Intuitively, this correlation strengthens the redistribution motive in order to insure against ex-post heterogeneity. Furthermore, higher positive correlation between spousal wages limits the degree of within-family insurance that operates through the changes in labor supply. The resulting welfare gain is slightly higher than under the baseline optimal policy. Nevertheless, the conclusions from Section 6.1 continue to hold.

7.4 Joint and Separate Filing for Couples

Despite in reality U.S. married couples can choose between joint and separate filing, almost all choose the former option, and therefore in the baseline model I assume that they are taxed on the basis of combined spousal income.[22] In this section, I consider a version of the model where couples can choose between two options. In particular, the tax and transfer function is given

$$T^c\left(y^m, y^f\right) = \min\left\{y^m + y^f - \lambda_j\left(y^m + y^f\right)^{1-\tau_j}, y^m + y^f - \lambda_{sep}\left(y^m\right)^{1-\tau_{sep}} - \lambda_{sep}\left(y^f\right)^{1-\tau_{sep}}\right\} \tag{54}$$

To keep tractability, I make several assumptions. First, I assume that singles and couples filing separately face the same degree of tax progressivity, i.e. $\tau_s = \tau_{sep}$. Second, in my optimal policy exercise, I keep the ratio between scale parameters λ_{sep}/λ_s at the level corresponding to the benchmark economy. I calibrate parameter λ_{sep} to match the fraction of the U.S. married couple filing separately.[23] Table 16 reports the results.

[22] There are some situations when filing separately is preferable to joint filing. For example, some high-income couples where both spousal earnings are close to each other, may end up with lower tax liabilities under separate rather than joint filing.

[23] Using the SOI data, I calculate that in 2012-2016 the average fraction of these couples was equal to 5.3%.

Table 16: Optimal tax policy in an environment with joint and separate filing for couples

	U.S. Benchmark	Optimal (Baseline)	Optimal (+ Separate Filing)
Progressivity τ_s	0.125	0.151	0.147
Progressivity τ_j	0.147	0.108	0.105
Progressivity τ_{sep}	—	—	0.147
Welfare gain	—	1.31%	1.48%

NOTES: In this table, I report the value of the parameters of the tax and transfer functions (19) and (20) under different reforms. The last line reports the welfare gain in consumption-equivalent terms. Column "Benchmark" corresponds to the status-quo economy where couples are always taxed on their joint income.

In an environment where couples can choose between joint and separate filing, couples filing jointly are taxed less progressively than singles and couples filing separately (by construction). The aggregate welfare gain is 1.48% which is slightly higher than under the baseline optimal policy. An obvious shortcoming of this policy exercise is that I assume similar tax progressivity for singles and couples filing separately. Exploring how different are the results if this assumption is relaxed is an interesting avenue for future research.

7.5 Future Research

To keep the model tractable, I make some simplifying assumptions. First, I use ex-ante steady state expected utility of newborn households as a measure of social welfare. As Krueger and Ludwig (2016) show, a full characterization of the transition path is very important for policy evaluation. Other recent papers that evaluate welfare over the transition include Bakış et al. (2015), Boar and Midrigan (2021), and Dyrda and Pedroni (2021). A natural next step of this paper is to extend the analysis and account for the transition path towards the optimal steady state.

Next, to model couples, I use the unitary model of the households. An important avenue for future research is to characterize the optimal tax and transfer schedule in an environment where couples are modeled using a collective approach (Chiappori, 1988).

In this paper, I follow a Ramsey-style taxation literature and quantify optimal reforms within a parametric class of tax functions. A more general non-parametric Mirrleesian approach will allow to characterize the entire shape of the optimal tax and transfer schedule. One of the challenges that arises when we study the optimal tax schedule under this approach is multidimensional screening (as long as the couple's private type is given by a two-dimensional vector). Recent example of papers that characterize the optimal tax schedule in this environment include Moser and Olea de Souza e Silva (2019) and Alves et al. (2021). On top of that, it is interesting to explore how far are the welfare gains delivered by best policy in the class described by (1) from maximum potential welfare gains (Heathcote and Tsujiyama, 2021).

Finally, in the model, I do not distinguish between cohabiting couples and singles. Empirical studies document strong rise in cohabitation in the United States over the last 50 years (Gemici and Laufer, 2011; Blasutto, 2020). Exploring the implications of this phenomenon for the optimal fiscal policy is another fruitful avenue for future research.

8 Conclusion

In this paper, I characterize the optimal degree of tax progressivity for single and married households. To do this, I build and parameterize a general equilibrium overlapping generations model that incorporates single and married households, intensive and extensive margins of labor supply, human capital accumulation, and uninsurable idiosyncratic labor productivity risk. I show that the model matches the patterns from the data remarkably well, and hence it can be used as a laboratory to quantify the tax reforms.

My first finding is that tax progressivity in the United States should be lower for married couples than for singles. Second, the optimal tax reform reduces progressivity for couples and increases it for singles relative to the actual U.S. tax system. Furthermore, it results in higher married women's employment and generates welfare gain of about 1.3% in consumption-equivalent terms. Finally, I show that my results carry over into the other environments. In particular, I extend my baseline model by separately adding the government debt, marriage and divorce shocks, correlation between labor productivity shocks of spouses, and the choice between joint and separate filing for couples.

My paper contributes to the literature that emphasizes the importance of accounting for heterogeneity in gender and marital status in the quantitative macroeconomic models. My findings suggest that explicitly modeling couples and accounting for the extensive margin of labor supply and human capital accumulation is qualitatively as well as quantitatively important for the optimal tax policy design.

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Appendix A: Proofs

A.1 Proof of Proposition 1

I prove a more general version of Proposition 1. In particular, I also consider the case when married couples file separately, and hence spouses are taxed on their individual income.

Single Households. Suppose $q = 0$ and $\tilde{T} = 0$. Consider the problem of a single individual given in (2). Denoting by μ the Lagrange multiplier corresponding to the budget constraint, I obtain the following first-order conditions:

$$\frac{1}{c} = \mu \qquad [c]$$

$$\psi n_i^{\eta} = \mu \lambda_s \left(1 - \tau_s\right) w_i^{1-\tau_s} n_i^{-\tau_s} \qquad [n]$$

Plugging the budget constraint into the FOC for consumption and then plugging the resulting expression into the FOC for working hours, I get

$$n = \left(\frac{1-\tau_s}{\psi}\right)^{\frac{1}{1+\eta}} \tag{A.1}$$

Next, the optimal labor income and consumption are given by

$$y = \left(\frac{1-\tau_s}{\psi}\right)^{\frac{1}{1+\eta}} w_i \tag{A.2}$$

$$c = \lambda_s \left(\frac{1-\tau_s}{\psi}\right)^{\frac{1-\tau_s}{1+\eta}} \left(w_i\right)^{1-\tau_s} \tag{A.3}$$

Taking logarithms, I obtain the elasticities of consumption, working hours, and labor income to wage shock (transmission coefficients):

$$\frac{d\log(c)}{d\log\left(w_i\right)} = 1 - \tau_s \tag{A.4}$$

$$\frac{d\log(n)}{d\log\left(w_i\right)} = 0 \tag{A.5}$$

$$\frac{d\log(y)}{d\log\left(w_i\right)} = 1 \tag{A.6}$$

This completes the proof of Proposition 1 for singles.

Married Couples (Joint Taxation). Suppose $q = 0$ and $\tilde{T} = 0$. Consider the problem of a married couple given in (3). Denoting by μ the Lagrange multiplier corresponding to the budget constraint, I obtain the following first-order conditions:

$$\frac{2}{c} = \mu \qquad [c]$$

$$\psi n_m^\eta = \mu\lambda_j (1-\tau_j) w_m (w_m n_m + w_f n_f)^{-\tau_j} \qquad [n_m]$$

$$\psi n_f^\eta = \mu\lambda_j (1-\tau_j) w_f (w_m n_m + w_f n_f)^{-\tau_j} \qquad [n_f]$$

Plugging the budget constraint into the FOC for consumption and then plugging the resulting expression into the FOCs for working hours, I get

$$\psi n_m^\eta = 2(1-\tau_j) w_m (w_m n_m + w_f n_f)^{-1}$$

$$\psi n_f^\eta = 2(1-\tau_j) w_f (w_m n_m + w_f n_f)^{-1}$$

Note that it follows from the FOCs for working hours that

$$\frac{n_m}{n_f} = \left(\frac{w_m}{w_f}\right)^{\frac{1}{\eta}}$$

Plugging this relation into the equations above, I obtain

$$\psi n_m^{1+\eta} = 2(1-\tau_j)\left[1 + \left(\frac{w_f}{w_m}\right)^{\frac{1+\eta}{\eta}}\right]^{-1}$$

$$\psi n_f^{1+\eta} = 2(1-\tau_j)\left[1 + \left(\frac{w_m}{w_f}\right)^{\frac{1+\eta}{\eta}}\right]^{-1}$$

Finally, the optimal working hours, labor income, and consumption are given by

$$n_i = \left(\frac{2(1-\tau_j)}{\psi}\right)^{\frac{1}{1+\eta}}\left[1 + \left(\frac{w_{-i}}{w_i}\right)^{\frac{1+\eta}{\eta}}\right]^{-\frac{1}{1+\eta}} \qquad \text{(A.7)}$$

$$y_i = \left(\frac{2(1-\tau_j)}{\psi}\right)^{\frac{1}{1+\eta}}\left[1 + \left(\frac{w_{-i}}{w_i}\right)^{\frac{1+\eta}{\eta}}\right]^{-\frac{1}{1+\eta}} w_i \qquad \text{(A.8)}$$

$$c = \lambda_j\left(\frac{2(1-\tau_j)}{\psi}\right)^{\frac{1-\tau_j}{1+\eta}}\left[(w_m)^{\frac{1+\eta}{\eta}} + (w_f)^{\frac{1+\eta}{\eta}}\right]^{\frac{\eta(1-\tau_j)}{1+\eta}} \qquad \text{(A.9)}$$

where I denote the gender of a spouse by $-i$.

Taking logarithms, I obtain the elasticities of consumption, individual i's labor income, and his/her spouse's labor income to individual i's wage shock (transmission coefficients):

$$\frac{d\log(c)}{d\log(w_i)} = \frac{(w_i)^{\frac{1+\eta}{\eta}}}{(w_i)^{\frac{1+\eta}{\eta}} + (w_{-i})^{\frac{1+\eta}{\eta}}}(1-\tau_j) < 1-\tau_j \tag{A.10}$$

$$\frac{d\log(y_i)}{d\log(w_i)} = \underbrace{1}_{\text{direct wage effect}} + \underbrace{\frac{1}{\eta}\cdot\frac{(w_{-i})^{\frac{1+\eta}{\eta}}}{(w_i)^{\frac{1+\eta}{\eta}} + (w_{-i})^{\frac{1+\eta}{\eta}}}}_{\text{labor supply effect}} > 1 \tag{A.11}$$

$$\frac{d\log(y_{-i})}{d\log(w_i)} = -\frac{1}{\eta}\cdot\frac{(w_i)^{\frac{1+\eta}{\eta}}}{(w_i)^{\frac{1+\eta}{\eta}} + (w_{-i})^{\frac{1+\eta}{\eta}}} < 0 \tag{A.12}$$

This completes the proof of Proposition 1 for married couples under joint taxation.

Married Couples (Separate Taxation). Consider the problem of a married couple given by

$$\max_{c,n_m,n_f} 2\log(c) - \psi\frac{n_m^{1+\eta}}{1+\eta} - \psi\frac{n_f^{1+\eta}}{1+\eta} \tag{A.13}$$

$$\text{s.t.}\quad c = \lambda_{sep}(w_m n_m)^{1-\tau_{sep}} + \lambda_{sep}(w_f n_f)^{1-\tau_{sep}}$$

Denoting by μ the Lagrange multiplier corresponding to the budget constraint, I obtain the following first-order conditions:

$$\frac{2}{c} = \mu \tag*{[c]}$$

$$\psi n_m^{\eta} = \mu\lambda_{sep}(1-\tau_{sep})\,w_m^{1-\tau_{sep}} n_m^{-\tau_{sep}} \tag*{[n_m]}$$

$$\psi n_f^{\eta} = \mu\lambda_{sep}(1-\tau_{sep})\,w_f^{1-\tau_{sep}} n_f^{-\tau_{sep}} \tag*{[n_f]}$$

Plugging the budget constraint into the FOC for consumption and then plugging the resulting expression into the FOCs for working hours, I get

$$\psi n_m^{\eta+\tau_{sep}} = 2(1-\tau_{sep})\,w_m^{1-\tau_{sep}}\left[(w_m n_m)^{1-\tau_{sep}} + (w_f n_f)^{1-\tau_{sep}}\right]^{-1}$$

$$\psi n_f^{\eta+\tau_{sep}} = 2(1-\tau_{sep})\,w_f^{1-\tau_{sep}}\left[(w_m n_m)^{1-\tau_{sep}} + (w_f n_f)^{1-\tau_{sep}}\right]^{-1}$$

Note that it follows from the FOCs for working hours that

$$\frac{n_m}{n_f} = \left(\frac{w_m}{w_f}\right)^{\frac{1-\tau_{sep}}{\eta+\tau_{sep}}}$$

Plugging this relation into the equations above, I obtain

$$\psi n_m^{1+\eta} = 2\left(1-\tau_{sep}\right)\left[1+\left(\frac{w_f}{w_m}\right)^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}\right]^{-1}$$

$$\psi n_f^{1+\eta} = 2\left(1-\tau_{sep}\right)\left[1+\left(\frac{w_m}{w_f}\right)^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}\right]^{-1}$$

Finally, the optimal working hours, labor income, and consumption are given by

$$n_i = \left(\frac{2(1-\tau_{sep})}{\psi}\right)^{\frac{1}{1+\eta}}\left[1+\left(\frac{w_{-i}}{w_i}\right)^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}\right]^{-\frac{1}{1+\eta}} \tag{A.14}$$

$$y_i = \left(\frac{2(1-\tau_{sep})}{\psi}\right)^{\frac{1}{1+\eta}}\left[1+\left(\frac{w_{-i}}{w_i}\right)^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}\right]^{-\frac{1}{1+\eta}} w_i \tag{A.15}$$

$$c = \lambda_{sep}\left(\frac{2(1-\tau_{sep})}{\psi}\right)^{\frac{1-\tau_{sep}}{1+\eta}}\left[w_m^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_s+\eta}} + w_f^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}\right]^{\frac{\tau_{sep}+\eta}{1+\eta}} \tag{A.16}$$

where I denote the gender of a spouse by $-i$.

Taking logarithms, I obtain the elasticities of consumption, individual i's labor income, and his/her spouse's labor income to individual i's wage shock (transmission coefficients):

$$\frac{d\log(c)}{d\log(w_i)} = \frac{w_i^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}}{w_i^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}} + w_{-i}^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}}\left(1-\tau_{sep}\right) < 1-\tau_{sep} \tag{A.17}$$

$$\frac{d\log(y_i)}{d\log(w_i)} = \underbrace{1}_{\text{direct wage effect}} + \underbrace{\frac{1-\tau_{sep}}{\tau_{sep}+\eta}\cdot\frac{w_{-i}^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}}{w_i^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}} + w_{-i}^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}}}_{\text{labor supply effect}} > 1 \tag{A.18}$$

$$\frac{d\log(y_{-i})}{d\log(w_i)} = -\frac{1-\tau_{sep}}{\tau_{sep}+\eta}\cdot\frac{w_i^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}}{w_i^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}} + w_{-i}^{\frac{(1+\eta)(1-\tau_{sep})}{\tau_{sep}+\eta}}} < 0 \tag{A.19}$$

This completes the proof of Proposition 1. ■

A.2 Proof of Proposition 2

First, consider the case when a single individual works. Solving problem (2) along the lines of the proof of Proposition 1, I obtain the indirect utility:

$$V_1^s\left(c_1^*, n^*; q\right) = \log\left(\lambda_s\left(wn^*\right)^{1-\tau_s} + \tilde{T}\right) - \psi\frac{\left(n^* + q\right)^{1+\eta}}{1+\eta} \tag{A.20}$$

where c_1^* and n^* denote the optimal choices.

Next, in the case when a single individual does not work, the indirect utility is given by

$$V_0^s\left(c_0^*, 0\right) = \log\left(\tilde{T}\right) \tag{A.21}$$

Define a threshold on the fixed cost of work $\bar{q}_s$ through the following equation:

$$V_1^s\left(c_1^*, n^*; \bar{q}_s\right) = V_0^s\left(c_0^*, 0\right) \tag{A.22}$$

Using (A.20) and (A.21), I obtain

$$\log\left(\lambda_s\left(wn^*\right)^{1-\tau_s} + \tilde{T}\right) - \psi\frac{\left(n^* + \bar{q}_s\right)^{1+\eta}}{1+\eta} = \log\left(\tilde{T}\right) \tag{A.23}$$

Equation (A.23) implicitly defines $\bar{q}_s$ as a function of τ_s. Using the envelope theorem, it follows that

$$\frac{\partial V_1^s\left(c_1^*, n^*; \bar{q}_s\right)}{\partial \tau_s} + \frac{\partial V_1^s\left(c_1^*, n^*; \bar{q}_s\right)}{\partial q} \cdot \frac{\partial \bar{q}_s}{\partial \tau_s} = \frac{\partial V_0^s\left(c_0^*, 0\right)}{\partial \tau_s} = 0 \tag{A.24}$$

I have

$$\frac{\partial V_1^s\left(c_1^*, n^*; \bar{q}_s\right)}{\partial q} < 0 \tag{A.25}$$

Furthermore,

$$\frac{\partial V_1^s\left(c_1^*, n^*; \bar{q}_s\right)}{\partial \tau_s} > 0 \tag{A.26}$$

because $wn^* < 1$, i.e. the individual earns less than the average income.

Combining (A.26) and (A.25) and plugging them into (A.24), I obtain

$$\frac{\partial \bar{q}_s}{\partial \tau_s} = -\frac{\partial V_1^s\left(c_1^*, n^*; \bar{q}_s\right)/\partial \tau_s}{\partial V_1^s\left(c_1^*, n^*; \bar{q}_s\right)/\partial q} > 0 \tag{A.27}$$

This completes the proof of Proposition 2. ■

A.3 Proof of Proposition 3

First, consider the case when both spouses work. Solving problem (3) along the lines of the proof of Proposition 1, I obtain the indirect utility:

$$V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; q\right) = 2\log\left(\lambda_j\left(w_m n_{m,2}^* + w_f n_f^*\right)^{1-\tau_j}\right) - \psi\frac{\left(n_{m,2}^*\right)^{1+\eta}}{1+\eta} - \psi\frac{\left(n_f^* + q\right)^{1+\eta}}{1+\eta} \tag{A.28}$$

where c_2^*, $n_{m,2}^*$, and n_f^* denote the optimal choices.

Next, in the case of a single-earner couple, the indirect utility is given by

$$\begin{aligned} V_1^c\left(c_1^*, n_{m,1}^*, 0\right) = 2\log\left(\lambda_j\left(w_m n_{m,1}^*\right)^{1-\tau_j}\right) - \psi\frac{\left(n_{m,1}^*\right)^{1+\eta}}{1+\eta} = \\ 2\left[\log(\lambda_j) + \frac{1-\tau_j}{1+\eta}\log\left(\frac{2\left(1-\tau_j\right)}{\psi}\right) + \left(1-\tau_j\right)\log\left(w_m\right)\right] - \frac{1-\tau_j}{1+\eta} \end{aligned} \tag{A.29}$$

where c_1^* and $n_{m,1}^*$ denote the optimal choices.

Define a threshold on the fixed cost of work $\bar{q}_c$ through the following equation:

$$V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right) = V_1^c\left(c_1^*, n_{m,1}^*, 0\right) \tag{A.30}$$

Using (A.28) and (A.29), I obtain

$$\begin{aligned} 2\log\left(\lambda_j\left(w_m n_{m,2}^* + w_f n_f^*\right)^{1-\tau_j}\right) - \psi\frac{\left(n_{m,2}^*\right)^{1+\eta}}{1+\eta} - \psi\frac{\left(n_f^* + \bar{q}_c\right)^{1+\eta}}{1+\eta} = \\ 2\log\left(\lambda_j\left(w_m n_{m,1}^*\right)^{1-\tau_j}\right) - \psi\frac{\left(n_{m,1}^*\right)^{1+\eta}}{1+\eta} \end{aligned} \tag{A.31}$$

Equation (A.31) implicitly defines $\bar{q}_c$ as a function of τ_j. Using the envelope theorem, it follows that

$$\frac{\partial V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right)}{\partial \tau_j} + \frac{\partial V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right)}{\partial q}\cdot\frac{\partial \bar{q}_c}{\partial \tau_j} = \frac{\partial V_1^c\left(c_1^*, n_{m,1}^*, 0\right)}{\partial \tau_j} \tag{A.32}$$

I have

$$\frac{\partial V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right)}{\partial q} < 0 \tag{A.33}$$

Furthermore,

$$\frac{\partial V_1^c\left(c_1^*, n_{m,1}^*, 0\right)}{\partial \tau_j} - \frac{\partial V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right)}{\partial \tau_j} < 0 \tag{A.34}$$

because consumption of a dual-earner couple is higher than consumption of a single-earner couple.

Combining (A.34) and (A.33) and plugging them into (A.32), I obtain

$$\frac{\partial \bar{q}_c}{\partial \tau_j} = -\frac{\partial V_1^c\left(c_1^*, n_{m,1}^*, 0\right)/\partial \tau_j - \partial V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right)/\partial \tau_j}{\partial V_2^c\left(c_2^*, n_{m,2}^*, n_f^*; \bar{q}_c\right)/\partial q} < 0 \tag{A.35}$$

This completes the proof of Proposition 3. ■

Appendix B: Tax and Transfer Function

B.1 Properties of Tax and Transfer Function

As discussed in the main text, I use the tax and transfer function given by

$$T(y) = y - \lambda y^{1-\tau} \tag{B.1}$$

This function is characterized by two parameters. Parameter λ governs the average level of taxes. Parameter τ, which is the focus of this paper, stands for the degree of tax progressivity. It is tightly related to the coefficient of residual income progression (Musgrave, 1959; Jakobsson, 1976). In particular,

$$1 - \underbrace{\frac{1-MTR}{1-ATR}}_{\text{residual income progression}} = 1 - \frac{\lambda(1-\tau)y^{-\tau}}{\lambda y^{-\tau}} = \tau \tag{B.2}$$

where MTR is the marginal tax rate and ATR is the average tax rate. Furthermore, from

$$\underbrace{\log\left(y - T(y)\right)}_{\text{log post-tax/transfer income}} = \log(\lambda) + (1-\tau) \times \underbrace{\log(y)}_{\text{log pre-tax/transfer income}} \tag{B.3}$$

it follows that the average elasticity of post-tax/transfer income to pre-tax/transfer income is equal to $1-\tau$.

In the case of $\tau \in (0,1]$, the tax and transfer system is progressive. In the context of (B.2), it means that marginal tax rates always exceed average tax rates. Furthermore, through the lens of equation (B.3), it means that the more progressive tax system, i.e. with higher τ, reduces the elasticity of post-tax/transfer to pre-tax/transfer income. In turn, when $\tau < 0$, the tax and transfer system is regressive. Finally, in the case of $\tau = 0$, the tax and transfer system is flat, and the marginal and average tax rates are equal to $1-\lambda$. Note that specification (B.1) allows for transfers. In particular, if the gross household income y is below the break-even level $\lambda^{\frac{1}{\tau}}$, then $T(y) < 0$.

In Appendix B.2, I discuss the details of the estimation of parameters τ and λ.

B.2 Estimation of Tax and Transfer Function Parameters

Taking logarithms on both sides of $y - T(y) = \lambda y^{1-\tau}$, I obtain

$$\log\left(y - T(y)\right) = \log(\lambda) + (1-\tau)\log(y) \tag{B.4}$$

Using (B.4), I estimate parameters λ and τ by regressing the logarithm of post-tax/transfer household income on the logarithm of the pre-tax/transfer taxable household income separately for single individuals and married couples. Importantly, I express y in terms of the average wage earnings.

I use the data from the PSID for survey years 2013, 2015, and 2017. For each household in the sample, I construct the measures of pre-tax/transfer and post-tax/transfer income. Having done that, I use the NBER TAXSIM (Feenberg and Coutts, 1993) to calculate the corresponding tax liabilities. To prepare the inputs for the NBER TAXSIM, I follow Kimberlin et al. (2015) and Heathcote et al. (2017). The pre-tax/transfer gross household income is defined as the sum of all income received in a given tax year, including labor income, self-employment income, property income, interest income, dividends, retirement income, and private transfers. The pre-tax/transfer taxable household income is defined as the pre-tax/transfer gross household income minus deductible expenses (medical expenses, mortgage interest, state taxes, and charitable contributions)[24] plus the employment share (50%) of the Federal Insurance Contribution Act (FICA) tax. The post-tax/transfer income is defined as the pre-tax/transfer taxable income plus public transfers minus tax liabilities (federal, state, and FICA) calculated by NBER TAXSIM.

I take the data on medical expenses, mortgage interest, and state taxes directly from the PSID. Medical expenses are comprised of nursing home and hospital bills, doctor, outpatient surgery, and dental bills, and prescriptions, in-home medical care, special facilities, and other medical services.[25] To calculate the mortgage interest, I use the amount reported in response to the PSID question: *"About how much is the remaining principal on this mortgage?"*[26] I cap this amount at \$1 million. To obtain the interest payments, I multiply it by 3.87% which is the average 30-year conventional annual mortgage rate between 2012 and 2016.[27] Because the PSID does not have data on charitable contributions, I impute them. From the SOI data, I calculate that in 2012 charitable contributions constitute about 3% of income for individuals with income above \$75000.[28]

As stated above, I add the employment share (50%) of the FICA tax to the measure of pre-

[24] Given the value of deductions, the NBER TAXSIM calculates whether it is better to take the standard deduction or to itemize deductions.

[25] Variables ER57491, ER64613, ER70689 (expenditures on nursing home and hospital bills), ER57497, ER64619, ER70694 (expenditures on doctor, outpatient surgery, and dental bills), ER57503, ER64625, ER70698 (expenditures on prescriptions, in-home medical care, special facilities, and other services).

[26] Variables ER53048, ER60049, and ER66051.

[27] Source: https://fred.stlouisfed.org/series/MORTG

[28] Table 2.1 "Returns with Itemized Deductions: Sources of Income, Adjustments, Itemized Deductions by Type, Exemptions, and Tax Items." The resulting fraction, 3%, is consistent with the evidence from List (2011) and Heathcote et al. (2017).

tax/transfer taxable income. The FICA tax is comprised of the Old-Age, Survivors, and Disability Insurance (OASDI) tax and the Medicare Hospital Insurance (HI) tax. In 2012-2016, the OASDI tax rate was set at 6.2% for both employees and employers. It was applicable up to an earnings limit which varied from $110100 in 2012 to $118500 in 2016 (in nominal USD).[29] In 2012-2016, the HI tax rate was set at 1.45% for both employees and employers. There was no earnings limit.

In constructing the measure of post-tax/transfer income, I also add the present value imputed gain in social security benefits ($\widetilde{ssb}^{i}_{\tilde{a}}$) that individual i accrues from working at age $\tilde{a}$ to the measure of public transfers. To calculate its value, I follow Heathcote et al. (2017). In particular, for every individual in the sample, I estimate an age-earnings profile $\varphi(a; g, e)$ conditional on gender g and education e using a cubic polynomial in age. I consider four education categories: less than high-school, high-school degree, some college, and college degree and above. Estimated earnings at age a^* are then given by

$$\hat{y}^{i}_{a^*} = \frac{\varphi(a^*; g, e)}{\varphi(a; g, e)} y^{i}_{a}$$

Denote the Average Index of Monthly Earnings (AIME) by $AIME_i$. When individual i works from age $a = 1$ to retirement age $a_R = 41$ (from age 25 to age 65 in the data), it is given by

$$AIME_i = \frac{1}{12} \cdot \left(\frac{\sum_{a=1}^{a_R} \hat{y}^{i}_{a}}{a_R} \right)$$

Next, I define the counterfactual AIME calculated under the assumption that an individual does not work at age $\tilde{a}$:

$$AIME^{\tilde{a}}_{i} = AIME_i - \frac{1}{12} \cdot \frac{y^{i}_{\tilde{a}}}{a_R}$$

The associated annualized gain in social security benefits from working at age $\tilde{a}$ is given by

$$ssb^{i}_{\tilde{a}} = \left[PIA\left(AIME_i\right) - PIA\left(AIME^{\tilde{a}}_{i}\right) \right] \cdot 12$$

where PIA is the "Primary Insurance Amount" (PIA) formula that determines monthly benefits as a function of AIME.[30]

Assuming the annual interest rate $R = 1.04$ and the maximum possible age $A = 76$ (age 100 in the data), I calculate the present value of individual i's pension gain from working at age $\tilde{a}$:

$$\widetilde{ssb}^{i}_{\tilde{a}} = \left(\frac{1}{a_R} \right)^{a_R - \tilde{a}} \cdot ssb^{i}_{\tilde{a}} \cdot \sum_{a=a_R}^{A} \left(\frac{1}{R} \right)^{a - a_R} \zeta_{\tilde{a},a}$$

where $\zeta_{\tilde{a},a}$ is the survival probability from age $\tilde{a}$ to age a (see Table F.1 for ages 65-100). I add $\widetilde{ssb}^{i}_{\tilde{a}}$ to the measure of post-government income as a part of the public transfers.

[29] Source: https://www.ssa.gov/oact/COLA/cbb.htmlSeries

[30] See https://www.ssa.gov/oact/COLA/piaformula.html for the details.

Appendix C: Data and Parameterization

C.1 Data

My main data sources include the Panel Study of Income Dynamics (PSID) and the Current Population Survey (CPS). The PSID is the longest-running representative household panel of U.S. individuals and the family units in which they reside. The waves are annual between 1968 and 1997, and biennial starting from 1999. I use the PSID to estimate the parameters of the tax and transfer function and the labor productivity processes for men and women. The sample consists of single and married individuals (heads and wives) who are observed at least twice over the period of 1968-2017. The CPS is the source of official U.S. government statistics on employment, and is designed to be representative of the civilian non-institutional population. I use the CPS to construct the lifecycle profiles of working hours and employment.

In addition, to get the estimates of the age-dependent survival probabilities, I use the data from the National Center for Health Statistics. To estimate the degree of tax progressivity for households with and without children, I use the data from the Congressional Budget Office.

I deflate all nominal variables into 2013 U.S. dollars using the Consumer Price Index for All Urban Consumers (CPI-U). In general, since the CPI suffers from well-documented biases, there are several other price indices that are actively used in the literature. One alternative is the Personal Consumption Expenditures price index (PCE price index). The Bureau of Economic Analysis uses a Fisher index to construct it, and therefore mitigates the small-sample and substitution biases, as well as the weighting bias because it computes weights using business sales data. However, Furth (2017) estimates that a conservative lower bound on the upward bias in the PCE price index is still non-zero and equals to 0.4% p.a.

C.2 Method of Simulated Moments

I parameterize my model using a two-stage procedure. In the first stage, I estimate the vector of parameters $\boldsymbol{\chi}$ without explicitly using the structural model. For example, as discussed by Gourinchas and Parker (2002), to estimate the variance of permanent and transitory income shocks, one can use time-series moment conditions and true household-level panel data on income, rather than using the data on average consumption and income profiles, where identification might prove difficult in practice. In the second stage, I use the Method of Simulated Moments (MSM) (Pakes and Pollard, 1989; Duffie and Singleton, 1993) to estimate the remaining parameters $\boldsymbol{\Theta}$:

$$\boldsymbol{\Theta} = \left(\beta, \psi, \gamma_0^m, \left(\alpha_0^{i,\iota}, \alpha_1^{i,\iota}, \alpha_2^{i,\iota}\right), \bar{L}_\iota^i\right) \tag{C.1}$$

In particular, given the parameters obtained in the first stage, I use the model to simulate the lifecycle profiles of a representative population of people, and then choose the parameter values that minimize the distance between simulated and empirical profiles. To pin down the parameters (C.1), I use the following moments from the U.S. data: the capital-income ratio, the average female-to-male hourly wage ratio, and the lifecycle profiles of employment and hours of work (conditional on employment) for single men and women and married men and women between age 25 and age 65.

Suppose there is data on n individuals, each is observed for up to T years. Denote by $g\left(\boldsymbol{\Theta};\boldsymbol{\chi}_0\right)$ the vector of the moment conditions, and by $\hat{g}_n\left(\boldsymbol{\Theta};\boldsymbol{\chi}_0\right)$ its sample analog. The MSM estimator minimizes over $\boldsymbol{\Theta}$ and is given by

$$\hat{\boldsymbol{\Theta}} = \underset{\boldsymbol{\Theta}}{\operatorname{argmin}}\, \hat{g}_n\left(\boldsymbol{\Theta};\boldsymbol{\chi}_0\right)' \widehat{\boldsymbol{W}}_n \hat{g}_n\left(\boldsymbol{\Theta};\boldsymbol{\chi}_0\right) \tag{C.2}$$

where $\widehat{\boldsymbol{W}}_n$ is a $T\times T$ weighting matrix. In the case when $\widehat{\boldsymbol{W}}_n$ is the identity matrix, the estimation procedure is equivalent to minimizing the sum of squared residuals. Following the literature, I treat vector of parameters $\boldsymbol{\chi}_0$ as known.

Under the regularity conditions stated in Pakes and Pollard (1989) and Duffie and Singleton (1993), the MSM estimator $\hat{\boldsymbol{\Theta}}$ is both consistent and asymptotically normally distributed:

$$\sqrt{n}\left(\widehat{\boldsymbol{\Theta}} - \boldsymbol{\Theta}_0\right) \rightsquigarrow \mathcal{N}\left(0, \boldsymbol{V}\right) \tag{C.3}$$

The variance-covariance matrix is given by

$$\boldsymbol{V} = \left(\boldsymbol{\Gamma}'\boldsymbol{W}\boldsymbol{\Gamma}\right)^{-1} \boldsymbol{\Gamma}'\boldsymbol{W}\boldsymbol{\Sigma}\boldsymbol{W}\boldsymbol{\Gamma}\left(\boldsymbol{\Gamma}'\boldsymbol{W}\boldsymbol{\Gamma}\right)^{-1} \tag{C.4}$$

where $\boldsymbol{\Sigma}$ is the variance-covariance matrix of the data. Next, $\boldsymbol{\Gamma}$ is the gradient matrix of the population moment vector:

$$\boldsymbol{\Gamma} = \left.\frac{\partial g\left(\boldsymbol{\Theta};\boldsymbol{\chi}_0\right)}{\partial \boldsymbol{\Theta}'}\right|_{\boldsymbol{\Theta}=\boldsymbol{\Theta}_0} \tag{C.5}$$

and

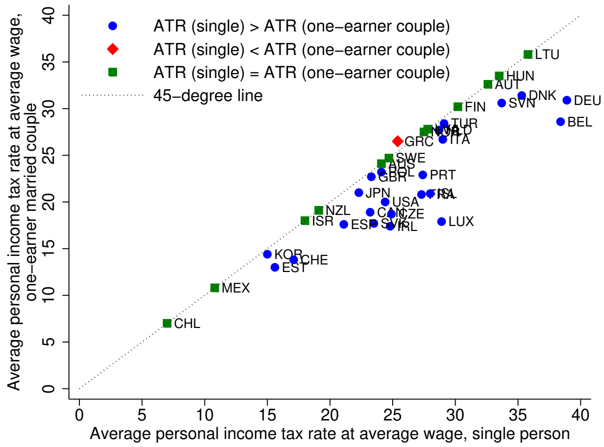
$$\boldsymbol{W} = \underset{n\to\infty}{\operatorname{plim}}\, \widehat{\boldsymbol{W}}_n \tag{C.6}$$

If $\boldsymbol{W} = \boldsymbol{\Sigma}^{-1}$, then

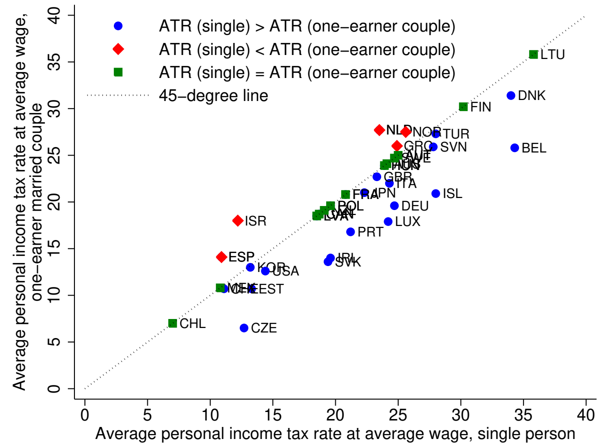
$$\boldsymbol{V} = \left(\boldsymbol{\Gamma}'\boldsymbol{\Sigma}^{-1}\boldsymbol{\Gamma}\right)^{-1} \tag{C.7}$$

When $\widehat{\boldsymbol{W}}_n$ converges to $\boldsymbol{\Sigma}^{-1}$, the weighting matrix is asymptotically efficient. As Altonji and Segal (1996) emphasize, the optimal weighting matrix can suffer from the small-sample bias, and the correlation between sampling errors in the second moments and the sample weighting matrix generates bias in the optimal minimum distance estimator. I use the weighting matrix that contains the diagonal elements of $\boldsymbol{\Sigma}$ and zeros off the diagonal. I estimate matrices $\boldsymbol{\Gamma}$ and $\boldsymbol{W}$ using their sample analogs.

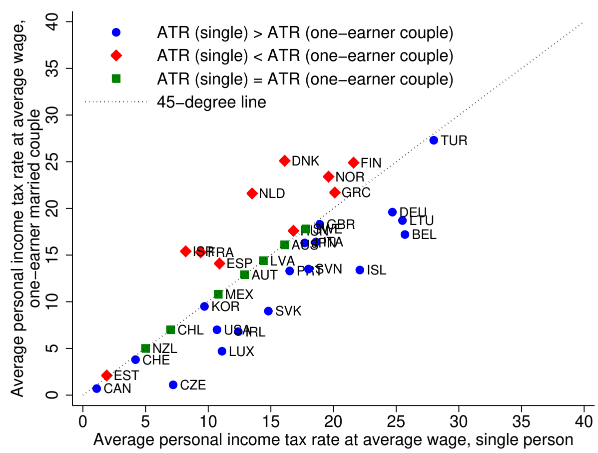
Appendix E: Additional Figures



(a) Households without children (with transfers)



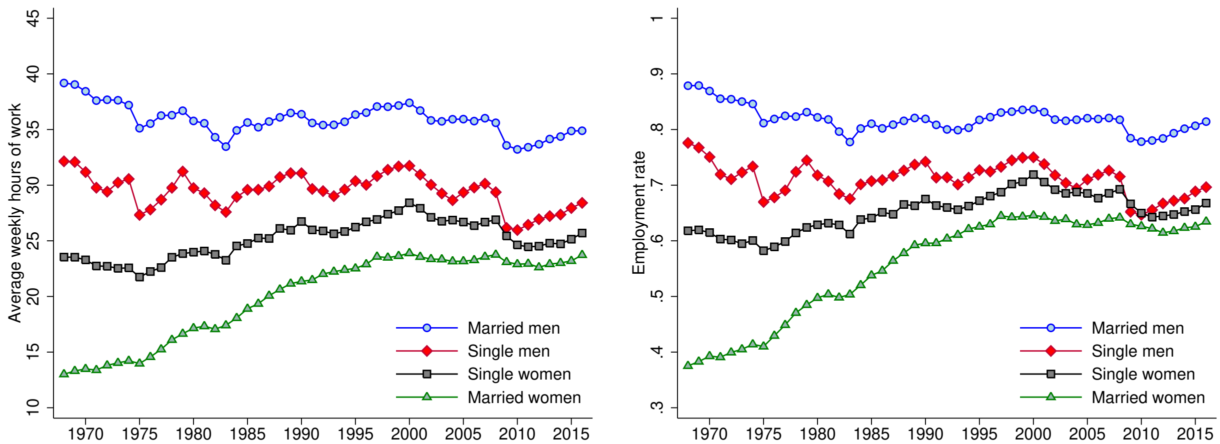
(b) Households with two children (with transfers)



(c) Households with two children (no transfers)

Figure E.1: Average income tax rates at average wage for singles and married couples by country

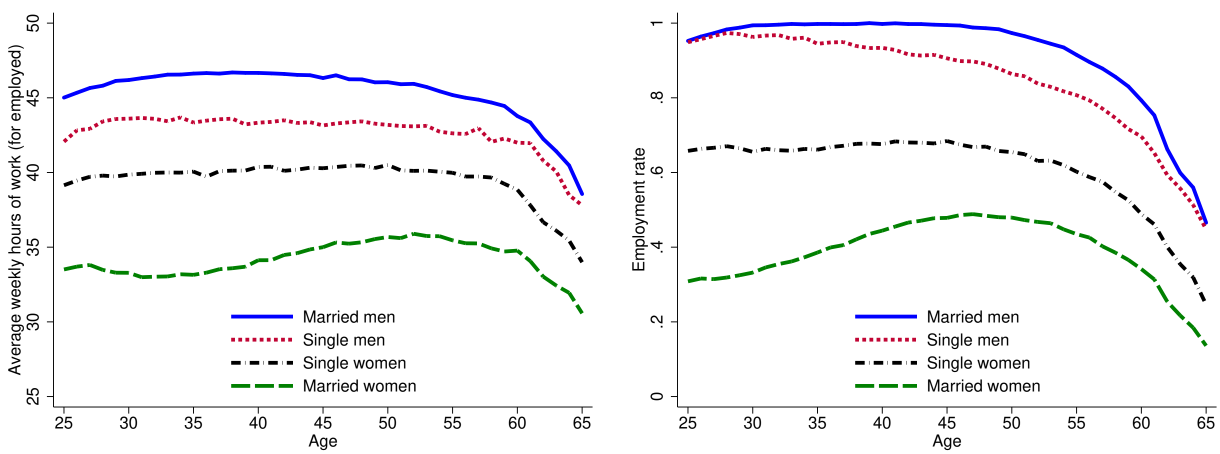
Notes: I use the data from the OECD Tax Database (Table I.6) for year 2020. The figure reports average personal income tax rates for single individuals and one-earner married couples without children (panel (a)) and with two children (panels (b) and (c)), calculated at the average wage. The tax rates in panels (a) and (b) are inclusive of universal family cash transfers. The tax rates in panel (c) are exclusive of universal family cash transfers.



(a) Average weekly hours of work (b) Employment rate

Figure E.2: Labor supply trends by gender and marital status in the United States

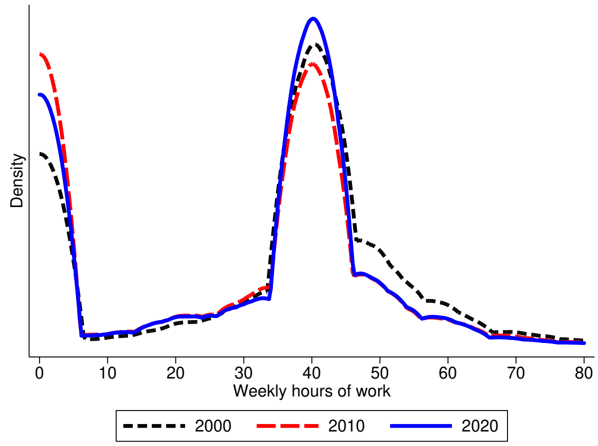
Notes: I use the CPS data for individuals aged 25-65. An individual is defined as employed if he/she worked a positive number of hours during the previous week. I drop those who are employed but who report working less than 5 hours, those who report working more than 80 hours, and those who earn less than half of the federal minimum wage.



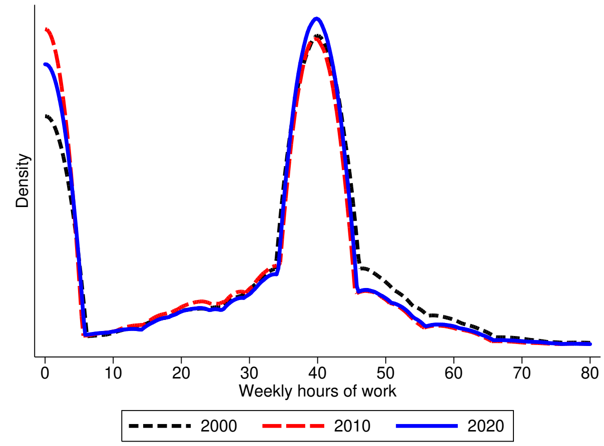
(a) Average weekly hours of work (for employed) (b) Employment rate

Figure E.3: Lifecycle profiles by gender and marital status in the United States

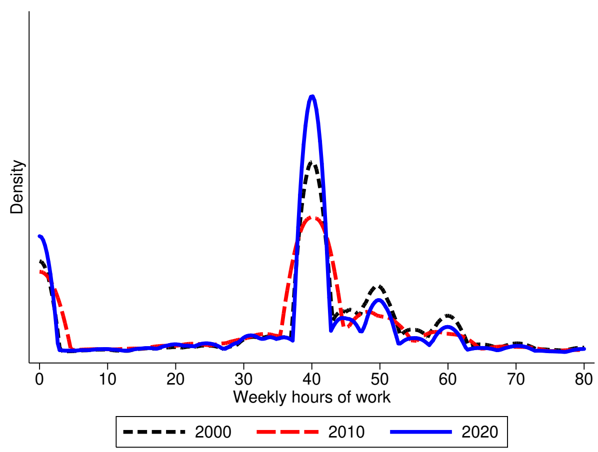
Notes: I use the CPS data for individuals aged 25-65. An individual is defined as employed if he/she worked a positive number of hours during the previous week. I drop those who are employed but who report working less than 5 hours, those who report working more than 80 hours, and those who earn less than half of the federal minimum wage. The profiles are constructed by cleaning cohort effects following the usual procedure in the literature.



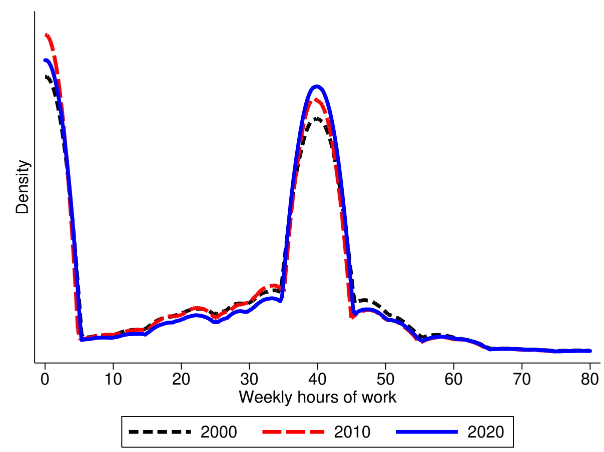
(a) Single men



(b) Single women



(c) Married men



(d) Married women

Figure E.4: Distribution of weekly hours of work by gender and marital status

NOTES: To construct the figures, I use the CPS data on the reported hours worked during the previous week by individuals aged 25-65.

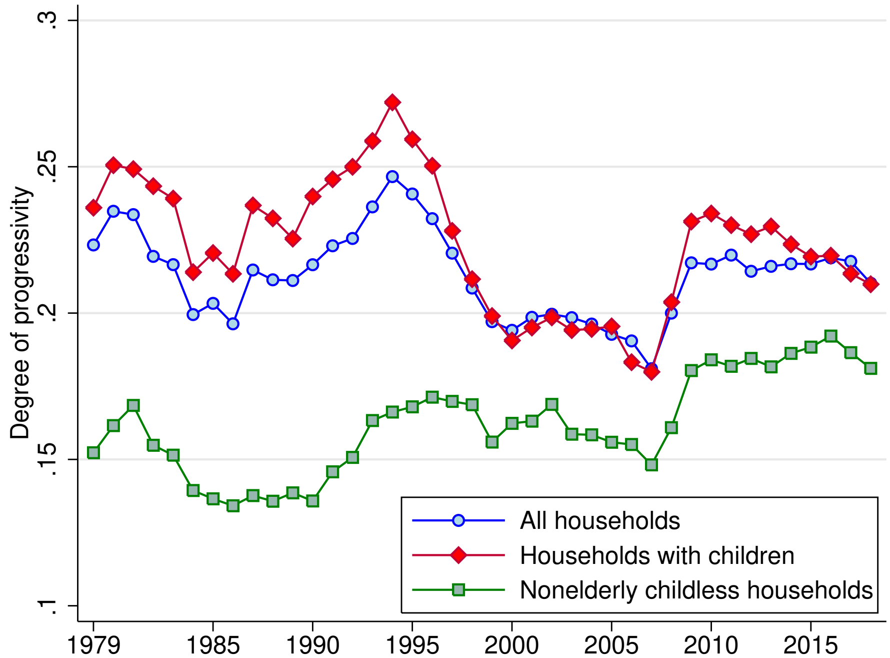


Figure E.5: Tax progressivity for U.S. households with and without children

NOTES: Progressivity of the tax and transfer system is measured by parameter τ from function (1). I estimate it using the data from the Congressional Budget Office between 1979 and 2018.

Appendix F: Additional Tables

Table F.1: Age-dependent probability of dying and survival probability in the United States, 2014

Age a	Probability of dying	Survival probability ζ_a
65-66	0.0125	0.9875
66-67	0.0134	0.9866
67-68	0.0144	0.9856
68-69	0.0156	0.9844
69-70	0.0170	0.9830
70-71	0.0187	0.9813
71-72	0.0205	0.9795
72-73	0.0226	0.9774
73-74	0.0247	0.9753
74-75	0.0270	0.9730
75-76	0.0295	0.9705
76-77	0.0323	0.9677
77-78	0.0357	0.9643
78-79	0.0395	0.9605
79-80	0.0439	0.9561
80-81	0.0488	0.9512
81-82	0.0540	0.9460
82-83	0.0597	0.9403
83-84	0.0664	0.9336
84-85	0.0739	0.9261
85-86	0.0820	0.9180
86-87	0.0915	0.9085
87-88	0.1020	0.8980
88-89	0.1135	0.8865
89-90	0.1260	0.8740
90-91	0.1395	0.8605
91-92	0.1540	0.8460
92-93	0.1696	0.8304
93-94	0.1861	0.8139
94-95	0.2036	0.7964
95-96	0.2220	0.7780
96-97	0.2412	0.7588
97-98	0.2611	0.7389
98-99	0.2815	0.7185
99-100	0.3024	0.6976
100+	1	0