

# Taxation and Household Labor Supply

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## Abstract

We evaluate reforms to the U.S. tax system in a life-cycle setup with heterogeneous married and single households, and with an operative extensive margin in labor supply. We restrict our model with observations on gender and skill premia, labor force participation of married females across skill groups, children, and the structure of marital sorting. We concentrate on two revenue-neutral tax reforms: a proportional income tax and a reform in which married individuals file taxes separately (*separate filing*). Our findings indicate that tax reforms are accompanied by large increases in labor supply that differ across demographic groups, with the bulk of the increase coming from married females. Under a proportional income tax reform, married females account for more than 50% of the changes in hours across steady states, while under separate filing reform, married females account for all the change in hours.

*JEL Classifications:* E62, H31, J12, J22

*Key Words:* Taxation, Two-earner Households, Labor Force Participation.

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# 1 Introduction

Tax reforms have been at the center of numerous debates among academic economists and policy makers. As a part of this debate, there have been calls for tax reforms that would simplify the tax code, change the tax base from income to consumption, and adopt a more uniform marginal tax rate structure.<sup>1</sup>

In the existing literature, the decision maker is typically an individual who decides how much to work, how much to save, and in some cases how much human capital investments to make. Yet, current households are neither a collection of bread-winner husbands and house-maker wives, nor a collection of single people. In 2000, the labor force participation of married women between ages 25 and 54 was about 69%. Furthermore, their participation rate increases markedly by educational attainment, and is known to respond strongly to hourly wages. Moreover, the economic environment that these households face does not feature wages that are gender-neutral. Hourly earnings of females relative to males, the gender-gap, is of about 70% nowadays and has been around this value for some time.<sup>2</sup>

These observations have long been deemed important in discussions of tax reforms, but are largely unexplored in dynamic equilibrium analyses in the macroeconomic and public-finance literatures. We fill this void in this paper. We quantify the effects of tax reforms taking carefully into account the labor supply of married females as well as the current demographic structure. For these purposes, we develop a dynamic equilibrium model with an operative extensive margin in labor supply, and a structure of individual and household heterogeneity that is consistent with the current U.S. demographics.

We consider a life-cycle economy populated with males and females who differ in their labor market productivities. Individuals start economic life as either *married* or *single* and do not change their marital status as they age. Married couples and single females have children that appear exogenously along their life-cycle; they can be childless or have these children early or late in their life-cycle. Singles decide how much to work and how much to save out of their total after-tax income. Married households decide on the labor hours of each household member, and like singles, how much to save. A novel feature in our analysis is the explicit modeling of the participation decision of married females in two-earner households and its interplay with the structure of heterogeneity and taxation. In the model, female labor-force participation is not a trivial decision for a household. First, children are associated to fixed time costs. Furthermore, if a female with a child decides to work, the household incurs

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<sup>1</sup>See Auerbach and Hassett (2005) for a review.

<sup>2</sup>Our calculations. See Section 4.1 for details.

child care expenses. Second, her labor market productivity depreciates if she chooses not to participate. Finally, if a married female enters the labor force, the household faces a utility cost. This cost allows us to capture residual heterogeneity in labor force participation. It represents heterogeneity in the additional difficulty of coordinating multiple household activities, taste for children and home production or any other utility cost that might arise when two adults work instead of one. As a result of these assumptions, females in married households may choose *not* to work at all. This is a key feature of our analysis since the structure of taxation can affect the participation decision of married females, and available evidence suggests that it does so significantly.

There are several reasons that point to the relevance of our analysis. First, in the current U.S. tax system the household (not the individual) constitutes the basic unit of taxation, which results in high tax rates on secondary earners. When a married female considers entering the labor market, the first dollar of her earned income is taxed at her husband's current marginal rate. Second, from a conceptual standpoint, wages of each member as well as the presence of children in a two-earner household affect joint labor supply decisions as well as the reactions to changes in the tax structure. Finally, a common view among many economists has been that tax changes may have moderate impacts on labor supply. This view is supported by empirical findings on the low or near zero labor supply elasticities of prime-age males. Recent developments, however, started to challenge this wisdom. Tax reforms in the 1980's have been shown to affect female labor supply behavior significantly, but have relatively small effects on males (Bosworth and Burtless (1992), Triest (1990), and Eissa (1995)).<sup>3</sup> These findings are consistent with ample empirical evidence that female labor supply in general, and female labor force participation in particular are quite elastic (Blundell and MaCurdy (1999), Keane (2010)). If *households*, not individuals, react to taxes much more than previously thought, the potential effects of tax reforms can be more significant.

We use our framework to conduct two hypothetical tax reform experiments, and then ask: What is the importance of the labor supply responses of married females in these experiments? What is the importance of micro, labor-supply elasticities for the long-run effects on output and the labor input?

We concentrate on two revenue-neutral tax reforms. The first one eliminates all progressivity via a *proportional* income tax. This is a prototypical reform, which allows us to highlight and quantify the forces at work within the model. In our second reform, *separate*

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<sup>3</sup>More recently, Eissa and Hoynes (2006) show that the disincentives to work embedded in the Earned Income Tax Credit (EITC) for married women are quite significant (effectively subsidizing some married women to stay at home).

*filing*, we keep the progressivity and the tax base of the current system, but married individuals file their taxes separately. This reform, which arises naturally in our environment, shifts the unit of taxation from households to *individuals*. As a result, it can drastically change marginal tax rates within married households, while effectively eliminating tax penalties (and bonuses) associated to marital status built into the current tax code.

A central finding of our exercises is that the differential labor supply behavior of different groups is key for an understanding of the aggregate effects of tax reforms. The related finding is that married females account for a disproportionate fraction of the changes in hours and labor supply. Furthermore, the relative importance of the labor supply responses of married females increases sharply for *low* values of the intertemporal elasticity of labor supply.

Replacing current income taxes by a proportional tax increases aggregate output by about 7.4% across steady states. This increase is accompanied by differential effects on labor supply: while hours per worker increase by about 3.3%, the labor force participation of married females increases by about 4.6% and married females increase their total hours by 8.8%, with a significant response in the participation rate of married females with children which increases by 6.8%.

Our results show that *separate filing* goes a long way in generating significant aggregate output effects. With separate filing, aggregate output goes up by nearly 4%, which is more than half of the increase from a proportional income tax reform. The increase in aggregate output mainly comes from the rise in aggregate hours by married females. The labor force participation of married females rises more than twice as it does under a proportional income tax reform: an increase of 10.4% versus 4.6%. The rise in labor force participation of married females with children is even stronger, increasing by about 18.1% with separate filing. In contrast, male hours per worker remains nearly constant across steady states.

We find that both reforms lead to aggregate welfare gains for the generations that are alive at the time of reforms. The welfare gains are larger under a proportional income tax than under separate filing; the consumption compensation amounts to 1.3% under a proportional income tax and 0.2% under the separate filing case. We also find that a majority of households that alive at the time of reforms benefit from them. More households benefit from a move to separate filing (about 69%) than under a proportional tax (54%).

In answering the first question posed above, “what is the importance of the labor supply responses of married females in these experiments?”, we find that married females account for a disproportionate fraction of the changes in hours and labor supply. Under proportional taxes, married females account for about 51% of the total increase in labor hours, and about 48% of the aggregate increase in labor supply (efficiency units). With separate filing almost

all of the rise in hours and labor supply comes from married females. Hence, considering explicitly the behavior of this group is key in assessing the effects of tax reforms on labor supply.

In answering the second question, “what is the importance of micro, labor-supply elasticities for the long-run effects on output and the labor input?”, we find that when reducing the intertemporal elasticity from the benchmark value of 0.4 to 0.2, the long-run response of aggregate hours and output to tax changes is *not* critically affected. This occurs as while households react much less to tax changes along the intensive margin under a low elasticity parameter, they respond disproportionately via changes in labor force participation.

**Related Literature** Our work largely builds on two main strands of literature. First, our evaluation of tax reforms using a dynamic model with heterogeneity follows the work by Ventura (1999), Altig, Auerbach, Kotlikoff, Smetters and Walliser (2001), Castañeda, Díaz-Jiménez and Ríos-Rull (2003), Díaz-Jiménez and Pijoan-Mas (2005), Nishiyama and Smetters (2005), Conesa and Krueger (2006), Erosa and Koreshkova (2007), and Conesa, Kitao and Krueger (2009), among others. In contrast to these papers, we study economies populated with married and single households, where married households can have one or two earners. In this vein, Kaygusuz (2008) studies the effects of the 1980s tax reforms on female labor force participation in the U.S. Hong and Ríos-Rull (2007) and Kaygusuz (2011) study social security in environments with an explicit role for two-member households. Chade and Ventura (2002) study the effects of tax reforms on labor supply and assortative matching in a model with heterogenous individuals and endogenous marriage decisions. They abstract, however, from the extensive margin in labor supply, among other things. Alesina, Ichino and Karabarbounis (2011) study the Ramsey optimal taxation problem of a two-earner household within a static environment, where lower tax rates for females emerge. Kleven, Kreiner and Saez (2009) study a similar optimal taxation of problem in Mirrlessian framework, where second earner makes an explicit labor force participation decision. Second, as Cho and Rogerson (1988), Mulligan (2001), and Chang and Kim (2006), we study the aggregate effects of changes in labor supply along the extensive margin. As Rogerson and Wallenius (2009), we differ from these papers by explicitly analyzing the role of the extensive margin for public policy.

Our paper is also related to two recent literatures. First, it is related to recent work that argues that the structure of taxation can significantly affect labor choices, and play a central role in accounting for cross-country differences in labor supply behavior. Prescott (2004), Rogerson (2006), Ohanian, Raffo and Rogerson (2008), and Olovsson (2009) are examples of

papers in this group. Our paper is also related to recent work that studies female labor supply in macroeconomic setups; Jones, Manuelli and McGrattan (2004), Greenwood, Seshadri and Yorukoglu (2005), Erosa, Fuster, Restuccia (2010), Albanesi and Olivetti (2007), Knowles (2007), Attanasio, Low and Sánchez Marcos (2008), and Greenwood and Guner (2009) are representative papers in this group.

The paper is organized as follows. Section 2 presents an example that highlights the role of taxation with two-earner households, and motivates the parameterization of the model economy. Section 3 presents the model economy. Section 4 discusses the parameterization of the model and the mapping to data. Results from tax reforms are presented in section 5. Section 6 quantifies the role of married females and the extensive margin in labor supply. Section 7 discusses the implications of a lower labor supply elasticity. Section 8 presents some welfare results. Section 9 concludes.

## 2 Taxation, Two-Earner Households and the Extensive Margin

In this section, we present a simple static, decision-problem that illustrates how taxes affect labor supply decisions with two-earner households with and without children, with an emphasis on the potential changes in labor force participation. The example serves to highlight key features of our general environment, and to understand some of the calibration choices we make later.

Consider a married household. The household decides whether only one or both members should work and if so, how much. Let  $x$  and  $z$  denote the labor market productivities (wage rates) of males and females, respectively. Let  $\tau$  be a proportional tax on labor income. The household can be childless ( $k = 0$ ) or have children ( $k = 1$ ). Couples with children have to pay for child care services *only* if both household members works. Taking care of children costs  $d > 0$  units of consumption.

**A one-earner household** Consider first the problem if only one member (husband) works. For couples with and without children, the household problem is given by

$$\max_{l_{m,1}} \{ 2 \underbrace{[\log((1 - \tau)z l_{m,1} + T)]}_{=\log(c)} - \varphi l_{m,1}^{1+\frac{1}{\gamma}} \},$$

where  $l_{m,1}$  is the labor choice of the primary earner (husband) and  $T$  is a transfer received from the government. The subscript 1 represents the choices of a one-earner household. The function  $W \equiv \varphi l^{1+\frac{1}{\gamma}}$  stands for the disutility associated to work time.

We introduce government transfers in order to capture in a simple way the role of progressive taxation. This follows as household choices under non-linear, progressive taxes are qualitatively equivalent to choices under a linear tax system that combines a proportional tax rate plus a lump-sum transfer. Under a progressive tax system, changes in marginal tax rates affect labor choices even for preferences for which income and substitution effects cancel out; the same occurs under the linear tax system that we consider.

Household utility when only one member works is given by

$$V_1(\tau) = 2[\log((1 - \tau)zl_{m,1}^* + T)] - W(l_{m,1}^*),$$

where a '\*' denotes an optimal choice.

**A two-earner household** When both members work, the household incurs a utility cost  $q$ , drawn from a distribution with cumulative distribution function  $\zeta(q)$ . Then the problem is given by

$$\begin{aligned} \max_{l_{m,2}, l_{f,2}} \quad & \{2[\underbrace{\log((1 - \tau)(zl_{m,2} + xl_{f,2}) + T - d\chi(k))}_{=\log(c)}] \\ & - \varphi l_{m,2}^{1+\frac{1}{\gamma}} - \varphi l_{f,2}^{1+\frac{1}{\gamma}} - q\}, \end{aligned}$$

where  $\chi(k)$  is an indicator for the presence of children, and the subscript 2 represents the choices of a two-earner household. Let the solutions to this problem be denoted by  $l_{m,2}^*(k = 0)$  and  $l_{f,2}^*(k = 0)$ . Similarly, let  $l_{m,2}^*(k = 1)$  and  $l_{f,2}^*(k = 1)$  be the optimal decisions when children are present. Household utility levels are given by

$$\begin{aligned} V_2(\tau, k) - q &= 2[\log((1 - \tau)(zl_{m,2}^*(k) + xl_{f,2}^*(k)) + T - d\chi(k))] \\ &\quad - W(l_{m,2}^*(k)) - W(l_{f,2}^*(k)) - q, \end{aligned}$$

**Taxes and the extensive margin in labor supply** A married household is indifferent between having one and two earners for a sufficiently high value of the utility cost. Hence, there exist values of  $q$ ,  $q^*(k = 0)$  and  $q^*(k = 1)$  that obey  $q^*(k = 0) = V_2(\tau, k = 0) - V_1(\tau)$  and  $q^*(k = 1) = V_2(\tau, k = 1) - V_1(\tau)$ . For households with a  $q$  higher than the corresponding threshold value, it is optimal to have only one earner, while for those with a  $q$  lower than the threshold it is optimal to be a two-earner household. Since children are costly, it follows

that  $q^*(k = 0) > q^*(k = 1)$ . Hence, everything else the same, childless couples are more likely to have two members working in the market than couples with children.

Thresholds will change as taxes change. Using the envelope theorem, it follows that

$$\frac{\partial q^*(k)}{\partial \tau} = \frac{\partial V_2(\tau, k)}{\partial \tau} - \frac{\partial V_1(\tau)}{\partial \tau} < 0,$$

This derivative is negative if household consumption with two earners is higher than with one earner, a condition that necessarily holds in our case.<sup>4</sup> That is,  $q^*(k = 0)$  and as a result, the labor force participation of married females without children, will be lower (higher) when taxes are high (low) if the above condition holds. This is illustrated in Figure 1. Thus, a change in tax rates affects also the *extensive* margin in labor supply. For couples with children, a similar result can be shown.

Furthermore, since children are costly in terms of resources, it is possible to show that

$$\left| \frac{\partial q^*(k = 1)}{\partial \tau} \right| > \left| \frac{\partial q^*(k = 0)}{\partial \tau} \right|.$$

Hence, the participation *response* of married couples with children to tax changes is larger than for couples without children.<sup>5</sup>

This example has important implications for the mapping of our model economy to the data. On the one hand, the relative size of households with and without children affects the size of labor supply response. On the other hand, as the bottom panel of Figure 1 shows, exactly how much the labor force participation of married females will increase depends on the shape of  $\zeta(q)$ . Therefore, selecting the functional form for the distribution of utility costs will be an important part of the model parameterization; the magnitude of the response along the extensive margin depends on slope  $\zeta'(q)$ . We capture this slope by exploiting the observed differences in female labor force participation in response to changes in the gender gap,  $x/z$ . The key to this procedure is that an increase in  $x$ , for a given  $z$ , implies an increase in labor force participation whose magnitude hinges precisely on the magnitude of  $\zeta'(q)$ .

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<sup>4</sup>This follows from the fact that income effects from female labor supply imply that males work less when they are in a two-earner household, i.e.  $l_{m,2}^* < l_{m,1}^*$ . Since the first-order condition for husband's hours implies that marginal disutility from work has to be equal to the marginal utility from consumption times the after-tax wage rate, household consumption with two earners must be higher than with one earner.

<sup>5</sup>For this inequality to hold household consumption with two earners must be lower with children than without children, which follows naturally from the negative income effect of children on labor supply decisions.



### 3 The Economic Environment

We study a stationary overlapping generations economy populated by a continuum of males ( $m$ ) and a continuum of females ( $f$ ). Let  $j \in \{1, 2, \dots, J\}$  denote the age of each individual. Population grows at rate  $n$ . For tractability, individuals differ in terms of their marital status: they are born as either single or married, and their marital status does not change over time.

Married households and single females also differ in terms of the number of children attached to them. Married households and single females can be childless or endowed with two children. These children appear either *early* or *late* in the life-cycle exogenously, and affect the resources available to households for three periods. Children do not provide any utility.

The life-cycle of agents is split into two parts. Each agent starts life as a worker and at age  $J_R$ , individuals retire and collect pension benefits until they die at age  $J$ . We assume that married households are comprised by individuals who are of the same age. As a result, members of a married household experience identical life-cycle dynamics.

Each period, working households (married or single) make labor supply, consumption and savings decisions. Children imply a fixed time cost for females. If a female with children, married or single, works, then the household also has to pay child care costs. Not working for a female is *costly*; if she does not work, she experiences losses of labor efficiency units for next period. Furthermore, if the *female* member of a married household supplies positive amounts of market work, then the household incurs a utility cost.

**Heterogeneity and Demographics** Individuals differ in terms of their labor efficiency units. At the start of life, each *male* is endowed with an exogenous type  $z$ , where  $z \in Z$  and  $Z \subset R_{++}$  is a finite set. The type of a male agent remains constant over his life cycle. Let the age- $j$  productivity of a type- $z$  agent be denoted by the function  $\varpi_m(z, j)$ . Let  $\Omega_j(z)$  denote the fraction of age- $j$ , type- $z$  males in male population, with  $\sum_{z \in Z} \Omega_j(z) = 1$ .

Each female starts her working life with a particular intrinsic type. As males, this type is fixed over time and is denoted by  $x \in X$ , where  $X \subset R_{++}$  is a finite set. Let  $\Phi_j(x)$  denote the fractions of age- $j$ , type- $x$  females in female population, with  $\sum_{x \in X} \Phi_j(x) = 1$ .

As women enter and leave the labor market, their labor market productivity levels evolve *endogenously*. Each female starts life with an initial productivity level that depends on her intrinsic type,  $h_1 = \eta(x) \in H$ . The next period's productivity level ( $h'$ ) depends on the female's intrinsic type  $x$ , her age, the current level of  $h$  and current labor supply ( $l$ ). Formally, for  $j \geq 1$ ,

$$h' = G(x, h, l, j)$$

all  $h \in H$ . The function  $G$  is increasing in  $h$  and  $x$  and non-decreasing in  $l$ . It captures the combined effects of a female intrinsic type, age and labor supply decisions on her labor market productivity growth. We specify this function in detail in section (4).

Let  $M_j(x, z)$  denote the fraction of marriages between an age- $j$ , type- $x$  female and an age- $j$  type- $z$  male, and let  $\omega_j(z)$  and  $\phi_j(x)$  be the fraction of single type- $z$  males and the fraction of single type- $x$  females, respectively. Then, the following accounting identity must hold

$$\Omega_j(z) = \sum_{x \in X} M_j(x, z) + \omega_j(z). \quad (1)$$

Furthermore, since the marital status does not change,  $M_j(x, z) = M(x, z)$  and  $\omega_j(z) = \omega(z)$  for all  $j$ , which implies  $\Omega_j(z) = \Omega(z)$ . Similarly, for age- $j$  females, we have

$$\Phi_j(x) = \sum_{z \in Z} M_j(x, z) + \phi_j(x). \quad (2)$$

Since marital status does not change  $\phi_j(x) = \phi(x)$  and  $\Phi_j(x) = \Phi(x)$  for all  $j$

We assume that each cohort is  $1 + n$  bigger than the previous one. These demographic patterns are stationary so that age  $j$  agents are a fraction  $\mu_j$  of the population at any point in time. The weights are normalized to add up to one, and obey the recursion,  $\mu_{j+1} = \mu_j / (1+n)$ .

**Children** Children are assigned exogenously to married couples and single females at the start of life, depending on the intrinsic type of parents. Each married couple and single female can be of three types: *early* child bearers, *late* child bearers, and those *without* any children. Early and late child bearers have *two* children for three periods. Early child bearers have these children in ages  $j = 1, 2, 3$  while late child bearers have children attached to them in ages  $j = 2, 3, 4$ .

**Child Care Costs** We assume that if a female with children works, married or single, then the household has to pay for child care costs. Child care costs depend on the age of the child ( $s$ ). For a female with children of age  $s \in \{1, 2, 3\}$ , the household needs to purchase  $d(s)$  units of (child care) labor services for their two children. Since the competitive price of child care services is the wage rate  $w$ , the total cost of child care services for two children equals  $wd(s)$ .

**Utility Cost of Joint Work** We assume that at the start of their lives married households draw a  $q \in Q$ , where  $Q \subset R_{++}$  is a finite set. These values of  $q$  represent the *utility costs* of joint market work for married couples. For a given household, the initial draw of a utility cost depends on the intrinsic type of the husband. Let  $\zeta(q|z)$  denote the probability that the cost of joint work is  $q$ , with  $\sum_{q \in Q} \zeta(q|z) = 1$ .

**Preferences** The momentary utility function for a single female is given by

$$U_f^S(c, l, k_y) = \log(c) - \varphi(l + k_y \varkappa)^{1+\frac{1}{\gamma}},$$

where  $c$  is consumption,  $l$  is time devoted to market work,  $\varphi$  is a parameter controlling the disutility of work,  $\varkappa$  is fixed time cost having two age-1 (young) children for a female, and  $\gamma$  is the intertemporal elasticity of labor supply. Here  $k_y = 0$  stands for the absence of age-1 (young) children in the household, whereas  $k_y = 1$  stands for young children being present. Since a single male does not have any children, his utility function is simply given by

$$U_m^S(c, l) = \log(c) - \varphi(l)^{1+\frac{1}{\gamma}}.$$

Married households maximize the sum of their members utilities. We assume that when the female member of a married household works, the household incurs a utility cost  $q$ . Then, the utility function for a married female is given by

$$U_f^M(c, l_f, q, k_y) = \log(c) - \varphi(l_f + k_y \varkappa)^{1+\frac{1}{\gamma}} - \frac{1}{2} \chi\{l_f\} q,$$

while the one for a married male reads as

$$U_m^M(c, l_m, l_f, q) = \log(c) - \varphi l_m^{1+\frac{1}{\gamma}} - \frac{1}{2} \chi\{l_f\} q,$$

where  $\chi\{\cdot\}$  denote the indicator function. Note that consumption is a public good within the household. Note also that the parameter  $\gamma > 0$ , the intertemporal elasticity of labor supply, and  $\varphi$ , the weight on disutility of work, are independent of gender and marital status.

**Production and Markets** There is an aggregate firm that operates a constant returns to scale technology. The firm rents capital and labor services from households at the rate  $R$  and  $w$ , respectively. Using  $K$  units of capital and  $L_g$  units of labor, firms produce  $F(K, L_g) = K^\alpha L_g^{1-\alpha}$  units of consumption (investment) goods. We assume that capital depreciates at rate  $\delta_k$ . Households save in the form of a risk-free asset that pays the competitive rate of return  $r = R - \delta_k$ .

**Incomes, Taxation and Social Security** Let  $a$  stand for household's assets. Then, the total pre-tax resources of a single working male of age  $j$  and a single female worker of age  $j$  without any children are given by  $a + ra + w\varpi_m(z, j)l_m$  and  $a + ra + whl_f$ , respectively. For a single female worker with children, they amount to  $a + ra + whl - wd(s)\chi\{l_f\}$ . The pre-tax total resources for a married working couple with children are given by  $a + ra + w\varpi_m(z, j)l_m + whl_f - wd(s)\chi\{l_f\}$ , while they are  $a + ra + w\varpi_m(z, j)l_m + whl_f$  for those without children.

Retired households have access to social security benefits. We assume that social security benefits depend on agents' intrinsic types, i.e. initially more productive agents receive larger social security benefits. This allows us to capture in a parsimonious way the positive relation between lifetime earnings and social security transfers, as well as the intra-cohort redistribution built into the system. Let  $p_f^S(x)$ ,  $p_m^S(z)$ , and  $p^M(x, z)$  indicate the level of social security benefits for a single female of type  $x$ , a single male of type  $z$  and a married retired household of type  $(x, z)$ , respectively. Hence, retired households pre-tax resources are simply  $a + ra + p_f^S(x)$  and  $a + ra + p_m^S(z)$  for singles, and  $a + ra + p^M(x, z)$  for married ones.

Income for tax purposes,  $I$ , is defined as total labor and capital income. Hence, for a single male worker, it equals  $I = ra + w\varpi_m(z, j)l_m$ , while for a single female worker, it reads as  $I = ra + whl_f$ . For a married working household, taxable income equals  $I = ra + w\varpi_m(z, j)l_m + whl_f$ . We assume that social security benefits are not taxed, so income for tax purposes is simply given by  $ra$  for retired households. The total income tax liabilities of married and single households are affected by the presence of children in the household, and are represented by tax functions  $T^M(I, k)$  and  $T^S(I, k)$ , respectively, where  $k = 0$  stands for the absence of children in the household, whereas  $k = 1$  stands for children of any age being present. These functions are continuous in  $I$ , increasing and convex. This representation captures the actual variation in tax liabilities associated to the presence of children in households.

There is also a (flat) payroll tax that taxes individual labor incomes, represented by  $\tau_p$ , to fund social-security transfers. Moreover, each household pays an additional flat capital income tax for the returns from his/her asset holdings, denoted by  $\tau_k$ .

### 3.1 Decision Problem

We now present the decision problem for different types of agents in the recursive language. For single males, the individual state is  $(a, z, j)$ . For single females, the individual state is given by  $(a, h, x, b, j)$ . For married couples, the state is given by  $(a, h, x, z, q, b, j)$ . Note that

the dependency of taxes on the presence of children in the household ( $k$ ) is summarized by age ( $j$ ) and childbearing status ( $b$ ): (i)  $k = 1$  if  $b = \{1, 2\}$  and  $j = \{b, b + 1, b + 2\}$ , and (ii)  $k = 0$  if  $b = 2$  and  $j = 1$ , or  $b = \{1, 2\}$  for all  $j > b + 2$ , or  $b = 0$  for all  $j$ . Similarly, the presence of age-1 (young) children ( $k_y$ ) depends on  $b$  and  $j$ .

**The Problem of a Single Male Household** Consider now the problem of a single male worker of type  $(a, z, j)$ . A single worker of type- $(a, z, j)$  decides how much to work and how much to save. His problem is given by

$$V_m^S(a, z, j) = \max_{a', l} \{U_m^S(c, l) + \beta V_m^S(a', z, j + 1)\} \quad (3)$$

subject to

$$c + a' = \begin{cases} a(1 + r(1 - \tau_k)) + w\varpi_m(z, j)l(1 - \tau_p) - T^S(w\varpi_m(z, j)(j)l + ra, 0) & \text{if } j < J_R \\ a(1 + r(1 - \tau_k)) + p_m^S(z) - T^S(ra), & \text{otherwise} \end{cases},$$

and

$$l \geq 0, a' \geq 0 \text{ (with strict equality if } j = J)$$

**The Problem of a Single Female Household** In contrast to a single male, a single female's decisions also depends on her current human capital  $h$  and her child bearing status  $b$ . Hence, given her current state,  $(a, x, h, b, j)$ , the problem of a single female is

$$V_f^S(a, h, x, b, j) = \max_{a', l} \{U_f^S(c, l, k_y) + \beta V_f^S(a', h', x, b, j + 1)\},$$

subject to

(i) With kids: if  $b = \{1, 2\}$ ,  $j \in \{b, b + 1, b + 2\}$ , then  $k = 1$ , and

$$c + a' = a(1 + r(1 - \tau_k)) + whl(1 - \tau_p) - T^S(whl + ra, 1) - wd(j + 1 - b)\chi(l).$$

Furthermore, if  $b = j$ , then  $k_y = 1$ .

(ii) Without kids but not retired: if  $b = 0$ , or  $b = \{1, 2\}$  and  $b + 2 < j < J_R$ , or  $b = 2$  and  $j = 1$ , then  $k = 0$  and

$$c + a' = a(1 + r(1 - \tau_k)) + whl(1 - \tau_p) - T^S(whl + ra, 0)$$

(ii) Retired: if  $j \geq J_R$ ,  $k = 0$  and

$$c + a' = a(1 + r(1 - \tau_k)) + p_f^S(x) - T^S(ra, 0).$$

In addition,

$$h' = G(x, h, l, j),$$

$$l \geq 0, a' \geq 0 \text{ (with strict equality if } j = J)$$

Note how the cost of children depends on the age of children. If  $b = 1$ , the household has children at ages 1, 2 and 3, then  $wd(j+1-b)$  denote cost for ages 1, 2 and 3 with  $j = \{1, 2, 3\}$ . If  $b = 2$ , the household has children at ages 2, 3 and 4, then  $wd(j+1-b)$  denotes the cost for children of ages 1, 2 and 3 with  $j = \{2, 3, 4\}$ . A female only incurs the time cost of children if her kids are 1 year old, and this happens if  $b = j = 1$  or  $b = j = 2$ .

**The Problem of Married Households** Like singles, married couples decide how much to consume, how much to save, and how much to work. They also decide whether the female member of the household should work. Their problem is given by

$$\begin{aligned} V^M(a, h, x, z, q, b, j) &= \max_{a', l_f, l_m} \{ [U_f^M(c, l_f, q, k_y) + U_m^M(c, l_m, l_f, q)] \\ &+ \beta V^M(a', h', x, z, q, b, j+1) \}, \end{aligned}$$

subject to

(i) With kids: if  $b = \{1, 2\}$ ,  $j \in \{b, b+1, b+2\}$ , then  $k = 1$  and

$$\begin{aligned} c + a' &= a(1 + r(1 - \tau_k)) + w(\varpi_m(z, j)l_m + hl_f)(1 - \tau_p) \\ &- T^M(w\varpi_m(z, j)l_m + whl_f + ra, 1) - wd(j+1-b)\chi(l_f) \end{aligned}$$

Furthermore, if  $b = j$ , then  $k_y = 1$ .

(ii) Without kids but not retired: if  $b = 0$ , or  $b = \{1, 2\}$  and  $b+2 < j < J_R$ , or  $b = 2$ ,  $j = 1$ , then  $k = 0$  and

$$\begin{aligned} c + a' &= a(1 + r(1 - \tau_k)) + w(\varpi_m(z, j)l_m + hl_f)(1 - \tau_p) \\ &- T^M(w\varpi_m(z, j)l_m + whl_f + ra, 0) \end{aligned}$$

(ii) Retired: if  $j \geq J_R$ , then  $k = 0$  and

$$c + a' = a(1 + r(1 - \tau_k)) + p^M(x, z) - T^M(ra, 0).$$

In addition,

$$h' = G(x, h, l_f, j)$$

$$l_m \geq 0, l_f \geq 0, a' \geq 0 \text{ (with strict equality if } j = J)$$

### 3.2 Stationary Equilibrium

The aggregate state of this economy consists of distribution of households over their types, asset and human capital levels. In particular, let the function  $\psi_j^M(a, h, x, z, q, b)$  denote the number of married individuals of age  $j$  with assets  $a$ , female human capital  $h$ , when the female is of type  $x$ , the male is of type  $z$ , the household faces a utility cost  $q$  of joint work, and is of child bearing type  $b$ . The functions  $\psi_{f,j}^S(a, h, x, h, b)$ , for single females, and  $\psi_{m,j}^S(a, z)$ , for single males, are defined in a similar way. As we mentioned earlier, we restrict  $x, z$ , and  $q$  to take values from finite sets and  $b$  is finite by construction. In contrast, household assets,  $a$ , and female human capital levels,  $h$ , are continuous decisions. We denote by  $A = [0, \bar{a}]$  and  $H = [0, \bar{h}]$  the sets of possible assets and female human capital levels.

By construction,  $M(x, z)$ , the number married households of type  $(x, z)$ , must satisfy for all ages

$$M(x, z) = \sum_{q,b} \int_{A \times H} \psi_j^M(a, h, x, z, q, b) dh da.$$

Similarly, the fraction of single females and males must be consistent with the corresponding measures  $\psi_{f,j}^S$  and  $\psi_{m,j}^S$ . For all ages,

$$\phi(x) = \sum_b \int_{A \times H} \psi_{f,j}^S(a, h, x, b) dh da,$$

and

$$\omega(z) = \int_A \psi_{m,j}^S(a, z) da.$$

In stationary equilibrium, factor markets clear. Aggregate capital ( $K$ ) and aggregate labor ( $L$ ) are given by

$$\begin{aligned}
K &= \sum_j \mu_j \left[ \sum_{x,z,q,b} \int_{A \times H} a \psi_j^M(a, h, x, z, q, b) dh da + \sum_z \int_A a \psi_{m,j}^S(a, z) da \right. \\
&\quad \left. + \sum_{x,b} \int_{A \times H} a \psi_{f,j}^S(a, h, x, b) dh da \right] \tag{4}
\end{aligned}$$

and

$$\begin{aligned}
L &= \sum_j \mu_j \left[ \sum_{x,z,q,b} \int_{A \times H} (h l_f^M(a, h, x, z, q, b, j) + \varpi_m(z, j) l_m^M(a, h, x, z, q, b, j)) \psi_j^M(a, h, x, z, q, b) dh da \right. \\
&\quad \left. + \sum_z \int_A \varpi_m(z, j) l_m^S(a, z, j) \psi_m^S(a, z) da + \sum_{x,b} \int_{A \times H} h l_f^S(a, h, x, b, j) \psi_{f,j}^S(a, x, b) dh da \right] \tag{5}
\end{aligned}$$

Furthermore, labor used in the production of goods,  $L_g$ , equals

$$\begin{aligned}
L_g &= L - \left[ \sum_{x,z,q} \sum_{b=1,2} \sum_{j=b,b+2} \mu_j \int_{A \times H} \chi\{l_f^M\} d(j+1-b) \psi_j^M(a, h, x, z, q, b) dh da \right. \\
&\quad \left. + \sum_x \sum_{b=1,2} \sum_{j=b,b+2} \mu_j \int_{A \times H} \chi\{l_f^S\} d(j+1-b) \psi_{f,j}^S(a, h, x, b) dh da \right], \tag{6}
\end{aligned}$$

where the term in brackets is the quantity of labor used in child care services.

In addition, factor prices are competitive so  $w = F_2(K, L_g)$ ,  $R = F_1(K, L_g)$ , and  $r = R - \delta_k$ . In Supplementary Appendix, we provide a formal definition of equilibria.

## 4 Parameter Values

We now proceed to assign parameter values to the endowment, preference, and technology parameters of our benchmark economy. To this end, we use aggregate as well as cross-sectional and demographic data from multiple sources. As a first step in this process, we start by defining the length of a period to be 5 years.

**Demographics and Endowments** We assume that agents start their life at age 25 as workers and work for forty years, corresponding to ages 25 to 64. Hence the first model period ( $j = 1$ ) corresponds to ages 25-29, while the first model period of retirement ( $j = J_R$ ) corresponds to ages 65-79. After 8 periods of working life, all agents retire at age 65, and live until age 80; i.e. we set  $J = 11$ . The population grows at the annual rate of 1.1%, the average values for the U.S. economy between 1960-2000.



We set the number of types for males to four. Each type corresponds to an educational attainment level: *less than or equal to high school* (hs), *some college* (sc), *college* (col) and *post-college* education (col+). We use data from the 2000 U.S. Census to calculate age-efficiency profiles for each male type. Efficiency levels correspond to mean weekly wage rates within an education group, which we construct using annual wage and salary income and weeks worked. We normalize wages by the overall mean weekly wages for all males and females between ages 25 and 64. We include in the sample the civilian adult population who worked as full time workers last year, and exclude those who are self-employed or unpaid workers or make less than half of the minimum wage.<sup>6</sup> Figure 2 shows the second degree polynomials that we fit to the raw wage data. In our quantitative exercises, we calibrate the male efficiency units,  $\varpi_m(z, j)$ , using these fitted values. Our estimates imply a wage growth of about 60% for college graduates from ages 25-29 to ages 45-49. The corresponding values for high school graduates are about 38%.

We assume that there are four intrinsic female types, corresponding to four education levels. Following the same procedure for males, we also calculate the initial (ages 25-29) efficiency levels for females. Table A1 in Supplementary Tables shows initial efficiency levels for males and females and the corresponding gender wage gap. We use the initial efficiency levels for females to calibrate their initial human capital levels. After ages 25-29, the human capital level of females evolves endogenously according to

$$h' = G(x, h, l, j) = \exp [\ln h + \alpha_j^x \chi(l) - \delta(1 - \chi(l))] . \quad (7)$$

We calibrate the values for  $\alpha_j^x$  and  $\delta$  following a simple procedure.<sup>7</sup> First, following Mincer and Ofek (1982), we set  $\delta$  to corresponds to an annual wage loss associated to non-participation of 2%. Then, we select  $\alpha_j^x$  so that if a female of a particular type  $x$  works in every period, her wage profile has exactly the same shape as males. This procedure takes the initial gender differences as given, and assumes that the wage growth rate for a female who works full time will be the same as for a male worker; hence, it sets  $\alpha_j^x$  values equal to the growth rates of male wages at each age. Table A2 in Supplementary Tables shows the calibrated values for  $\alpha_j^x$ .

We subsequently determine the distribution of individuals by productivity types for each gender, i.e.  $\Omega(z)$  and  $\Phi(x)$ , using data from the 2000 U.S. Census. For this purpose, we consider all household heads or spouses who are between ages 30 and 39 and for each gender

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<sup>6</sup>Our sample restrictions are standard in the literature and follow Katz and Murphy (1992).

<sup>7</sup>Our formulation of the human capital accumulation process follows Attanasio, Low and Sánchez Marcos (2008).

calculate the fraction of population in each education cell. For the same age group, we also construct  $M(x, z)$ , the distribution of married working couples as shown in Table A3 in Supplementary Tables.<sup>8</sup>

Given the fractions of individuals in each education group,  $\Phi(x)$  and  $\Omega(z)$ , and the fractions of married households,  $M(x, z)$ , in the data, we calculate the implied fractions of single households,  $\omega(z)$  and  $\phi(x)$ , from accounting identities (1) and (2). The resulting values are reported in Table A4 in Supplementary Tables. About 77% of households in the benchmark economy consists of married households, while the rest (about 23%) are single.

Since we assume that the distribution of individuals by marital status is independent of age, we use the 30-39 age group for our calibration purposes. This age group captures the marital status of recent cohorts during their prime-working years, while being at the same time representative of older age groups.

**Childbearing** Our model assumes that each single female and each married couple belong to one of three groups: *childless*, *early child bearer* and *late child bearer*. The early child bearers have two children at ages 1, 2 and 3, corresponding to ages 25-29, 30-34 and 35-39, while late child bearers have their two children at ages 2, 3, and 4, corresponding to ages 30-34, 35-39, 40-44. This particular structure captures two key features of the data from the 2002 CPS June supplement.<sup>9</sup> First, conditional on having a child, married couples tend to have two children.<sup>10</sup> Second, these two births occur within a short period of time, mainly between ages 25 and 29 for households with low education and between ages 30 and 34 for households with high education.<sup>11</sup>

For singles, we use data from the 2002 CPS June supplement and calculate the fraction of 40 to 44 years old single (never married or divorced) females with zero live births. We use these statistics as a measure of lifetime childlessness. Then we calculate the fraction of all single women above age 25 with a total number of two live births who were below age 30 at

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<sup>8</sup>Consistent with positive assortative matching by education, the largest entries in each row and column in Supplementary Table A3 are located along the diagonal. See Fernandez, Guner and Knowles (2005) for a study of positive assortative matching by education.

<sup>9</sup>The CPS June Supplement provides data on the total number of live births and the age at last birth for females, which are not available in the U.S. Census.

<sup>10</sup>For married households in which women are above age 25, the total number of live births varies from 2.4 for those households in which both husband and wife have at most high school degrees to 2 for those households in which both husband and wife have more than a college degree. For the majority of households, the total number of children is close to 2.

<sup>11</sup>The average age at first birth is 26.2 for those households in which both husband and wife have at most high school degrees, and 31.1 for those households in which both husband and wife have more than a college degree. For the same household types with two children, the average age at second were 26.8 and 31.3, respectively.

their last birth. This fraction gives us those who are early child bearers, and the remaining fraction of assigned as late child bearers. The resulting distribution is shown in Table A5 in Supplementary Tables.

We follow a similar procedure for married couples, combining data from the CPS June Supplement and the U.S. Census. For childlessness, we use the large sample from the U.S. Census.<sup>12</sup> The Census does not provide data on total number of live births but the total number of children in the household is available. Therefore, as a measure of childlessness we use the fraction of married couples between ages 35-39 who have no children at home.<sup>13</sup> Then, using the CPS June supplement we look at all couples above age 25 in which the female had a total of two live births and was below age 30 at her last birth. This gives us the fraction of couples who are early child bearers, with the remaining married couples labeled as the late ones. Table A6 in Supplementary Tables shows the resulting distributions.

**Child Care Costs** To calibrate child care costs we use the U.S. Bureau of Census data from the Survey of Income and Program Participation (SIPP).<sup>14</sup> In 2005, the total yearly cost for employed mothers, who have children between ages 0 and 5 and who make child care payments, was about \$6,414.5. We take this figure from the Census as the child care costs for two young children, which represents about 10% of average household income in 2005. The Census estimates of total child care costs for children between 5 and 14 is about \$4851, which amounts to about 7.7% of average household income in 2005. We set  $d(1) = d_1$  and  $d(2) = d(3) = d_2$  and select  $d_1$  and  $d_2$  so that the total expenditure of families with children, i.e.  $wd_1$  and  $wd_2$ , are about 10% and 7.7% of average household income for young (0-4) and older (5-14) children, respectively.<sup>15</sup> The calibrated values of  $d_1$  and  $d_2$  are 0.062 and 0.048.

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<sup>12</sup>The CPS June Supplement is not particularly useful for the calculation of childlessness in married couples. The sample size is too small for some married household types for the calculation of the fraction of married females, aged 40-44, with no live births.

<sup>13</sup>Since we use children at home as a proxy for childlessness, we use age 35-39 rather than 40-44. Using ages 40-44 generates more childlessness among less educated people. This is counterfactual, and simply results from the fact that less educated people are more likely to have kids younger, and hence these kids are less likely to be at home when their parents are between ages 40-44.

<sup>14</sup>See Table 6 in <http://www.census.gov/population/www/socdemo/child/tables-2006.html>

<sup>15</sup>According to the The National Association of Child Care Resources and Referral Agencies, NACCRRA (2008a), the cost of a day care for two young kids, one infant and one toddler, in Utah, the median state with respect to infant care costs, was about \$10,632 per year in 2005. However, NACCRRA (2008b) reports that about 25% of children have their grandparents and other relatives as primary caregivers. Making this adjustment, the yearly cost is \$7,974. This is comparable with the Census data, which includes other cheaper types of child care arrangements (such as family day care). Similarly, according to NACCRRA (2008a) the cost of school-age children is about 60% of infants, which is again in line with Census estimates.

**Technology** We specify the production function as Cobb-Douglas, and calibrate the capital share and the depreciation rate using a notion of capital that includes fixed private capital, land, inventories and consumer durables. For the period 1960-2000, the resulting capital to output ratio averages 2.93 at the annual level. The capital share equals 0.343 and the (annual) depreciation rate amounts to 0.055.<sup>16</sup>

**Taxation** To construct income tax functions for married and single individuals, we estimate *effective taxes* paid as a function of reported income, marital status and children. For these purposes we use tax return micro data from Internal Revenue Service for the year 2000 (Statistics of Income Public Use Tax File). For married households, we estimate tax functions corresponding to the legal category *married filing jointly*. For singles without children, we estimate a tax function from the legal category *singles*; for singles with children, we estimate a tax function from the legal category *head of household*.<sup>17</sup>

We partition the sample in income brackets, and for each of these, we calculate total income taxes paid, total income earned, number of taxable returns and the number of returns. Hence, we find the mean income and the average tax rate corresponding to every income bracket. We calculate the average tax rates as

$$average\ tax\ rate = \frac{\left\{ \frac{total\ amount\ of\ income\ tax\ paid}{number\ of\ taxable\ returns} \right\}}{\left\{ \frac{total\ adjusted\ gross\ income}{number\ of\ returns} \right\}}.$$

In each case we fit the following equation to the data,

$$average\ tax\ rate\ (income) = \eta_1 + \eta_2 \log(income) + \varepsilon,$$

where *average tax (income)* is the average tax rate that applies when average income in an income bracket equals *income*. We calculate *income* by normalizing average income in each income bracket by the mean household income in 2000. Table 1 shows the estimates of the coefficients for married and single households, with and without children. To estimate the tax functions for household with children, we restrict our sample to households in which there are two dependent children for tax purposes. Given these estimates, we calculate the tax liabilities for each household as [*average tax rate (income)*]  $\times$  (*income*  $\times$  *mean household income*).

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<sup>16</sup>We estimate the capital share and the capital to output ratio following the standard methodology; see Cooley and Prescott (1995). The data for capital and land are from Bureau of Economic Analysis (Fixed Asset Account Tables) and Bureau of Labor Statistics (Multifactor Productivity Program Data).

<sup>17</sup>We use the 'head of household' category for singles with children, since in practice it is clearly advantageous for most unmarried individuals with dependent children to file under this category. For instance, the standard deduction is larger than for the 'single' category, and a larger portion of income is subject to lower marginal tax rates.

Figures 3 and 4 display estimated average and marginal tax rates for different multiples of household income. Our estimates imply that a single person without kids (with kids) with twice mean household income in 2000 faces an average tax rate of about 19.3 (15.8%) and a marginal tax rate equal to about 24.9% (24.9%). The corresponding rates for a married household with the same income are about 16.4% (14.6%) and 23.7% (23.6%).

Finally, we need to assign a value for the (flat) capital income tax rate  $\tau_k$ , which we use to proxy the corporate income tax. We estimate this tax rate as the one that reproduces the observed level of tax collections out of corporate income taxes after the major reforms of 1986. For the period 1987-2000, such tax collections averaged about 1.92% of GDP. Using the technology parameters we calibrate in conjunction with our notion of output (business GDP), we obtain  $\tau_k = 0.097$ . Overall, our choices imply tax collections that amount to about 12.7% of output. The corresponding value in the data for the year 2000 was 12.3%.

**Social Security** We calculate  $\tau_p = 0.086$ , as the average value of the social security contributions as a fraction of aggregate labor income for 1990-2000 period.<sup>18</sup> Using the 2000 U.S. Census we calculate total Social Security income for all single and married households.<sup>19</sup> Tables A7 and A8 in Supplementary Tables show Social Security benefits, normalized by the level corresponding to single males of the lowest types. Agents with higher types receive larger payments: a single male with post-college education receives about 30% more than a single male whose education is less than college, while a couple with two members with post-college education receives about 28% more than a couple with two members with less than high school education. Then, given the payroll tax rate, the value of the benefit for a single retired male of the lowest type,  $p_m^S(x_1)$ , balances the budget for the social security system. The value of  $p_m^S(x_1)$  is about 17.8% of the average household income in the economy.

**Preferences** There are three utility function parameters: the intertemporal elasticity of labor supply ( $\gamma$ ), the parameter governing the disutility of work ( $\varphi$ ), and the fixed time cost of young children ( $\varkappa$ ). We consider two values for  $\gamma$ : a low value of 0.2 and a higher value of 0.4. Both values are consistent with recent estimates for males. While  $\gamma = 0.2$  is in line with microeconomic evidence reviewed by Blundell and MaCurdy (1999),  $\gamma = 0.4$  is contained in the range of recent estimates by Domeij and Floden (2006, Table 5). Domeij

<sup>18</sup>The contributions considered are those from the Old Age, Survivors and DI programs. The Data comes from the Social Security Bulletin, Annual Statistical Supplement, 2005, Tables 4.A.3.

<sup>19</sup>Social Security income is all pre-tax income from Social Security pensions, survivors benefits, or permanent disability insurance. Since Social Security payments are reduced for those with earnings, we restrict our sample to those above age 70. For married couples we sum the social security payments of husbands and wives.

and Floden (2006) results are based upon estimates for married males that control for the bias emerging from borrowing constraints.<sup>20</sup> We proceed by presenting first results when the intertemporal elasticity of substitution equals 0.4. In subsequent sections, we discuss the implications of a lower value for this parameter. Given  $\gamma$ , we select the parameter  $\varphi$  to reproduce average market hours per worker observed in the data. These average hours per worker amounted to about 40.1% of available time in 2000.<sup>21</sup> We set  $\varkappa = 0.141$  to match the labor force participation of married females with young, 0 to 4 years old, children. From the 2000 U.S. Census, we calculate the labor force participation of females between ages 25 to 39 who have two children and whose oldest child is less than 5 as 55.6%. We select the fixed cost such that the labor force participation of married females with children less than 5 years (i.e. early child bearers between ages 25 and 29 and late child bearers between ages 30 and 34), has the same value.<sup>22</sup> Finally, we choose the discount factor  $\beta$ , so that the steady-state capital to output ratio matches the value in the data consistent with our choice of the technology parameters (2.93 in annual terms).

This leaves us with the utility cost of joint work,  $q$ , to determine. Note that even without this utility cost, married females face a non-trivial labor force participation decision due to child care costs and human capital accumulation. The presence of utility costs associated to joint work allows to capture residual heterogeneity among couples, beyond heterogeneity in endowments and children, that is needed to generate observed labor supply behavior, and in particular, labor force participation. As we explain in Section 2, all else the same, couples for which utility costs are high will have one earner whereas those with low costs will have both members in the labor force. Public policy via taxes and transfers will affect this decision and thus, the resulting degrees of labor force participation.

We assume that the utility cost parameter is distributed according to a (flexible) gamma distribution, with parameters  $k_z$  and  $\theta_z$ . Thus, conditional on the husband's type  $z$ ,

$$q \sim \zeta(q|z) \equiv q^{k_z-1} \frac{\exp(-q/\theta_z)}{\Gamma(k_z)\theta_z^{k_z}},$$

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<sup>20</sup>Rupert, Rogerson and Wright (2000) provide estimates within a similar range in the presence of a home production margin. Heathcote, Storesletten and Violante (2009) report an estimate of 0.38, using a model with incomplete markets.

<sup>21</sup>The numbers are for people between ages 25 and 54 and are based on data from the Consumer Population Survey. We find mean yearly hours worked by all males and females by multiplying usual hours worked in a week and number of weeks worked. We assume that each person has an available time of 5000 hours per year. Our target for hours corresponds to 2005 hours in the year 2000.

<sup>22</sup>Our calibrated value for  $\varkappa$  is in the ballpark of available estimates in the literature. Hotz and Miller (1988) estimate that the time cost of a newborn is about 660 hours per year and this cost declines at 12% per year. This would imply that parents spend about 520 hours per children, who are between ages 0 and 5. With 5000 available hours per year, this is more than 10% per child.

where  $\Gamma(\cdot)$  is the Gamma function, which we approximate on a discrete grid. By proceeding in this way, we exploit the information contained in the *differences* in the labor force participation of married females as their own wage rate differ with education (for a given husband type). We emphasize that this allows us to control the slope of the distribution of utility costs, which is potentially important in assessing the effects of tax changes on labor force participation.

Using CPS data, we calculate that the employment-population ratio of married females between ages 25 and 54, for each of the educational categories defined earlier.<sup>23</sup> Table 2 shows the resulting distribution of the labor force participation of married females by the productivities of husbands and wives for married households. The aggregate labor force participation for this group is 69.3%, and it increases from 59.7% for the lowest education group to 82.1% for the highest. Our strategy is then to select the two parameters governing the gamma distribution, for every husband type, so as to reproduce each of the rows (four entries) in Table 2 as closely as possible. Altogether, this process requires estimating 8 parameters (i.e. a pair  $(\theta, k)$  for each husband educational category).

**Summary** Table 3 summarizes our parameter choices. As we detailed above,  $n$  (population growth rate),  $\gamma$  (labor supply elasticity),  $\delta_k$  (depreciation rate of capital),  $\alpha$  (capital share),  $\delta$  (depreciation of female human capital) and  $\alpha_j^x$  (growth factors for female human capital) are set from external estimates. We also take tax functions  $T^S(\cdot)$  and  $T^M(\cdot)$  as well as payroll taxes  $\tau_p$  from the data. The remaining parameters are selected to match jointly several targets. First, we choose  $p_m^S(z_1)$ , the social security benefits for the lowest type male, to balance the social security budget. Second, the additional proportional tax on capital,  $\tau_k$ , is selected to collect taxes that match corporate tax collections from data. Third,  $d_1$  and  $d_2$ , child care time requirements for children, are calibrated so that households spend the right amount of resources on child care. Fourth, the discount factor is selected to match capital-to-output ratio. Fifth, disutility from market work,  $\varphi$ , is chosen to match hours per worker. Sixth, time cost of children,  $\varkappa$ , is used to match labor force participation of married females with young children. Finally, eight gamma function parameters are calibrated to generate married female force participation by husbands and wives types.

Table 4 shows the performance of the benchmark model in terms of the targets we impose for  $\varphi$ ,  $\beta$  and  $\varkappa$ . The table also shows how well the benchmark calibration matches the labor force participation of married females. The model has no problem in reproducing jointly these observations as the table demonstrates.

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<sup>23</sup>We consider all individuals who are *not* in armed forces.

## 4.1 The Benchmark Economy

Before proceeding to investigate the effects of tax reforms, we report on properties of the benchmark economy, and compare these with the corresponding values from data. This is critical for the questions at hand: to conduct tax reforms within our framework we want to be confident that it offers a good model of female labor supply. We focus on different aspects of the model economy here. In particular, (i) how does female labor force participation change by age and the presence of children? (ii) what is the gender gap in our model economy? The answer to the first question is important since the interaction between children and female labor force participation plays a key role in our model. The answer to the second question is also critical, since married females in our economy have a non-trivial labor force participation decision which results in an endogenous gender gap. In assessing the model performance, it is important to bear in mind that the empirical targets for the model are the levels of aggregate participation rates by marriage type, and the participation rates of women with young children. No age-related statistics are used, so the match between model and data in this dimension is due to the forces governing household labor supply within the model.

At the aggregate level, the model is in conformity with data. The model reproduces, by construction, the labor force participation rate of women with young children and the economy-wide level of participation, as it targets participation rates by type. It also captures the consequences of the presence of children on participation rates. Participation rates of women with children are lower than those without children, both in the model and in the data; about 64.4% versus 67.4%. Females without children participate more, their labor force participation are 82.9% and 82.5% in the model and in the data, respectively.

What are the female labor supply elasticities implied by the model economy? Although there are different ways one can measure the elasticity of female labor supply, given our model a natural one is to ask how much female labor force participation and aggregate hours will increase if female productivity levels were increased by 1%. Our model implies an aggregate elasticity of female labor force participation to changes in female productivity levels of about 0.72 and an aggregate elasticity of total hours worked by married females to changes in female productivity levels of about 0.95.<sup>24</sup> If we were to calculate the same elasticities to changes in the economy wide wage rate, we find elasticities of 0.36 and 0.35, respectively, which are (not surprisingly) lower.<sup>25</sup>

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<sup>24</sup>These elasticities are in line with estimates surveyed in Blundell and MaCurdy (1999) and Keane (2010).

<sup>25</sup>Consistent with available empirical evidence, elasticity of male hours with respect to the wage rate is about zero.



Figure 5 shows married female labor force participation by age and by the presence of children. As the figure shows, the labor force participation of married females with children increases monotonically with age both in the model and the data, and its level is always below that for women without children. Both in the model economy and the data, those who have their children early on, at ages 25-29, are women with low levels of education; not surprisingly, their labor force participation is low. Those who have their children in later ages tend to be skilled women, whose labor force participation is higher. Furthermore, those who have their children early are more likely to participate in the labor market in later ages, since their children age and the associated child care costs decline. The participation rate of women without children, on the other hand, declines slightly between ages 25-29 to 40-44. The decline in later ages is mainly due to women who had their children in the first period and enter the labor force in later ages as these children age. Since these women are mainly from lower education groups and could not accumulate human capital in the initial years, they have low labor force participation.

Figure 6 displays the wage gender gap in the model and the data. In the model economy we observe the labor market productivity levels for all females, whether they participate in the labor market or not. Since this is a more informative statistic, we report the gender gap from the model for *all* females. In order to produce a comparable measure from the data, we have to *impute* wages for females who do not participate in the labor market. In order to do that, we estimate a standard Mincer regression with Heckman (1979) selection correction, which provides us with wage estimates for women who do not participate in the labor market. When we report data on wages, we report an average of observed wages (for women who work) and imputed wages (for women who do not work). What is critical is that Heckman's procedure allows us to assign a wage for females who do not work.<sup>26</sup> The model does a very good job in generating both the level and the age pattern of the wage gender gap. In interpreting these results, it is important to bear in mind that wage gender gap is critically determined by labor force participation decisions. Moreover, we have selected the parameters of human capital accumulation process for females a priori without targeting any endogenous variables. Both in the data and the model, the ratio of female to male wages starts at about 80% and declines monotonically as women age, reaching less than 65% by

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<sup>26</sup>For the *population* equation for wages, we assume that log wages of women depend on years of education, age, age-squared and an interaction between age and years of education. For the *selection* equation, we assume that the probability of participation in the labor market for a female depends on her marital status, number of children younger than age 5, and the variables in the population equation. We estimate the parameters using Maximum Likelihood and use the corrected parameters of the Mincer equation to impute wages for women with missing wages. Our selection equation is similar to ones used by Chang and Kim (2006) and Mulligan and Rubinstein (2008).

age 54. The average gender gap for ages 25 to 54 is about 70%. As women with children decide to stay out of the labor force, their human capital declines generating endogenously a larger gender gap in later ages.<sup>27, 28</sup>

**The Importance of Costly Childbearing** What is the quantitative importance of child care costs in the benchmark economy? To this end, and motivated by the evidence presented earlier in this section, we run two counterfactual exercises. First, we double the child care expenses for working mothers, by doubling  $d(s)$  values. This has a dramatic effect on female labor force participation. Female labor force participation declines by about twenty percent (from 69.3% to 55.4%). As a result, aggregate hours and output decline by 4.1% and 5.7%, respectively. Second, we double the fixed time cost for children. With higher time costs, married female labor force participation declines by 8.4% (from 69.3% to 63.5%). The effect is much stronger for married females with young children, as their labor force participation declines by 80%. As with the higher child care costs, aggregate hours and aggregate output declines by about 1.9% and 4.1%, respectively. Hence, variation in child care costs critically matters in the determination of participation decisions.

**Participation Rates and the Temporal Variation in Wages** What are the implications for labor force participation rates, within our model, of a wage structure consistent with observed ones in the past? The answer to this question is important in assessing whether our model generates female labor force participation responses that are reasonable from a time-series point of view. To this end, we parameterize our economy with the wage structure of 1970, i.e. we take male wages for all ages and types as well as initial (age-1) wages for males from 1970 data. We keep all other parameters in their benchmark values. We find that in this scenario, female labor force participation declines by 2.3 percentage points relative to our benchmark, or about 10% of the observed change in the data.

Childcare services were more expensive in 1970; see Attanasio et al (2008). Hence, if in addition we increase the values of child cost parameters that we get from the first experiment

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<sup>27</sup>Our results on the gender gap are quite similar to those by Erosa, Fuster and Restuccia (2010). They also show that differences in human capital accumulation explain the widening gender gap over the life-cycle and children play a key role in determining lower human capital accumulation by females.

<sup>28</sup>Note that in the simulations, the initial (age 25-29) human capital levels for females are set according to data in Table A1 in online Appendix. In the data, these initial productivity levels are calculated for females who participate in the labor market. In the model, females observe these initial productivity levels and then decide whether to work or not. Hence, the gender gap in the model is exactly same as the *observed* gender gap in the data (79.9%). This is almost identical to *corrected* gender gap in Figure 6 (81.7%) as selection does not play a role for this age group.

by 25%, aggregate labor force participation drops by about 5.2 percentage points.<sup>29</sup> This indicates that the model accounts for about 21% of the observed change in the data. Given that many other factors changed from 1970 to 2000 (i.e. the structure of taxes as well as the marital structure of population), we conclude from these findings that the underlying elasticities in our model are sensible, as the model does not overshoot the observed decline in participation from 2000 to 1970.<sup>30</sup>

## 5 Tax Reforms

We now consider two hypothetical reforms to the current U.S. tax structure: a proportional income tax and a move from joint to separate filing for married couples. The first reform flattens the current income tax schedule while keeping the household as unit subject to taxation. The second reform reintroduces progressivity into the system, but changes the unit of taxation from households to *individuals*. The proportional income tax allows us to illustrate the effects of a rather well-studied case within the current framework, and relate our results with the existing literature. The second reform, which is impossible to analyze within a standard single-earner framework, illustrates the value-added of the model features of the current framework.

The findings we report are based on steady-state comparisons of pre and post-reform economies. In all cases, we keep the social security tax rate unchanged, which implies that benefits adjust with the reforms under consideration. For our benchmark set of experiments, we also keep the residual tax rate on capital income ( $\tau_k$ ) fixed. The exercises are in all cases *revenue neutral*.

### 5.1 A Proportional Income Tax

Table 5 reports the key findings from this exercise. To assess these results, the reader should bear in mind that by construction, a proportional income tax makes marginal and average tax rates equal for all households. Before the reform average and marginal tax rates covered a wide range, as indicated in Figures 3 and 4; in the new steady state, the uniform tax rate that balances the budget equals 11.9%. Thus, via the removal of distortions associated with

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<sup>29</sup>A 25% decline in child care costs is empirically plausible. Attanasio et al (2008) document that the level of child care costs declined by 15% between 1970s and 1980s and that the decline relative to female wages was even larger. Since the 1970s, the tax treatments of child care expenses has also become more favorable. Arguably, the availability of child care has improved significantly as well.

<sup>30</sup>See Kaygusuz (2010) for a decomposition of the changes in the post-1980 increase in female labor supply into parts that come from changes in taxation, wages, educational attainment and marital structure, in an environment without children.

a progressive income tax, this reform leads to substantial effects on output and factor inputs. The capital-to-output ratio increases by about 5.3% across steady states, leading to changes in the wage rate of about 2.4%. Total labor supply (hours adjusted by efficiency units) increases by 4.6%. As a result of these changes, aggregate output increases substantially by about 7.4%.

Our economy allows us to identify and quantify differential responses in labor supply to tax changes that take place at the intensive margin for both males and females, as well as at the *extensive* margin for married females. Recall that in the benchmark economy, the tax structure generates non-trivial disincentives to work since average and marginal tax rates increase with incomes. In addition, married females who decide to enter the labor force are taxed at their partner's current marginal tax rate. With the elimination of these disincentives, the change in labor supply of married females is substantially larger than the aggregate change in hours. The introduction of a flat-rate income tax implies that the labor force participation of married females increases by about 4.6%, while hours per worker rise by about 3.5% for females, and about 3.1% for males. Due to changes along the intensive and the extensive margins, total hours for married females increase by about 8.8%. This is a dramatic rise and is nearly three times the changes in total male hours. These results are especially worth noting as the parameter governing intertemporal substitution of labor is the same for males and females, and take place despite the equilibrium increase in the cost of child care (i.e. the wage rate goes up).

It is important to highlight three aspects of the results emerging from this experiment. First, as we show in Table 6, low-type married females increase their labor supply much more than high-type females. Over the life cycle, females with the lowest intrinsic type (those with high school education or less) increase their labor force participation by 8.0%, while highest types (those with post-college education) increase theirs only by 2.1%. This might come as a surprise, since a proportional income tax reform would likely increase marginal tax rates for lower types and reduce them for high types. There are several reasons that account for this phenomenon. Note first that the labor force participation of high-type married females is quite large in the benchmark economy to begin with, leaving relatively little room to react to tax changes. Secondly, relative to the benchmark economy, marginal tax rates effectively drop or remain relatively constant for low and middle income households after the introduction of the proportional income tax. In the benchmark economy, the marginal tax rate on a household with an income equal to one half average income is about 11%, little less than the rate after the reform, while the marginal rate amounts to about 17.4% for those with a mean income level. In other words, a proportional tax leads to a reduction

in marginal tax rates *even* for low and middle-income households in the new steady state.<sup>31</sup> Finally, the relative shapes of the distributions (cdf) of utility costs indicates the scope for a much larger reaction of less skilled types.<sup>32</sup>

Second, the response of married females with children is *larger* than those without children, as Table 5 and the lower panel of Table 6 demonstrate. While for married females who are childless the labor force participation increases by about 2.2%, the rise is much larger, about 7.0%, for those who are early child bearers, whereas the response increases up to about 10.5% for those with young children. This phenomenon is connected with the reasons for females with children to react more strongly to tax changes (see section 2), and to the stronger participation reaction of less-skilled females discussed above; lower types are more likely to have children as well as to have them early.

Finally, the increasing labor force participation of married females leads to higher efficiency units (human capital) for this group, by about 1.9%. As we document in Table 6, the increase in human capital is larger for lower types and those with children, which reflects the changes in labor force participation. It is about 3.7% for those with less than high school education, in contrast to nearly 1% for those with post-college education.

**Eliminating  $\tau_k$**  In Table 5, we also report the results where we eliminate  $\tau_k$  in a proportional income tax reform. Note that the tax rate that balances the budget is obviously higher when the capital income tax rate is included (13.8% versus 11.9%), as larger tax collections need to be generated. The results indicate that the inclusion of the flat-rate capital income tax in the tax reforms is largely unimportant for the magnitudes of labor supply responses. The key differences where  $\tau_k$  is kept intact are in the magnitude of output changes: when the capital income tax is included in the reform, output changes amount to 8.6% versus 7.4% when the capital income tax rate is maintained.

These differences are due to the larger effects on capital accumulation that take place when the capital income tax rate is eliminated in the tax reform. This is simply accounted for by the different tax burden on capital in the two cases. When the capital income tax rate is part of the reform, the effective tax rate on capital income is simply 13.8% (i.e. the

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<sup>31</sup>We abstract from means-tested welfare programs, such as food stamps and Medicaid. It is well known that such programs can generate very high marginal tax rates at low levels of income, as earning more might imply not qualifying for benefits; see Moffitt (1992) and Meghir and Phillips (2010). These programs are likely to dampen the responses by lower income households.

<sup>32</sup>We plot in Supplementary Figure A1 the distributions for a married household with a husband with high school and more than college education levels. As it can be seen, the slopes of the distributions are much larger for a typical less-skilled couple (both with high school or less) versus a typical high skilled couple (both with more than college education). Hence, tax changes will have larger effects for less skilled females.

income tax rate), whereas it is much higher (21.6%, which is the sum of the proportional tax, 11.9% and  $\tau_k$ , 9.75%) when the reform does not include the flat-rate capital income tax.

## 5.2 Separate Filing

A prominent feature of the current U.S. tax system is that it treats married and single individuals differently. The problem arises since the unit subject to taxation is the *household*, not the individual, with tax schedules that differ according to marital status. This creates much discussed marriage-tax penalties and bonuses, affecting the marginal tax rates that married individuals face. In particular, note that when a married female enters the labor market the first dollar of her earned income is taxed at her husband's current marginal rate, potentially distorting her labor supply in a critical way. This reasoning motivates our second experiment, where we move from the current system to one in which each individual files his/her taxes separately. We label this hypothetical reform experiment *separate filing*.

We assume that a married person's tax liabilities consists of his/her labor income plus half of household's asset income, and each working member of a married household with children declares one of the two children for tax purposes. In particular, for a married household without children we use the same tax function that singles without children face in the benchmark economy. For married households with children, we use a tax function from the legal category *head of household* (with one child) for each member. In addition, in order to collect the same amount of tax revenue as the benchmark economy, we assume that each individual faces an additional proportional tax (or subsidy) on his/her income.<sup>33</sup>

The possibility of separate filing can lower taxes on married females significantly.<sup>34</sup> To see this, consider a married household with kids with total income equal to twice mean household income, and suppose earnings of both members are equal. Under the current system, this household faces a marginal tax rate of about 23.6%. The marginal tax rate declines to about 17.4% if the household income is split equally between husband and wife. The gain is larger for the majority of wives who earn less than their husbands.

The effects of a move from the current system to separate filing are substantial. Table 5 shows that aggregate output goes up by about 3.8%, and aggregate labor by 2.7%. This is more than half of the increase associated with a proportional income tax reform. In contrast to a proportional income tax reform, however, the increase in aggregate labor is almost fully

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<sup>33</sup>We estimate a tax function for heads of households with one child, resulting in parameters  $\eta_1 = 0.107$  and  $\eta_2 = 0.082$ . In stationary equilibrium after the reform, a tax of 0.1% is needed to achieve revenue-neutrality.

<sup>34</sup>In contrast to Alessina, Ichino and Karabarbounis (2011), lower taxes on females emerge in the current framework from taxing individuals instead of households, and not from an optimal taxation argument to lower taxes on females who have more elastic labor supplies.

driven by the rise in aggregate hours by married females. The labor force participation of married females rises by 10.4% (more than twice as much as it does with a proportional income tax), and aggregate hours by married females increase by about 11.4%. In contrast, hours by male workers decline slightly. As it is shown in Table 6, separate filing generates significant increases in labor force participation and declines in gender gap for exactly the same groups that were affected by proportional taxes, married females with less education and with children, but with much larger magnitudes.

Why does married female labor force participation react so much with separate filing? The key is that separate filing reduces the tax burden associated with female labor force participation dramatically. Table 7 shows the *extra* taxes that a household has to pay as a fraction of the extra income that a female generates for younger households (aged 25-34). In the benchmark economy, the tax burden associated with female labor force participation is quite similar for females with different characteristics. It is larger for females with more education and for those who do not have any children. With separate filing, the situation is radically different.<sup>35</sup> Now females with lower education as well as those with children face much lower tax rates associated with movements along the extensive margin. Not surprisingly, their labor force participation increases dramatically. Incidentally, these are the groups that have the largest potential response to a tax reform.

The main message from this policy experiment is quite clear. A move from the current system to one in which individuals (not households) are the basic unit of taxation goes a long way in generating significant effects on aggregate labor and output. These effects take place without eliminating tax progressivity, or the taxation of capital income, and depend critically on the response of married females. These and previous findings motivate us to explicitly quantify the relative importance of married females as a group for our results. We do this in section 6.

### 5.3 Tax Reforms in an Open Economy

A concern with analysis of tax reforms in equilibrium models is the (typically) large effects on capital intensity and output driven by the reduction or elimination of distortions on capital accumulation. To address this issue, we conduct tax reform exercises under the assumption of a small economy open to capital movements. We fix the before-tax rate of return on capital at the benchmark level, and thus the wage rate, and calculate stationary equilibria under the proposed tax systems.

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<sup>35</sup>In the proportional tax reform case, the extra taxes associated to further labor market participation naturally amount to the equilibrium tax rate (11.9%).

Our main findings are summarized in Table 5, alongside the results from our main experiments. As the table shows, the effects on output are more moderate, as by construction the ratio of capital to labor in the production of goods is the same across steady states. However, a different picture emerges for the effects on labor supply. For instance, if a proportional income tax is considered, labor force participation (aggregate hours) increases by about 5.1% (4.5%) in the small-open economy case, whereas the corresponding increase is very similar, about 4.6% (4.7%) under the closed economy assumption. A similar pattern holds under a separate filing reform, and for different labor supply statistics. We conclude from these exercises that the effects of tax reforms on labor supply at multiple levels are essentially independent on whether the economy is open to capital movements or not.

## 5.4 Tax Reforms and Within-group Inequality

Our economy is parameterized considering only heterogeneity associated to schooling levels. As a result, the benchmark economy produces less dispersion in wages and earnings than the data. We calculate, using estimates from Heathcote, Storesletten and Violante (2004) for males, that the variance of log-wages in our first (fourth) age group is about 0.177 (0.240), while it is only 0.066 (0.089) in the model for males. This implies that our model accounts for about 37.3% (37.1%) of the variance of log-wages for males at the start (middle) of the life cycle.<sup>36</sup> More generally, our model implies an economy-wide Gini coefficient of household earnings of about 0.283. Heathcote, Perri and Violante (2010) report a corresponding value of about 0.4 for the year 2000.

Since the model accounts for only a fraction of observed wage inequality, we assess the robustness of our results to the explicit consideration of wage heterogeneity *within* education levels. We introduce wage heterogeneity within educational groups for both males and females in a simple way at the start of the life cycle. In particular, we assume that for each education category, there are two types, high and low, and half of each education group is high type and the other half is low type. For males, high (low) types have  $\Delta\%$  higher (lower) wages than the average wage for a given education group at any point along the life-cycle. For women, high (low) types imply  $\Delta\%$  higher (lower) wages at age 1 and female wages evolve endogenously afterwards as in the benchmark economy. Our strategy is to select  $\Delta$  to generate, inside the model, the wage dispersion for males at age 1 (variance of log-wages) observed in the data according to Heathcote et al (2004) estimates. Our specification implies that required  $\Delta$  is about 39.5%; i.e. high (low) types males and females at age-1 observe

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<sup>36</sup>We use for these purposes the authors' estimates for the structure of fixed effects and permanent shocks to wages. We exclude temporary shocks.



wages that are 39.5% above (below) the education-specific means. Given these estimates, we parameterize again our model economy in line with the discussion in Section 4.<sup>37</sup>

We find that the aggregate effects of reforms become more moderate with the inclusion of within-group inequality. Under a proportional tax (separate filing), output increases by about 6.8% (3.4%), and aggregate hours by 4.2% (2.7%). Under the benchmark specification, increases in output were 7.4% (3.8%) under a proportional tax (separate filing) reform, while aggregate hours increased by 4.7% (2.9%). At the center of the moderation in responses is the behavior of labor force participation rates. Under a proportional tax (separate filing), the participation rate of married females increases by about 2.8% (9.5%); the corresponding changes under our benchmark specification are 4.6% (10.4%).

The smaller changes in participation rates in the case of the proportional income tax reform are in turn driven by the behavior of married women in poorer households. With within-group heterogeneity, taxes actually go up for a large group of women with low levels of wages. As a result, the labor supply of response of these women with is now more muted. This happens in much smaller magnitudes, however, when we consider the separate filing case (i.e. a progressive tax scheme); labor force participation responses become very similar to the ones under the benchmark scenario in the absence of within-group inequality. We conclude from these exercises that the simple consideration of within-group inequality leads to moderately smaller effects on aggregates upon a reform, especially in the separate filing case. Our benchmark specification appears to capture the bulk of output and labor supply responses upon tax reforms.

## 6 The Role of Married Females

We now discuss in more detail the impact of changes in labor supply of married females. We ask: what is the overall contribution of married females to changes in labor supply? What is the importance of labor supply changes along the extensive margin?

In answering these questions, we first note that the type of the tax reform under consideration is critical. As expected from the results in the previous section, the role of married females is largest with a move to separate filing. Table 8 makes these points clear. In this table we report the contribution of married females to changes in total hours and total labor supply under our benchmark calibration. For proportional income taxes, the contribution of married females to changes in total hours (labor supply) is around 51% (48%). Under sepa-

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<sup>37</sup>We assume that child bearing status, marital status, wage growth factors for females, social security benefits depend only on agents' education level as in the benchmark economy. Within a particular education pair, couples are assumed to match randomly according to their high/low types.

rate filing they contribute to more than 100% of the changes in total hours and labor supply, as some groups effectively reduce their hours (e.g. men). We conclude from these findings that the overall contribution of married females to hours and labor supply changes is substantial; they contribute disproportionately given their share of the working age population (about 37.5%).

In the bottom panel of Table 8 we focus on the role of the extensive margin and report its contribution to the rise in hours and total labor supply. In order to assess the role of extensive margin, we carry out the following counterfactual exercise. For each age and  $(x, z, q, b)$ -type married woman we determine the labor force participation status in the benchmark economy.<sup>38</sup> Next, we run the tax reforms in an economy where the labor force participation decision is no longer a choice for a female. The female workers in the benchmark economy can change their hours in response to a tax reform, however, they are not allowed to drop out of the labor force. Moreover, the females who are out of the labor force in the benchmark economy are not allowed to enter the labor market. This allows us to quantify the significance of the intensive margin as well as the extensive margin in the tax reform exercises. We find that the extensive margin contributes about 25% of the changes in total hours under a proportional income tax, and about 86% of the changes in hours under separate filing. For changes in labor supply, the contributions are about 23% and 79%, respectively. By this measure, these calculations suggest that the bulk of the rise in the labor supply of married females can be attributed to movements along the extensive margin.

**Married Females with Children** How much of the increase in extensive margin and aggregates hours can be attributed to married females with children? As our results in Tables 5 and 6 show their labor supply increase more than married females without children. In order to highlight the role of females with children, we report in Table 8 the contribution of married females with children to overall changes in hours and labor supply. As the table demonstrates, the contribution of this group is substantial. Under a proportional tax, married females with children account for about 21% and 18% of the changes in hours and labor supply. In line with our previous discussion, these figures are bigger under a separate-filing reform: 57% and 49%, respectively.

To isolate further the contribution of married females with children we focus on the separate filing case, and consider the following version of it. Suppose only married females *without children* are allowed to file separately, while married females with children file taxes as they did in our benchmark economy. Not surprisingly, labor supply responses are much

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<sup>38</sup>Note that age,  $x, z, q$ , and  $b$  are exogenous characteristics of a married household.

more muted with this reform. The labor force participation of married females increases by 3.3% (in contrast to 10.4% in separate filing reform) and aggregate labor supply increases by 1.1% (in contrast to 2.7%), respectively. Hence, when we do not allow married females with children to file separately the effect on married female labor force participation is about 70% smaller, while the effects on aggregate labor are smaller by 60%. Hence, not only married females account for a large part of the changes in labor supply, a large part of this change comes from married females with children.

## 7 The Importance of the Intertemporal Elasticity

We now turn our attention to the role of the preference parameter  $\gamma$ ; the *micro* intertemporal elasticity of labor supply. For these purposes, we report results for the value on the low side of the empirical estimates for this parameter ( $\gamma = 0.2$ ), and calibrate the rest of the parameters following the procedure discussed in Section 4. The main results are summarized in Table 9. Our central findings are that while changes in hours per-worker are lower than under  $\gamma = 0.4$ , the relative importance of changes along the extensive margin is *larger* under  $\gamma = 0.2$ . As a result, the response of aggregate hours (and output) across steady states is *not* critically affected by a lower intertemporal elasticity.

Consider first the proportional income tax reform. As we have documented in Table 8, with  $\gamma = 0.4$  about 18% of the increase in aggregate labor supply was due to higher labor force participation by married females (i.e. due to extensive margin), while the rest came from higher per-worker hours. With a lower  $\gamma$ , changing labor supply along the intensive margin is more costly and therefore, changes along this margin are now about 40-45% lower than they were with a higher  $\gamma$ . However, aggregate hours (output) still increase by as much as 3.7% (6.1%), or about 78% (82%) of its increase with a high  $\gamma$ . This occurs since the increase along the extensive margin is now higher; the labor force participation of married females increases by 6.4% in contrast to a 4.6% increase under the high  $\gamma$  value. The net result is that the increase in aggregate hours by married females is not much affected by a lower  $\gamma$ . With an extensive margin playing a larger role now, the contribution of married females to changes in labor hours and labor supply goes up. As Table 9 shows, while the contribution of married females to changes in hours was 51.1% under  $\gamma = 0.4$ , it is now 67%.

Since the extensive margin plays a much bigger role in the separate filing case, lowering  $\gamma$  has practically no effect on reform outcomes. Again, households react much less along the intensive margin and the bulk of the adjustment takes place via changes in labor force

participation. The labor force participation of married female increase by 11.2% with a low  $\gamma$ , while the increase was 10.4% with high  $\gamma$ . As a result, both aggregate hours and aggregate output increase as much as they do with a high  $\gamma$ .

The message from this experiment is clear. Since adjusting along the intensive margin is costlier with a low  $\gamma$ , married households find it optimal to adjust hours worked largely along the extensive margin. This, in conjunction with the fact that the calibration under  $\gamma = 0.2$  has still to respect the underlying data on labor force participation, renders the substantial response of married females, which results in the similar changes in aggregate hours and output discussed above.

## 8 Welfare Effects

We report in this section some of the welfare implications associated to the tax reforms that we study, focusing on the small open-economy case under the benchmark value  $\gamma = 0.4$ . To assess the welfare consequences of reforms, we compute transitional dynamics between steady states under the assumption of unanticipated tax reforms, where we compute the tax rates that balance the budget in each period. This implies that for the case of a proportional income tax, we compute the sequence of tax rates that generate the same tax revenue as in the initial steady state. For the separate filing case, we compute sequence of residual tax rates that balance the budget in each period.

For those households alive at the moment of the reform, say  $t = t_0$ , we calculate an aggregate measure of welfare gains in consumption terms. This corresponds to the common, proportional, per-period consumption compensation that equalizes aggregate welfare under the status quo (i.e. in the steady state under current taxes), with the level of aggregate welfare under the transition path implied by each reform.

We find that both reforms lead to aggregate welfare gains at  $t = t_0$ . The magnitude of welfare gains is *larger* under a proportional income tax than under separate filing; the consumption compensation amounts to 1.3% under a proportional income tax whereas it is rather small (0.2%) under the separate filing case.

**Heterogeneity** We find that a majority of households benefit from the reforms at  $t = t_0$ . More households benefit from a move to separate filing (about 69%) than under a proportional tax (54%), despite the fact that gains are larger under a proportional tax.

Not surprisingly, there is a substantial degree of heterogeneity across different ages and types in the welfare changes driven by the reforms. Table 10 reports welfare changes by

age and types of newborn married households (i.e. born at  $t = t_0$ ). To save space, we report results only for those married households in which both husband and wife have the same productivity type. Consider first the effects across different ages. With a proportional income tax reform, welfare gains across ages display an inverted-U shape. As very young and very old individuals, who have low incomes, face low taxes in the benchmark economy, they are worse off with a proportional income tax. In contrast, the welfare gains are the highest for agents who are at their peak working ages (45-49). Welfare effects are much more muted under the separate filing case. There is not a clear age pattern in welfare gains/losses, as changes in the implied tax liabilities associated to separate filing reform are not as clear as in the case of the proportional income tax reform.

Table 10 also reports welfare changes for different types of newborn married households. For both reforms and for all three child bearing status, welfare gains are increasing in household productivity. In all cases, households with the lowest type (high school) husband and wives lose, while those with the highest types (more than college) gain. Furthermore, gains and losses are more pronounced with the proportional income tax reform, where changes in tax liabilities are stronger.

There is, however, an important difference in welfare changes between the two reform cases. Under separate filing, higher productivity households with children are the big winners, reflecting the decline in the tax burden associated with female labor force participation documented in Table 7. Households with college and more than college-educated partners who are early child bearers gain by about 1.3% and 1.6%. The same numbers for late child bearers are 0.8% and 1.2%, respectively, while all but the highest type (more than college) childless-households lose from this reform. In contrast, childless households are big winners from the shift to a proportional income tax. In particular, childless households with more than college- educated members (almost all them with two members working) gain 7.6% from this reform, while those with less education (high school or some college) lose significantly.

In the model we have abstracted from marriage and divorce decisions, which can be viewed as a shortcoming of our analysis. The tax reforms that we consider affect the values of being married and single. As Table 10 shows at the time of the reform on average newborn agents lose about 0.6% from a move to proportional income tax and are about indifferent from a move to separate filing. If we calculate welfare changes for married and single agents *separately*, it turns out that single agents fare better than married ones. For the proportional income tax reform, married newborn agents lose about 0.78%, while singles gain by 0.18%, while for separate filing married agents lose by 0.06% and singles gain by 0.19%. Hence,

both reforms make being single more attractive relative to being married.<sup>39</sup>

## 9 Concluding Remarks

Our results have clear implications for policy. First, our analysis demonstrates that reforms that change the unit of taxation from households to individuals can have substantial consequences on labor supply and output. Reforms of this sort respect the underlying nature of tax progressivity and do not rely on the elimination of taxes on capital income. They do not require large changes in other taxes to balance the budget, and can be easily implemented out of existing tax schedules. As a result, such reforms could be politically easier to undertake, while delivering large effects on output and labor supply.

A second implication relates to the interplay between distorting taxes, and other non-tax barriers to female labor force participation. Such barriers include the restrictive regulation of temporary work, and product market distortions such as restrictions on shopping hours, that are common in several developed economies. If married females drive the bulk of hour changes associated to tax reforms, these obstacles to increasing participation can interact with changes in the tax structure, and prevent the large predicted changes in labor supply to materialize. From this perspective, a more complete analysis of taxation and labor supply should study these issues. We leave this and other extensions for future work.

We conclude by commenting on two important issues we have abstracted from that might be important in future research. First, we have only considered the effects of labor market disruptions on the skills of females, but have ignored the effects of tax changes on standard human capital accumulation decisions. Recent papers have addressed this topic in economies with agent heterogeneity (e.g. Erosa and Koreshkova (2007)), and their findings suggest that the presence of human capital decisions can amplify the effects of tax reforms. No paper has focused on the topic taking into account two-earner households with an extensive margin decision. The second issue pertains to the role of heterogeneity within educational categories, and its interplay with idiosyncratic risk in two-earner households in tax reforms. Our analysis in section 5.4 is a preliminary, first step in this direction.

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<sup>39</sup>Previous work in models with marriage decisions indicates that the effects of changes in tax rules on the equilibrium number of married and single people is small. See Chade and Ventura (2002) and Chade and Ventura (2005).

Table 1: Tax Function Parameters

	$\hat{\eta}_1$	$\hat{\eta}_2$	$R^2$
Married (no children)	0.113	0.073	0.998
Married (two children)	0.084	0.090	0.992
Single (no children)	0.153	0.057	0.976
Single (two children)	0.094	0.092	0.947

Note: Entries show the parameter estimates for the postulated tax function. These result from regressing effective average tax rates against household income, using 2000 micro data from the U.S. Internal Revenue Service. For singles with two children, the data used pertains to the 'Head of Household' category – see text for details.

Table 2: Labor Force Participation of Married Females, 25-54

	Females			
Males	hs	sc	col	col+
hs	58.2	75.9	82.7	82.3
sc	64.6	74.8	82.9	88.4
col	61.6	68.7	73.2	83.2
col+	55.0	62.1	63.5	78.7
Total	59.7	73.4	74.8	82.1

Note: Each entry shows the labor force participation of married females ages 25 to 54, calculated from the 2000 U.S. Census. The outer row shows the weighted average for a fixed male or female type.

Table 3: Parameter Values

<u>Parameter</u>	<u>Value</u>	<u>Comments</u>
Population Growth Rate ( $n$ )	1.1	U.S. Data - see text.
Discount Factor ( $\beta$ )	0.974	Calibrated - matches $K/Y$
Intertemporal Elasticity (Labor Supply) ( $\gamma$ )	0.4	Literature estimates.
Disutility of Market Work ( $\varphi$ )	8.03	Calibrated - matches hours per worker
Time cost of Children ( $\varkappa$ )	0.141	Calibrated - matches LFP of married females with young (0-4) children
Child care costs for young children ( $d_1$ )	0.062	Calibrated - matches child care expenditure for young (0-4) children
Child care costs for young children ( $d_2$ )	0.048	Calibrated - matches child care expenditure for old (5-14) children
Dep. of human capital, females ( $\delta$ )	0.02	Mincer and Ofek (1982)
Growth of human capital, females ( $\alpha_j^x$ )	-	Calibrated - see text.
Capital Share ( $\alpha$ )	0.343	Calibrated - see text.
Depreciation Rate ( $\delta_k$ )	0.055	Calibrated - see text.
Payroll Tax Rate ( $\tau_p$ )	0.086	U.S. Data - see text.
Social Security Income ( $p_m^S(z_1)$ ) (for the lowest type single male as a % of average household income)	17.8%	Calibrated- to balance social security budget
Capital Income Tax Rate ( $\tau_k$ )	0.097	Calibrated - matches corporate income tax collections
Distribution of utility costs $\zeta(\cdot z)$ (Gamma Distribution)	-	Calibrated - matches LFP by education conditional on husband's type



Table 4: Model and Data

Statistic	Data	Model
Capital Output Ratio	2.93	2.95
Labor Hours Per-Worker	0.40	0.40
Labor Force Participation of Married Females with Young Children (%)	55.6	57.1
Participation rate of Married Females (%), 25-54		
Less than High School	59.7	59.9
Some College	73.4	72.4
College	74.8	79.3
More than College	82.1	81.4
Total	69.4	69.3
With Children	67.4	64.4
Without Children	82.5	82.9

Note: Entries summarize the performance of the benchmark model in terms of empirical targets and key aspects of data. Total participation rates, with children and without children are not explicitly targeted.

Table 5: Tax Reforms (%)

	Proportional Income			Separate Filing	
	Closed Economy	Closed Economy ( $\tau_k = 0$ )	Open Economy	Closed Economy	Open Economy
Married Fem. LFP	4.6	4.5	5.1	10.4	11.1
Married Fem. LFP with children	6.8	6.4	8.5	18.1	20.4
Agg. Hours	4.7	4.6	4.5	2.9	2.9
Agg. Hours (married fem.)	8.8	8.4	9.1	11.4	12.1
Hours per worker (female)	3.5	3.8	3.8	0.3	0.3
Hours per worker (male)	3.1	3.3	3.3	-0.2	-0.2
Aggregate Labor	4.6	4.4	4.2	2.7	2.5
Capital/Output	5.3	7.8	-	2.4	-
Aggregate Output	7.4	8.6	4.3	3.8	2.4
Tax Rate	11.9	13.8	10.8	0.1	-0.4

Note: Entries show the steady-state effects of replacing current income taxes via the specified reforms. The values are percentage changes relative to the benchmark economy. The values for "Tax Rate" correspond to the proportional rates that are necessary to achieve budget balance. See text for details.

Table 6: Effects on Labor Force Participation and Human Capital (%)

	Proportional Income Tax		Separate Filing	
	LFP (increase)	Human Capital (increase)	LFP (increase)	Human Capital (increase)
<u>Education</u>				
High School	8.0	3.7	20.6	10.4
Some College	4.2	1.9	7.8	4.1
College	1.9	0.8	3.2	1.9
College +	2.1	0.9	2.7	1.3
<u>Child Bearing Status</u>				
$b = 0$ , childless	2.2	0.8	2.2	1.0
$b = 1$ , early child bearer	7.0	3.2	14.4	7.0
$b = 2$ , late child bearer	2.3	0.7	7.6	2.9

Note: Entries show the steady-state effects of replacing current income taxes on labor force participation rates the human capital. The values are percentage changes relative to the benchmark economy.

Table 7: Tax Burden from Female Labor Force Participation, 25-34 (%)

	Benchmark Economy	Separate Filing
<u>Education</u>		
High School	15.0	3.6
Some College	15.8	4.4
College	17.6	7.8
College +	18.8	10.3
<u>Child Bearing Status</u>		
$b = 0$ , childless	17.2	11.2
$b = 1$ , early child bearer	15.4	2.7
$b = 2$ , late child bearer	17.1	7.2

Note: Entries show the additional taxes associated to labor force participation for younger females, in the benchmark economy and in the separate filing case. Additional taxes are reported as a percentage of females' earnings.

Table 8: Role of Females (%)

	Proportional Income	Separate Filing
<i>Panel A: Total Changes</i>		
$\Delta$ in Married Female Hours (% of Total $\Delta$ in Hours)	51.1	105.6
$\Delta$ in Married Female (w/ children) Hours (% of Total $\Delta$ in Hours)	20.9	57.0
<hr/>		
$\Delta$ in Married Female Labor (% of Total $\Delta$ in Labor)	47.9	105.7
$\Delta$ in Married Female (w/ children) Labor (% of Total $\Delta$ in Hours)	17.8	49.0
<hr/>		
<i>Panel B: Extensive Margin</i>		
$\Delta$ in Married Female Hours (% of Total $\Delta$ in Hours)	25.0	86.0
$\Delta$ in Married Female Labor (% of Total $\Delta$ in Labor)	23.0	79.0

Note: Entries show the contribution of changes in the labor supply of married females relative to total changes in labor supply, both in terms of raw hours changes as well as in terms of labor in efficiency units. The top panel shows the contribution of total changes. The bottom panel shows only the contribution of changes along the extensive margin.

Table 9: Reforms with Low Intertemporal Elasticity (%)

	Proportional Income	Separate Filing
Married Female LFP	6.4	11.2
Married Female LFP with children	8.7	18.4
Aggregate Hours	3.7	3.0
Aggregate Hours (married females)	8.7	11.4
Hours per worker (female)	2.1	0
Hours per worker (male)	1.7	-0.2
Capital/Output	4.9	2.2
Aggregate Labor	3.4	2.7
Aggregate Output	6.1	3.8
$\Delta$ in Married Female Hours (% of Total $\Delta$ in Hours)	67.0	106.7
$\Delta$ in Married Female Labor (% of Total $\Delta$ in Labor)	62.3	106.1

Note: Entries show the steady-state effects of replacing current income taxes via the specified reforms under a low value of the intertemporal elasticity parameter ( $\gamma = 0.2$ ). The values are percentage changes relative to a benchmark economy with  $\gamma = 0.2$ .

Table 10: Welfare Effects (%)

	Prop. Income	Sep. Filing		Prop. Income	Sep. Filing	Prop. Income	Sep. Filing	Prop. Income	Sep. Filing
Age			Education	Childless		Early		Late	
25-29	-0.6	0	High School	-1.5	-1.4	-5.2	-1.0	-2.9	-1.4
30-34	0.5	0.4	Some College	1.0	-1.1	-1.8	0.5	-0.7	0.0
45-49	3.1	0	College	4.9	-0.3	2.8	1.3	3.4	0.8
50-54	2.8	0.2	College +	7.6	0.3	5.1	1.6	6.2	1.2
55-59	2.2	0.3							
70-74	-1.3	-0.1							
75-80	-1.3	-0.1							
All	1.3	0.2							
Winners (%)	54	69							

Note: The entries show the per-period consumption compensation that equalizes welfare under the status quo (i.e. in the steady state under current taxes), with the level of welfare under the transition path implied by each reform. Entries on the left panel correspond to all household types of the same age, as well as for all those alive at the reform date. The last entry shows the percentage of households who experience a welfare gain. Entries on the right panel correspond to newborn married households where both partners have the same education level. See text for details.

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Figure 1: Taxes and Labor Force Participation of Secondary Earners

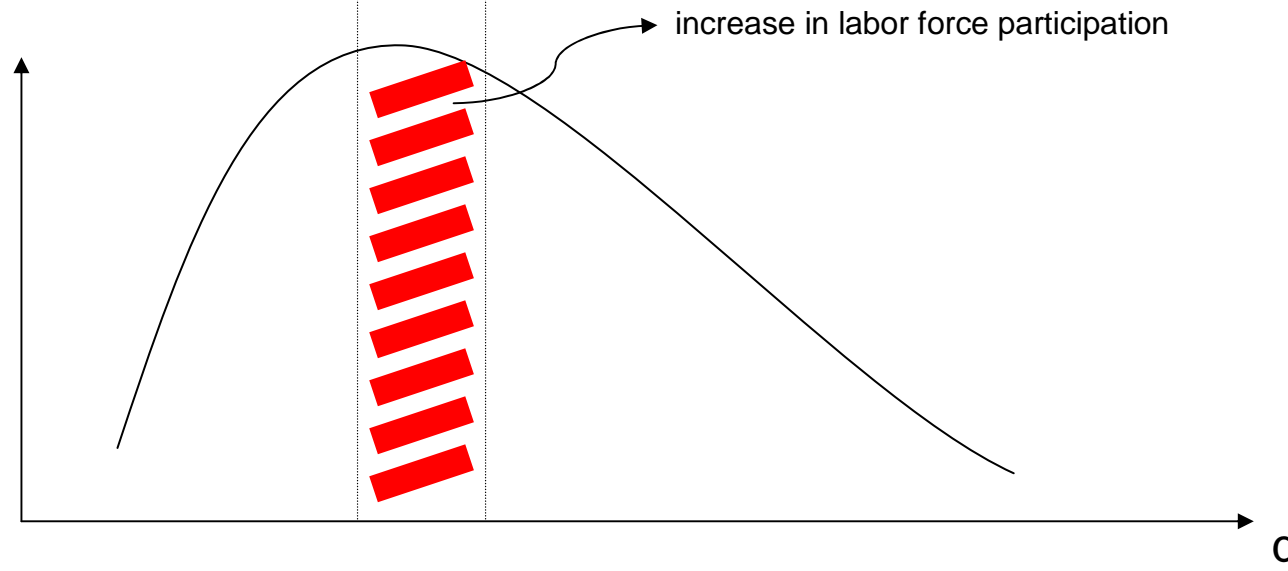
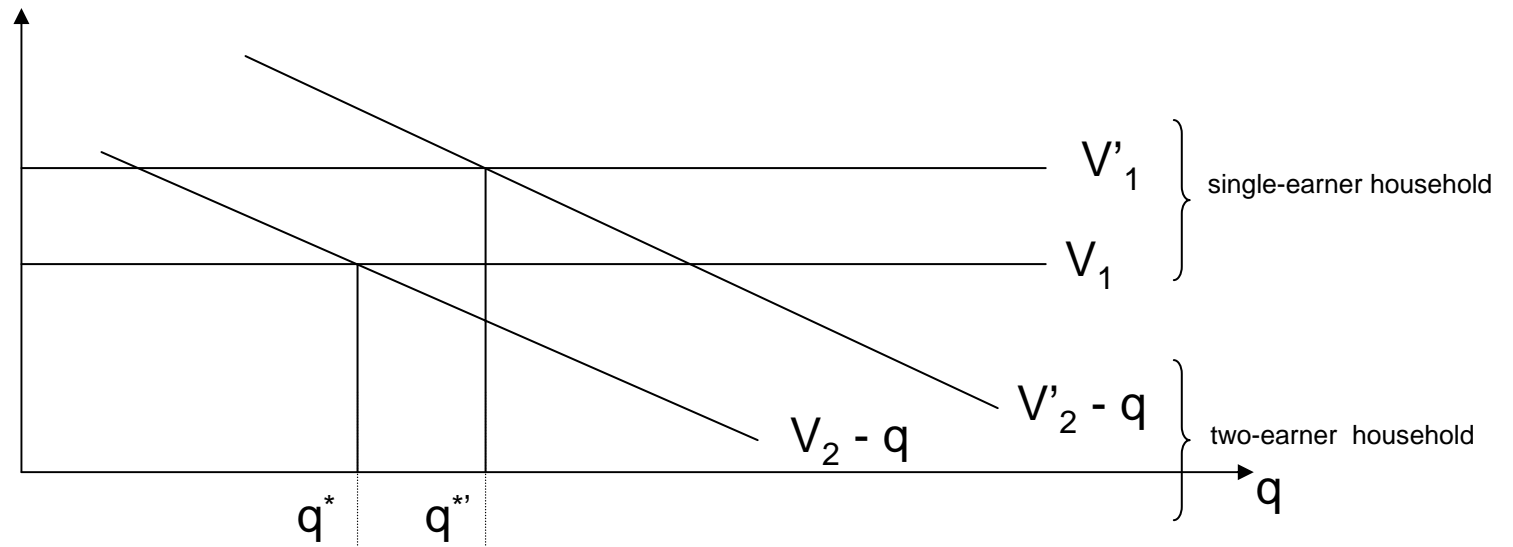


Figure 2: Labor Productivity Levels, Males

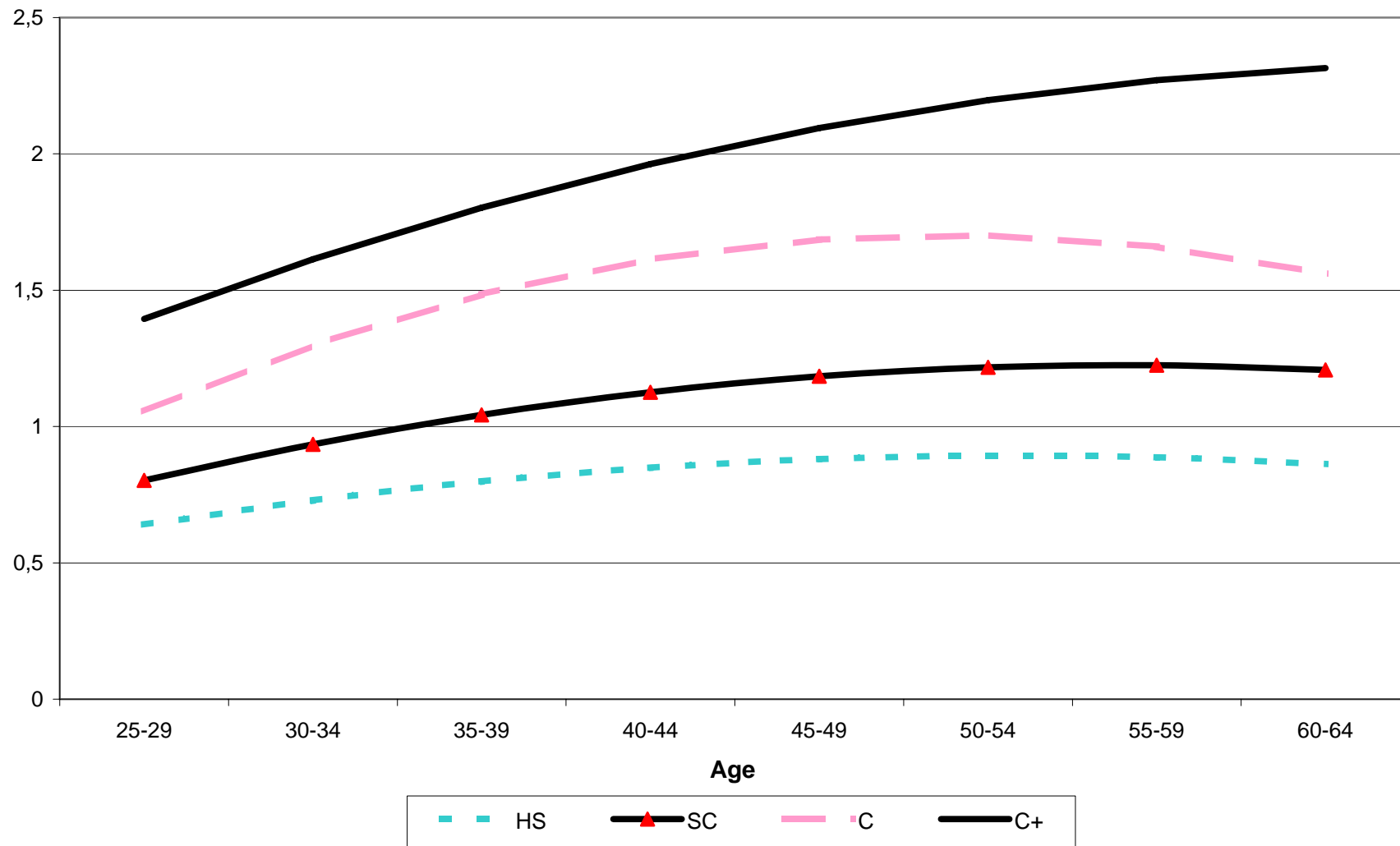


Figure 3: Tax Rates, Married

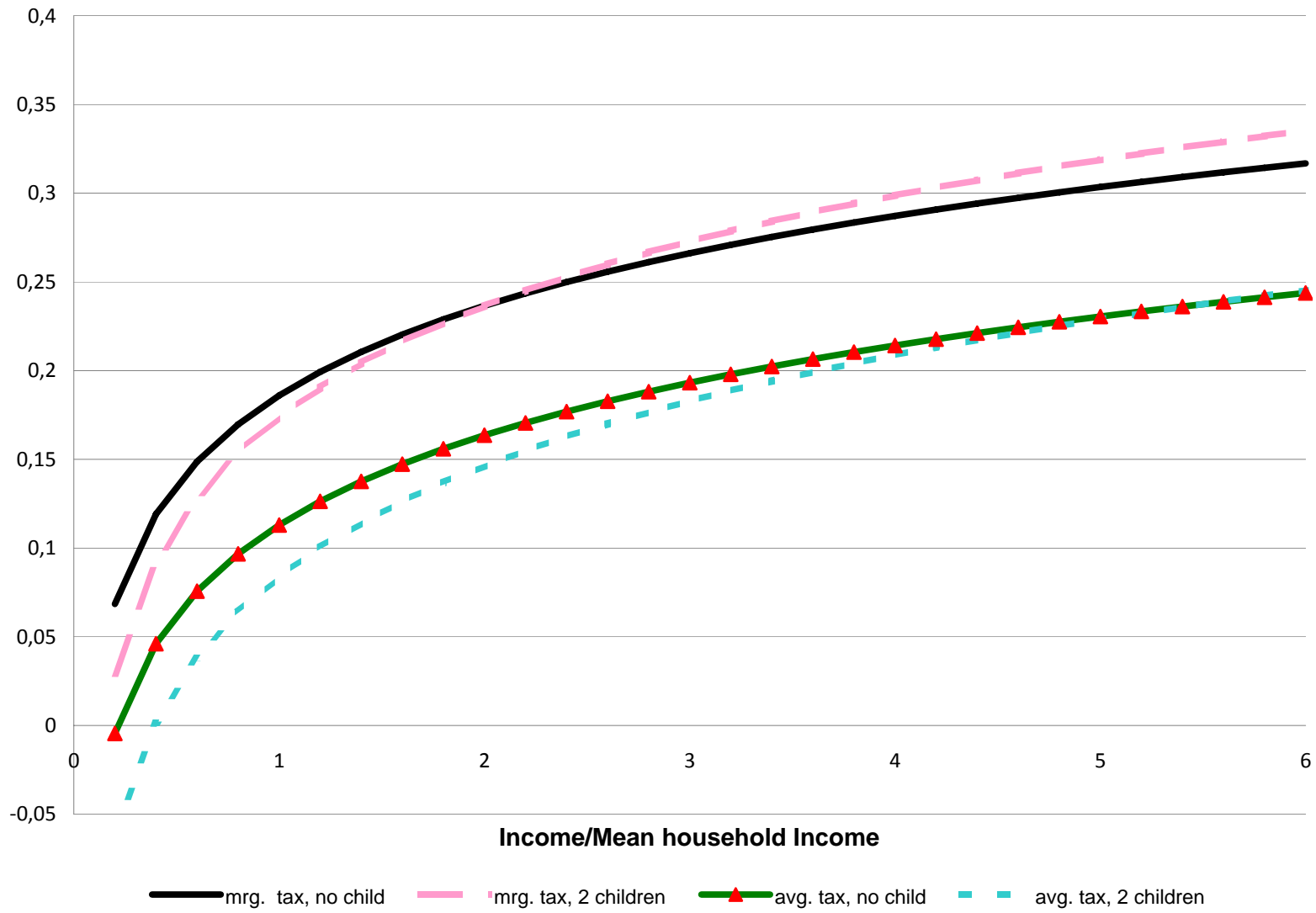


Figure 4: Tax Rates, Singles

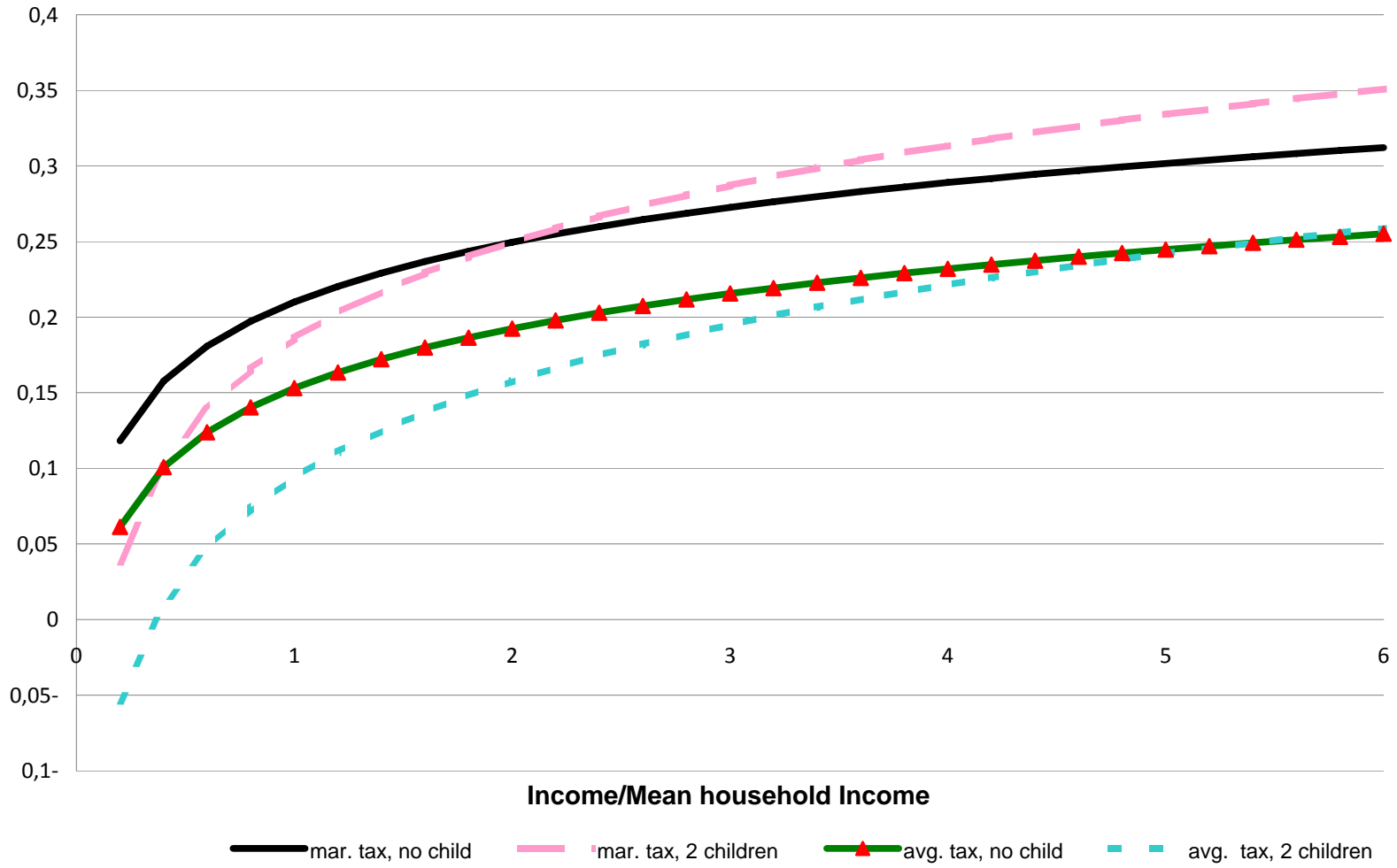


Figure 5: Labor Force Participation

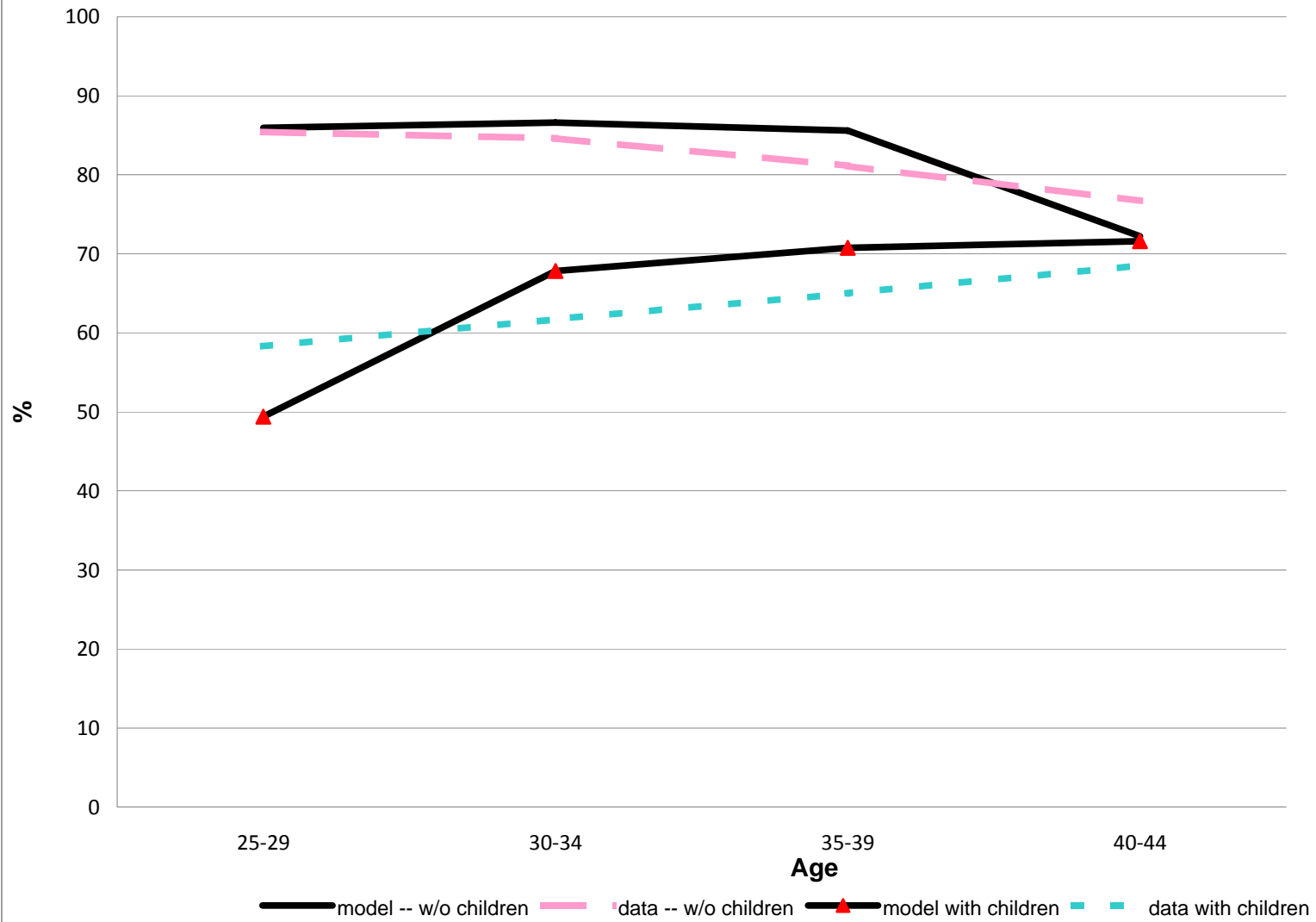
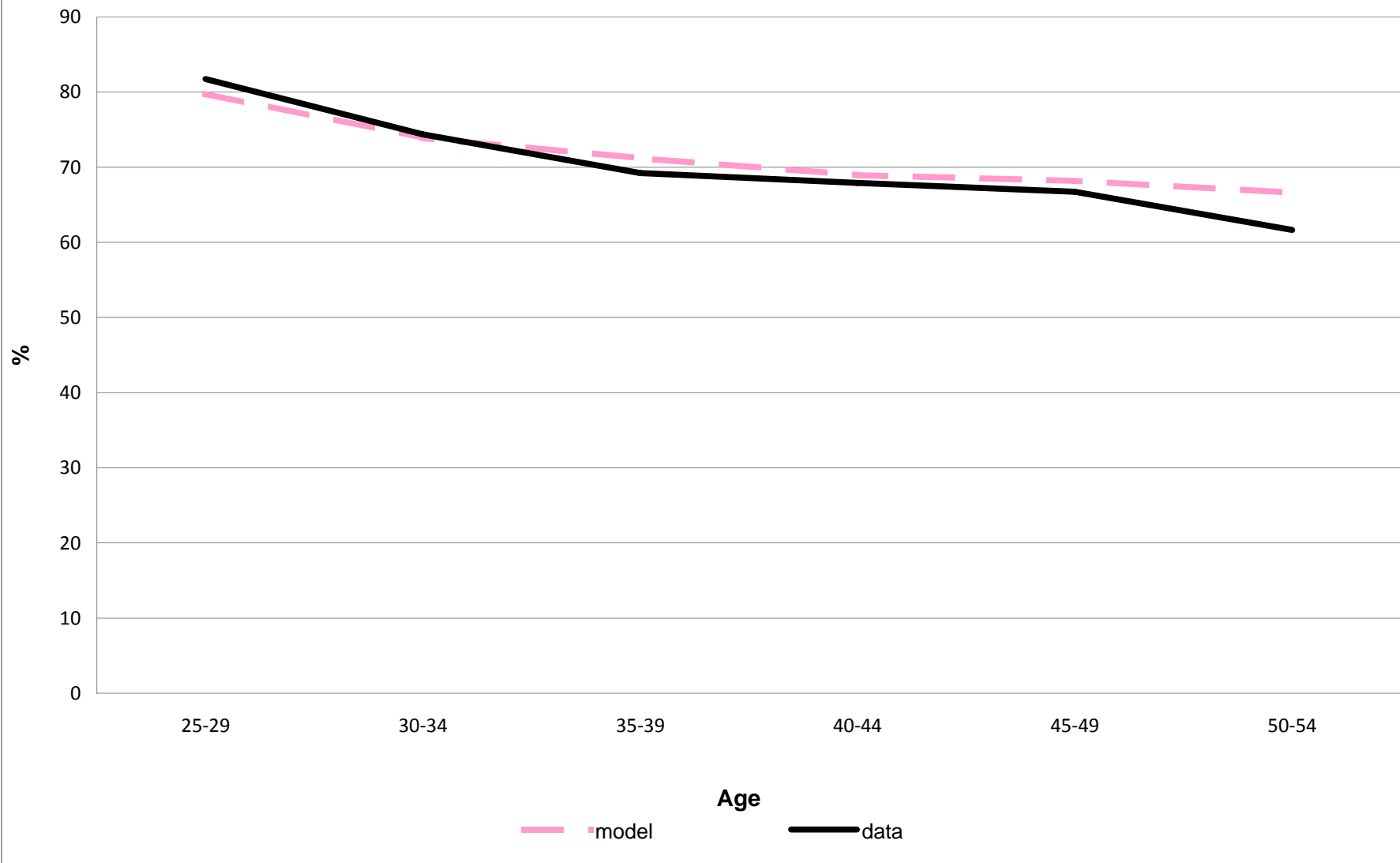


Figure 6: Wage Gender Gap



Supplementary Material  
(not for publication)

for

Taxation and Household Labor Supply

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## 1 Appendix – Definition of Equilibrium

For married couples, let  $\lambda_b^M(x, z)$  be the fraction of type- $(x, z)$  couples who have childbearing type  $b$ , where  $b \in \{0, 1, 2\}$  denotes no children, early childbearing and late childbearing, respectively, and  $\sum_b \lambda_b^M(x, z) = 1$ . Similarly, let  $\lambda_b^S(x)$  be the fraction of type- $x$  single females who have childbearing type  $b$ , with  $\sum_b \lambda_b^S(x) = 1$ .

Let  $a \in A = [0, \bar{a}]$  and  $H = [0, \bar{h}]$  be the sets of possible assets and female human capital levels. Let the function  $\psi_j^M(a, h, x, z, q, b)$  denote the number of married individuals of age  $j$  with assets  $a$ , female human capital  $h$ , when the female is of type  $x$ , the male is of type  $z$ , the household faces a utility cost  $q$  of joint work, and is of child bearing type  $b$ . The function  $\psi_{f,j}^S(a, h, x, h, b)$ , for single females, is defined similarly. Finally, the function  $\psi_{m,j}^S(a, z)$ , for single males, is defined over asset levels and the male type.

Let  $\chi\{\cdot\}$  denote the indicator function. Let the functions  $g^S(a, h, x, b, j)$  and  $g^M(a, h, x, z, q, b, j)$  describe the evolution of the female human capital over the life cycle. For  $j > 1$ ,

$$g^M(a, h, x, z, q, b, j) = G(x, h, l_f^M(a, h, x, z, q, b, j - 1), j - 1)$$

$$g^S(a, h, x, b, j) = G(x, h, l_f^S(a, h, x, b, j - 1), j - 1)$$

The functions defined above obey the following recursions:

Married agents



$$\psi_j^M(a', h', x, z, q, b) = \int_{A \times H} \psi_{j-1}^M(a, h, x, z, q, b) \chi\{(a^M(\cdot, j-1) = a', g^M(\cdot, j-1) = h')\} dh da,$$

for  $j > 1$ , and

$$\psi_1^M(a, h, x, z, q, b) = \begin{cases} M(x, z) \lambda_b^M(x, z) \zeta(q|z) & \text{if } a = 0, h = \eta(x), \\ 0, & \text{otherwise} \end{cases}$$

### Single female agents

$$\psi_{f,j}^S(a', h', x, b) = \int_{A \times H} \psi_{f,j-1}^S(a, h, x, b) \chi\{(a_f^S(\cdot, j-1) = a', g^S(\cdot, j-1) = h')\} dh da,$$

for  $j > 1$ , and

$$\psi_{f,1}^S(a, h, x, b) = \begin{cases} \phi(x) \lambda_b^S(x) & \text{if } a = 0, h = \eta(x) \\ 0, & \text{otherwise} \end{cases}.$$

### Single male agents

$$\psi_{m,j}^S(a', z) = \int_A \psi_{m,j-1}^S(a, z) \chi\{a_m^S(\cdot, j-1) = a'\} da,$$

for  $j > 1$ , and

$$\psi_{m,1}^S(a, z) = \begin{cases} \omega(z) & \text{if } a = 0 \\ 0, & \text{otherwise} \end{cases}.$$

**Equilibrium Definition** For a given government consumption level  $G$ , social security tax benefits  $p^M(x, z)$ ,  $p_f^S(x)$  and  $p_m^S(z)$ , tax functions  $T^S(\cdot)$ ,  $T^M(\cdot)$ , a payroll tax rate  $\tau_p$ , a capital tax rate  $\tau_k$ , and an exogenous demographic structure represented by  $\Omega(z)$ ,  $\Phi(x)$ ,  $M(x, z)$ , and  $\mu_j$ , a *stationary equilibrium* consists of prices  $r$  and  $w$ , aggregate capital ( $K$ ), aggregate labor ( $L$ ), labor used in the production of goods ( $L_g$ ), household decision rules  $l_f^M(a, h, x, z, q, b, j)$ ,  $l_m^M(a, h, x, z, q, b, j)$ ,  $l_m^S(a, z, j)$ ,  $l_f^S(a, h, x, b, j)$ ,  $a^M(a, h, x, z, q, b, j)$ ,  $a_m^S(a, z, j)$  and  $a_f^S(a, h, x, b, j)$ , and functions  $\psi_j^M$ ,  $\psi_{f,j}^S$ , and  $\psi_{m,j}^S$ , such that

1. Given tax rules and factor prices, the decision rules of households are optimal.
2. Factor prices are competitively determined; i.e.  $w = F_2(K, L_g)$ , and  $r = F_1(K, L_g) - \delta_k$ .
3. Factor markets clear; i.e. equations (4), (5) and (6) in the text hold.
4. The functions  $\psi_j^M$ ,  $\psi_{f,j}^S$ , and  $\psi_{m,j}^S$  are consistent with individual decisions.

5. The government and social security budgets are balanced; i.e.,

$$\begin{aligned}
G &= \sum_j \mu_j \left[ \sum_{x,z,q,b} \int_{A \times H} T^M(\cdot) \psi_j^M(a, h, x, z, q, b) dh da + \sum_z \int_A T^S(\cdot) \psi_{m,j}^S(a, z) da \right. \\
&\quad \left. + \sum_{x,b} \int_{A \times H} T^S(\cdot) \psi_{f,j}^S(a, h, x, b) dh da + \tau_k r K \right],
\end{aligned}$$

and

$$\begin{aligned}
&\sum_{j \geq J_R} \mu_j \left[ \sum_{x,z,q,b} \int_{A \times H} p^M(x, z) \psi_j^M(a, h, x, z, q, b) dh da + \sum_{x,b} \int_{A \times H} p_f^S(x) \psi_{f,j}^S(a, h, x, b) dh da \right. \\
&\quad \left. + \sum_z \int_A p_m^S(z) \psi_{m,j}^S(a, z) da \right] \\
&= \tau_p w L
\end{aligned}$$

## 2 Supplementary Tables and Figures

Table A1: Initial Productivity Levels, by Type and Gender

	males ( $z$ )	females ( $x$ )	$x/z$
hs	0.640	0.511	0.799
sc	0.802	0.619	0.771
col	1.055	0.861	0.816
col+	1.395	1.139	0.817

Note: Entries are the productivity levels of males and females, ages 25-29, using 2000 data from the U.S. Census. These levels are constructed as weekly wages for each type –see text for details.

Table A2: Labor Market Productivity Process for Females (%)

Types	hs	sc	col	col+
25-29	0.129	0.153	0.207	0.145
30-34	0.091	0.109	0.134	0.111
35-39	0.061	0.076	0.083	0.085
40-44	0.036	0.050	0.043	0.064
45-49	0.014	0.027	0.009	0.047
50-54	-0.008	0.006	-0.025	0.032
55-60	-0.029	-0.014	-0.062	0.019

Note: Entries are the parameters  $\alpha_j^x$  for the process governing labor efficiency units of females over the life cycle – see equation (7). These parameters are the growth rates of male wages.

Table A3: Distribution of Married Working Households by Type

	Females			
Males	hs	sc	col	col+
hs	26.38	10.9	2.63	0.7
sc	8.01	14.54	5.21	1.38
col	2.13	5.55	9.59	2.79
col+	0.59	1.77	4.1	3.73

Note: Entries show the fraction of marriages out of the total married pool, by wife and husband educational categories. The data used is from the 2000 U.S. Census, ages 30-39. Entries add up to 100. –see text for details.

Table A4: Fraction of Agents by Type, Gender and Marital Status

	Males			Females		
	All	Married	Singles	All	Married	Singles
hs	40.63	31.27	9.36	37.18	28.57	8.61
sc	29.16	22.44	6.72	33.21	25.23	7.99
col	20.23	15.45	4.78	20.71	16.59	4.12
col+	9.98	7.85	2.13	8.90	6.61	2.29

Note: Entries show the fraction of individuals in each educational category, by marital status, constructed under the assumption of a stationary population structure –see text for details.

Table A5: Childbearing, Single Females

	Childless	Early	Late
hs	29.44	59.27	11.29
sc	34.80	48.40	16.80
col	53.04	31.45	15.31
col+	70.56	8.33	21.11

Note: Entries show the distribution of childbearing among single females, using data from the CPS-June supplement. See text for details.

Table A6: Childbearing, Married Couples

		Childless				Early				
		Females				Females				
Male		hs	sc	col	col+	male	hs	sc	col	col+
hs		9.29	10.63	14.63	18.47	hs	68.03	59.90	42.14	42.39
sc		10.44	10.29	12.95	15.30	sc	60.74	59.91	38.72	29.38
col		8.05	10.64	11.48	13.85	col	59.78	54.13	32.46	19.62
col+		7.79	9.89	8.99	13.13	col+	56.73	39.50	31.30	23.98

Note: Entries show the distribution of childbearing among married couples. For childlessness, data used is from the U.S. Census. For early childbearing, the data used is from the CPS-June supplement. Values for late childbearing can be obtained residually for each cell. See text for details.

Table A7: Social Security Benefits, Singles

	Males	Females
hs	1	0.914
sc	1.173	1.059
col	1.213	1.067
col+	1.291	1.066

Note: Entries show Social Security incomes, normalized by the mean Social Security income of the lowest type male, using data from the 2000 U.S. Census. See text for details.

Table A8: Social Security Benefits, Married

	Females			
Males	hs	sc	col	col+
hs	1.755	1.874	1.969	1.879
sc	1.888	1.996	1.978	2.141
col	2.012	2.057	2.096	2.200
col+	2.033	2.110	2.175	2.254

Note: Entries show the Social Security income, normalized by the Social Security income of the single lowest type male, using data from the 2000 U.S. Census. See text for details.

Figure A1: Cumulative Distribution of Utility Costs by Male Types

