Taxation, Aggregates and the Household

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October 2007

Abstract

We evaluate reforms to the U.S. tax system in a dynamic 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, and the structure of marital sorting. We find that tax reforms are accompanied by large and differential effects on labor supply: while hours per-worker display small increases, total hours and labor force participation increase substantially. Married females account for more than 50% of the changes in hours associated to reforms, and their importance increases sharply for values of the intertemporal labor supply elasticity on the low side of empirical estimates. Tax reforms in a standard version of the model result in output gains that are up to 15% lower than in our benchmark economy.

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. These debates have been fueled by equity and economic efficiency trade-offs, by theoretical results establishing that taxing capital income might not be efficient, and by the fact that the current U.S. tax structure is complicated and distortionary. 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.[1]

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. As of 2000, about three fourths of women aged 25-64 were married, and as a group, they devote a large fraction of their available time to work outside the home. Their aggregate labor force participation rate was about 69%, their participation rate increased 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, a measure of the so called gender-gap, is of about 72% nowadays and has been around this value for some time.[2]

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 seriously into account the labor supply of married females as well as the current demographic (household) 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 broadly consistent with the current U.S. demographics. We use this framework to conduct a set of hypothetical tax reform experiments, and ask: what is the importance of the labor supply responses of married females in these experiments? What is the importance of different 'micro' labor supply elasticities for the long-run effects on

[1] Among such reform proposals, one can list Hall and Rabushka's (1995) flat tax, a simple proportional income tax or a proportional consumption tax – see Auerbach and Hassett (2005) for a review.

[2] Our calculations. See Section 4 for details.

output and the labor input? How do our results compare to those emerging from a standard macroeconomic model?

The model economy we consider is populated with males and females who differ in their labor productivities, and who exhibit life-cycle behavior. Individuals start economic life as either *married* or *single* and do not change their marital status as they age. They are born as workers with given, immutable labor efficiencies, and stochastically transit into retirement and subsequently to death. Hence, in the model agents differ along their gender, labor productivity, and marital status. 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-person households. We assume that if a married female enters the labor force, the household faces a utility cost. This cost represents the additional difficulty originating from the need to better coordinate multiple household activities, potential child-care costs, etc. As a result, it is possible that females in married households may choose *not* to work at all if this utility cost is sufficiently high, which yields naturally the labor supply of a married household along the extensive margin. 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. Our model thus permits us to separate and quantify changes in labor supply that take place at extensive and intensive margins.

We restrict model parameters so that our benchmark economy is consistent with relevant aggregate and cross-sectional U.S. data. Three aspects of our parameterization are critical. First, using data on tax returns we estimate effective tax functions for married and single households. These functions relate taxes paid to reported incomes and hence capture the complex relation between household's incomes and taxes in a parsimonious way. Second, we make our benchmark economy consistent with intertemporal elasticities of labor supply along the intensive margin, and with observations on the labor force participation of married females. In particular, we select parameter values so that the labor force participation of married females, conditional on their husbands' type, increases with their own wages as it does in the data. This aspect of our parameterization is crucial since it allows us to capture the underlying elasticities of labor force participation of married females. Finally, the demographic structure of the model is tightly mapped to U.S. observations. The marital structure of the benchmark economy (who is single, who is married, and who is married with whom) reproduces *exactly* the structure observed in the U.S. Census. This is of importance for our purposes; different households face different average and marginal tax rates, and reactions of different households to a tax reform are potentially not the same.

We consider three prototypical tax reforms: a proportional consumption tax, a proportional income tax, and a progressive consumption tax (e.g. Hall and Rabushka (1995)), which consists of a single tax rate above an exemption level. In line with existing literature, we find that tax reforms can have large effects across steady states on macroeconomic variables, such as output and capital intensity. A central finding emerging from our exercises is that the differential labor supply behavior of different groups is key for an understanding of the aggregate effects of tax reforms. A second important finding is that the impact of tax reforms on the labor supply of married females depends crucially of the structure of the particular reform under consideration. A third finding is that married females account for a disproportionate fraction of the changes in hours and labor supply, and that this fraction increases sharply for low values of the intertemporal elasticity of labor supply.

Replacing current income taxes by a proportional consumption (income) tax results in an increase in aggregate output of about 11.2% (5.9%). This output increase is accompanied by differential effects on labor supply: while hours along the intensive margin increase by about 2.7% (2.4%), the labor force participation of married females increases by about 7.3% (6.2%) and married females increase their total hours by 10.6% (9.3%). Both reforms have similar effects on labor supply, which suggest that the flattening of the tax schedule is what really matters for labor supply behavior. On the other hand, their effects on capital accumulation differ significantly, which is reflected in how much aggregate output rises.

The effects of a progressive consumption tax reform are different. The aggregate effects are more moderate and the positive effects on labor force participation of married females are much less pronounced. If the exemption level associated with the progressive consumption tax reform is relatively high (higher degree of progressivity), the aggregate output increase only by about 8.0% (as opposed to 11.2% with a proportional consumption tax reform). The rise in the labor force participation of married females is also less pronounced than the proportional consumption tax reform and is only 3.2% (instead of 7.3%).

In answering the first question posed above, 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 58-59% of the total increase in labor hours, and about 49-50% of the aggregate increase in labor supply (efficiency units). Under progressive consumption taxes, married females contribute even more significantly to changes in labor hours and labor supply; in our exercises married females can account for up to 80% and 65% of the total changes in total working hours and labor supply, respectively.

In answering the second question, we find that the importance of married females *rises* sharply when the parameter governing the intertemporal labor supply elasticity is lowered from our benchmark value of 0.4 to 0.2. In this case, the contribution of married females to changes in labor hours ranges, across different reforms, from about 76% to 96%, driven mostly by changes in participation. Hence, in the current framework the value of this preference parameter becomes of second-order importance in understanding the effects on output and labor supply associated to tax reforms.

Finally, in terms of the third question, we find that a version of our economy that mimics a standard macroeconomic model, captures only a fraction of the long-run output gains. For a proportional consumption tax, the standard model generates only 85%-89% of the changes in output implied by our framework. Thus, tax reform exercises in the context of macroeconomic models with single earners can be misleading *if* low labor supply elasticities are used.

Background 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. This determines that the tax rates facing otherwise identical single and married households can differ. A single woman's taxes depend only on her own income. Yet, 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 in a two-person household affect joint labor supply decisions as well as the reactions to changes in the tax structure. Thus, the degree of marital sorting (*who is married to whom*) could affect the aggregate responses to alternative tax rules. 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)). More recently, Eissa and Hoynes (2004) 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). 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)). If households react to taxes much more than previously thought, the potential effects of tax reforms can be much more significant.

Our work is largely related to four strands of literature. First, our evaluation of tax reforms using dynamic models with heterogenous agents is related to the work by Altig, Auerbach, Kotlikoff, Smetters and Walliser (2001), Chade and Ventura (2002), Díaz-Jiménez and Pijoan-Mas (2005), Erosa and Koreshkova (2007), Nishiyama and Smetters (2005), Conesa and Krueger (2006), and Ventura (1999) among others. In contrast to these papers, we study economies populated with married and single households, where the married households can have one or two earners.[3] Second, the current paper is related to recent papers that show that taxes can play a significant role in accounting for cross-country differences in labor supply behavior. Prescott (2004), Olovsson (2003), Davis and Henrekson (2003), Rogerson (2006) and Kaygusuz (2006a) are examples of papers in this group. Third, the current paper is related to papers that study the macroeconomic effects of changes in labor supply along the extensive margin; Cho and Rogerson (1988), Mulligan (2001), Attanasio, Low and Sánchez Marcos (2004), Chang and Kim (2006) and Kaygusuz (2006b) are examples. Finally, it is related to recent papers on the macroeconomics of the family; Regalia and Ríos-Rull (1999), Aiyagari, Greenwood and Guner (2000), Cubeddu and Ríos-Rull (2003), Greenwood and Guner (2004), Fernández, Guner and Knowles (2005) and Knowles (2005), are representative of papers in this group.

The paper is organized as follows. Section 2 presents an example that highlights the role of taxation with two-person 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.

[3]Kleven and Kreiner (2006) study optimal taxation of two-person households when households face an explicit labor force participation decision.

Section 7 discusses the implications of a lower labor supply elasticity. Section 8 compares the results of our framework with those in a standard macroeconomic model. Section 9 concludes.

2 Taxation, Two-Person Households and the Extensive Margin

In this section, we present a simple two-period example that illustrates how taxes affect labor supply decisions with two-earner households, with an emphasis on the effects on the potential changes in labor force participation. The example serves to highlight key features of our general environment. It also helps understanding some of the calibration choices we make later.

A one-earner household Consider a married household that lives for two periods; young (y) and old (o). Suppose household members can only work in the first period and retire in the second one. The household decides whether only one or both members should work in the first period, and how much to save for the retirement. Let R be the gross interest rate on savings, and let x and z denote the labor market productivities (wage rates) of males and females, respectively. Let τ be a proportional labor tax on first period's labor income.

Consider first the problem if only one member (husband) works. The household problem is given by

$$\max_{l_{m,1},s_1}\{2[\underbrace{U((1-\tau)zl_{m,1}-s_1+T)}_{=U(c_y)}+\beta\underbrace{U(s_1R)}_{=\ U(c_o)}]-W(l_{m,1})\}$$

where $l_{m,1}$ is the labor choice of the primary earner (husband), s_1 are assets for next period (savings) and T is a transfer received from the government in the first period. The functions $U(.)$ and $W(.)$ stand for the instantaneous utility and disutility, associated to household consumption and worktime, respectively. Both functions are differentiable; $U(.)$ is strictly concave while $W(.)$ is strictly convex. The subscript 1 represents the choices of a one-earner household.

We introduce government transfers in the problem in order to capture and illustrate in a simple way the role of progressive taxation. This follows as household choices under non-linear, progressive taxes are 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

$$V_1(\tau) = 2[U((1-\tau)zl^*_{m,1} - s^*_1 + T) + \beta U(s^*_1 R)] - W(l^*_{m,1}),$$

where a $'*'$ denotes an optimal choice.

A two-earner household Now consider the case when both members work. If this occurs, the household incurs a utility cost q, drawn from a distribution with c.d.f $\zeta(q)$. Then the problem is given by

$$\begin{aligned} \max_{l_{m,2}, l_{f,2}, s_2} \quad & \{2[\underbrace{U((1-\tau)(zl_{m,2} + xl_{f,2}) - s_2 + T)}_{=U(c_y)} + \beta \underbrace{U(s_2 R)}_{=U(c_o)}] \\ & -W(l_{m,2}) - W(l_{f,2}) - q\}, \end{aligned}$$

where the subscript 2 represents the choices of a two-earner household. Household utility in this case equals

$$\begin{aligned} V_2(\tau) - q &= 2[U((1-\tau)(zl^*_{m,2} + xl^*_{f,2}) - s^*_2 + T) + \beta U(s^*_2 R)] \\ & \quad -W(l^*_{m,2}) - W(l^*_{f,2}) - q. \end{aligned}$$

Taxes and the extensive margin in labor supply A married household is indifferent between one and two earners for a sufficiently high value of the utility cost. Hence, there exists a value of q, call it q^*, that obeys $q^* = V_2(\tau) - V_1(\tau)$. For households with a q higher than q^* it is optimal to have only one earner, while for those with a q lower than q^*, it is optimal to be a two-earner household. From this expression, it is clear that q^* will change as taxes change. In order to determine how exactly q^* changes with taxes, we appeal to the envelope theorem. First note that

$$\frac{\partial V_1(\tau)}{\partial \tau} = -2U'((1-\tau)zl^*_{m,1} - s^*_1 + T)(zl^*_{m,1}) < 0.$$

Similarly,

$$\frac{\partial V_2(\tau)}{\partial \tau} = -2U'((1-\tau)(zl^*_{m,2} + xl^*_{f,2}) - s^*_2 + T)(zl^*_{m,2} + xl^*_{f,2}) < 0.$$

Henceforth,

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

if and only if

$$\frac{U'((1-\tau)(zl^*_{m,2} + xl^*_{f,2}) - s^*_2 + T)}{U'((1-\tau)(zl^*_{m,1} - s^*_1 + T))} > \frac{zl^*_{m,1}}{zl^*_{m,2} + xl^*_{f,2}}.$$

That is, q^* and as a result, female labor force participation, will be lower when taxes are high if and only if the above condition holds. Suppose now that $U(c) = \log(c)$.[4] In this case, the above condition reduces (after some algebra) to

$$(1-\tau) + \frac{T}{(zl^*_{m,1})} > (1-\tau) + \frac{T}{(zl^*_{m,2} + xl^*_{f,2})}. \tag{1}$$

Thus, as long as condition (1) holds, lower (higher) taxes on labor will *increase* (decrease) the threshold q^*, and generate a higher (lower) labor force participation of the household's secondary earner. This is illustrated in the top panel of Figure 1. Thus, a change in tax rates affects not only the intensive margin in labor supply but also the *extensive* margin.

Notice that the above condition necessarily holds in our case. If the transfer and the marginal tax rate are not contingent on the number of earners in the household (as modeled here), then for a given household type, the labor income in the two earner case will be higher than in the first earner case. This follows simply from concavity of the utility function.

We note here three things. First, the fact that the transfer and the marginal tax rate are not contingent on the number of earners in the household captures U.S. tax rules that take the *household* as the unit of taxation. From this perspective, a reduction in the marginal tax rate on the household is effectively a reduction on the tax rate on secondary earners that may prompt a movement along the extensive margin. Second, the threshold q^* changes in response to changes in the tax rate even under log-preferences for consumption, for which income and substitution effects usually cancel out. Here, the presence of the common transfer is essential for the movement in q^*, as condition (1) shows. When a transfer is present, and

[4]This is our case of interest, as we use it in our general environment.

of course more generally under progressive taxation, changes in marginal tax rates affect not only q^*, but labor supply along the intensive margin. This occurs as income and substitution effects no longer cancel out.

Finally, from this analysis, changes in labor supply (in efficiency units) in response to tax rate changes can be decomposed in two parts. Focusing on married couples only, there are changes in labor supply from males and females currently working (intensive margin), plus changes due to female labor force participation (extensive margin). Assuming that couples differ only in terms of utility cost they face, aggregate labor supply of married couples (L), can be written as

$$L = \zeta(q^*)[zl^*_{m,2} + xl^*_{f,2}] + (1 - \zeta(q^*))zl^*_{m,1}$$

Hence, the change in aggregate labor supply from tax rate changes is given by

$$\frac{\partial L}{\partial \tau} = \underbrace{\zeta(q^*)[z\frac{\partial l^*_{m,2}}{\partial \tau} + x\frac{\partial l^*_{f,2}}{\partial \tau}] + (1 - \zeta(q^*))z\frac{\partial l^*_{m,1}}{\partial \tau}}_{\text{intensive margin}} + \underbrace{\zeta'(q^*)[zl^*_{m,2} + xl^*_{f,2} - zl^*_{m,1}]\frac{\partial q^*}{\partial \tau}}_{\text{extensive margin}} \tag{2}$$

This example has important implications for the mapping of our model economy to data. 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 a key part of the model parameterization; the magnitude of the response along the extensive margin depends on slope $\zeta'(q)$ as equation (2) illustrates. We capture this slope by exploiting the *observed* changes 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 $\zeta'(q)$.

3 The Economic Environment

We study a stationary economy populated by a continuum of males and a continuum of females. The total mass of agents in each gender is normalized to one. As in Gertler (1999), individuals have finite lives, that are divided in two stages, *work* and *retirement*. In particular, each agent is born as a worker and faces each period a constant probability of retirement ρ so that average time spent as a worker is $1/\rho$. Once an agent retires, he faces a constant risk of death δ every period so that average time spent in retirement is $1/\delta$.

Individuals differ in terms of their marital status: they are born either as *single* or *married*, and this marital status does not change over time. In addition, members of a married household experience identical life-cycle dynamics; i.e. they retire and die together.

Each period working households (married or single) make joint labor supply, consumption and savings decisions. As in Cho and Rogerson (1988), among other papers, if the *female* member of a married household supplies positive amounts of market work, then the household incurs a utility cost. This utility cost is drawn once and for all at the start of life and remains constant until the household members retire.

Heterogeneity The labor productivity of a female is denoted by $x \in X$, where $X \subset R_{++}$ is a finite set. Similarly, let the labor productivity of a male be denoted by $z \in Z$, where $Z \subset R_{++}$ is a finite set. Each agent is born with a particular z or x that remains constant throughout his/her life. Let $\Phi(x)$ and $\Omega(z)$ denote the fractions of type-x females in female population and of type-z males in male population, respectively. Since population of each gender is normalized to one, $\sum_{x \in X} \Phi(x) = 1$ and $\sum_{z \in Z} \Omega(z) = 1$.

Preferences The momentary utility function for a single person is given by

$$U^S(c, l) = \log(c) - Bl^{1+\frac{1}{\gamma}},$$

where c is consumption and l is time devoted to market work.

Married households maximize sum of their members utilities. We assume that when the female member a married household works, the household incurs a utility costs q. Denoting by $\chi\{l_f\}$ the indicator function for joint work, i.e.

$$\chi\{l_f\} = \left\{ \begin{array}{l} 1, \text{ if } l_f > 0 \\ 0, \text{ otherwise} \end{array} \right\},$$

the utility function for a person of gender $i = \{f, m\}$ who is married to a person from gender $j \neq i$, the momentary utility function reads

$$U_i^M(c, l_i, l_j, q) = \log(c) - Bl_i^{1+\frac{1}{\gamma}} - \frac{1}{2}\chi\{l_f\}q,$$

where c is consumption, a public good within the household. Note that the parameter $\gamma > 0$, independent of gender and marital status, is the intertemporal elasticity of labor supply.

We assume that $q \in Q$, where $Q \subset R_{++}$ is a finite set. We assume that for a given household, the distribution function for q depends on labor market productivity of the husband. Let $\zeta(q|z)$ denote the probability that the cost of joint work is q, with $\sum_{q \in Q} \zeta(q|z) = 1$ for all z, for a household with male productivity level z. This particular choice for ζ will become apparent when we discuss our calibration strategy in the next section. At the start of life, once a particular (x, z) household is formed, the household draws its q, which remains constant until retirement. We assume that each member of the household incurs half of this total utility cost.

Production and Markets There are competitive firms that operate a constant returns to scale technology. Firms rent capital and labor services from households at the rate R and w, respectively. Using k units of capital and l units of labor, firm produce $F(k, l) = k^{\alpha} l^{1-\alpha}$ units of consumption good. We assume that the capital depreciates at rate δ_k.

Households save in the form of a risk-free asset that pays the competitive rate of return r. There are no markets to insure mortality or retirement risk. We assume that assets of agents who die are not distributed among those who survive.

Incomes and Taxation Let a represent household's assets. Then, the total pre-tax resources of a single working male are given by $a + ra + wzl$, whereas for a single female worker they amount to $a + ar + wxl$. The pre-tax total resources for a married working couple are given $a + ra + wzl_m + wxl_f$. Let b_i^S and b^M indicate the level of social security benefits for singles, for $i = f, m$, and married retired households, respectively. Then, retired households pre-tax resources are simply $a + ra + b_i^S$ for single retired households and $a + ra + b^M$ for married ones.

Income for tax purposes, I, is defined as total labor and capital income; hence for a single male worker $I = ra + wzl$, while for a single female worker $I = ra + wxl$. For a married working household, taxable income equals $I = ra + wzl_m + wxl_f$. We assume that social security benefits are not taxed, so the income for tax purposes is simply given by ra for retired households. The total income tax liabilities of married and single households are represented by tax functions $T^M(I)$ and $T^S(I)$, respectively. These functions are continuous in I, increasing and convex. There is also a (flat) payroll tax that taxes individual labor incomes, represented by τ_p, to fund social security transfers. Besides the income and payroll taxes, each household pays an additional flat capital income tax for the returns from his/her asset holdings, denoted by τ_k.

Demographics Let $M(x,z)$ denote the number of marriages between a type-x female worker and a type-z male worker, and let $\omega(z)$ and $\phi(x)$ denote the number of single type-z male workers and the number of single type-x female workers, respectively. Let $M^r(x,z)$, $\omega^r(z)$ and $\phi^r(x)$ denote the similar quantities for retirees. Then, the following two accounting identities

$$\Phi(x) \equiv \sum_z M(x,z) + \phi(x) + \sum_z M^r(x,z) + \phi^r(x), \tag{3}$$

and

$$\Omega(z) \equiv \sum_x M(x,z) + \omega(z) + \sum_x M^r(x,z) + \omega^r(z), \tag{4}$$

hold by construction. Agents who die (married or single) are replaced by identical young agents, who are born with *no assets*. This implies that every period, $\delta M^r(x,z)$ working married couples are born; the corresponding numbers for singles are $\delta\phi^r(x)$ and $\delta\omega^r(z)$.

Note that the law of motion for the number of retired married people reads

$$M^{r\prime}(x,z) = \underbrace{(1-\delta)M^r(x,z)}_{\text{surviving retired couples}} + \underbrace{\rho M(x,z)}_{\text{newly retired couples}}, \tag{5}$$

which implies the following steady state condition

$$\delta M^r(x,z) = \rho M(x,z). \tag{6}$$

Therefore, in a steady state retired couples who die must be replaced by retiring couples of the same type. Similarly, for single retired males and females, the following steady state relations must hold

$$\delta\phi^r(x) = \rho\phi(x), \tag{7}$$

and

$$\delta\omega^r(z) = \rho\omega(z). \tag{8}$$

Equations (6), (7) and (8) imply that the number of working agents, married and single, are constant over time. Using the steady state restrictions implied by equations (6), (7) and

(8), we can rewrite equation (3) as

$$\Phi(x) = \sum_z M(x,z) + \frac{\rho}{\delta}\sum_z M(x,z) + \phi(x) + \frac{\rho}{\delta}\phi(x). \tag{9}$$

This equation restricts how $\Phi(x)$, $M(x,z)$, and $\phi(x)$ are related. Similarly, the steady state version of equation (4) is given by

$$\Omega(z) = \sum_x M(x,z) + \frac{\rho}{\delta}\sum_x M(x,z) + \omega(z) + \frac{\rho}{\delta}\omega(z). \tag{10}$$

When we parameterize the model (see below), our strategy is to treat $\Phi(x)$, $\Omega(z)$, and $M(x,z)$ as the primitives and select $\phi(x)$ and $\omega(z)$ to satisfy the stationarity assumption. Hence, these two equations allow us to pin down $\phi(x)$ and $\omega(z)$ given the data on $\Phi(x)$, $\Omega(z)$, and $M(x,z)$.

The Problem of a Single Household We now define the problem of single and married households recursively. First consider the problem of a retired single agent and without loss of generality focus on the problem of a single retired male with asset level a. A single retired male simply decides how much to save, a', and his problem is given by

$$V_m^{S,r}(a) = \max_{a'\geq 0}\{U^s(c,0) + (1-\delta)\beta V_m^{S,r}(a')\}, \tag{11}$$

subject to

$$c + a' = a(1+r) + b_m^S - T^S(ra) - \tau_k ra.$$

The value of being a single retired female with assets a, $V_f^{S,r}(a)$, is defined in a similar way. Let $a_j^{S,r}(a)$, for $j = \{f, m\}$, be the decision rules for retired single agents.

Consider now the problem of a single male worker of type (z,a). A single worker of type-(z,a) decides how much to work and how much to save, taking into account the retirement probability, ρ. Then, the problem of a single male worker is given by

$$V_m^S(z,a) = \max_{a',l_m^S}\{U^S(c,l_m^S) + \beta[(1-\rho)V_m^S(z,a') + \rho V_m^{S,r}(a')]\}, \tag{12}$$

subject to

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

and

$$l_m^S \geq 0,\ a' \geq 0.$$

The value of being a single female worker $V_f^S(x,a)$ can be defined in a similar fashion. Again, let $a_f^S(x,a)$ and $a_m^S(z,a)$ represent the savings decisions for single females and males, respectively, and let $l_f^S(x,a)$ and $l_m^S(z,a)$ be their labor supply decision rules.

The Problem of Married Households Again, consider first the problem of a retired couple with assets a. Their problem, with the associated decision rule $a^{M,r}(a)$, is given by

$$V^{M,r}(a) = \max_{a'}\{U_m^M(c,0,0,q) + U_f^M(c,0,0,q) + (1-\delta)\beta V^{M,r}(a')\}, \tag{13}$$

subject to

$$c + a' = a(1+r) + b^M - T^M(ra) - \tau_k ra.$$

Consider now the problem of a married working household of type (x,z,a,q). A married working household solves a *joint* maximization problem by choosing consumption, next-period assets and labor supply for each household member. The problem is given by

$$\begin{aligned} V^M(x,z,a,q) &= \max_{a',\, l_f^M,\, l_m^M,\, c} \{[U_m^M(c,l_m^M,l_f^M,q) + U_f^M(c,l_m^M,l_f^M,q)] \\ &+ \beta[(1-\rho)V^M(x,z,a',q) + \rho V^{M,r}(a')]\}, \end{aligned} \tag{14}$$

subject to

$$c + a' = a(1+r) + w(zl_m^M + xl_f^M)(1-\tau_p) + ra - T^M(wzl_m^M + wxl_f^M + ra) - \tau_k ra,$$

and

$$l_m^M \geq 0, \quad l_f^M \geq 0, \; a' \geq 0.$$

Like singles, a married couple decides how much to work and how much to save. Unlike singles, they might choose zero market hours for female member of the household. This will occur if q is too high, given the productivity levels x and z and asset holdings a. Let $l_f^M(x,z,a,q)$, $l_m^M(x,z,a,q)$, and $a^M(x,z,a,q)$ represent the optimal decision rules associated with this problem.

Aggregate Consistency The aggregate state of this economy consists of distribution of households over their types and asset levels. Suppose $a \in A = [0,\overline{a}]$. Consider first workers. Let $\psi^M(B,x,z,q)$ be the number (measure) of working married households of type (x,z,q), with assets $B \in \mathcal{A}$, the class of Borel subsets of A. Similarly, let $\psi_f^S(B,x)$ be the number of working single females of type x, with $a \in B$, and let $\psi_m^S(B, z)$ be the number of single working males of type (z), with $a \in B$. By construction, $M(x, z)$, the number of married working households of type (x, z), must satisfy

$$M(x, z) = \sum_q \int_A \psi^M(a, x, z, q)da.$$

Similarly, the number of single households (agents) must be consistent with $\psi_f^S(x, a)$ and $\psi_m^S(z, a)$, i.e. $\phi(x)$ and $\omega(z)$ must satisfy

$$\phi(x) = \int_A \psi_f^S(a, x)da,$$

and

$$\omega(z) = \int_A \psi_m^S(a, z)da.$$

Since retired agents are not allowed to work, they only differ by their marital status and asset holdings. Let $\psi^{M,r}(B)$, $\psi_f^{S,r}(B)$ and $\psi_m^{S,r}(B)$ denote the asset distribution among retired married, retired single female and retired single male households, respectively with $a \in B$. Like their counterparts for workers, these distributions must be consistent with $M^r(x, z)$, $\phi^r(x)$ and $\omega^r(z)$.

Equilibrium In stationary equilibrium, factor markets clear, so aggregate capital (K) and aggregate labor (L) are given by:

$$\begin{aligned} K &= \sum_{x,\ z,\ q} \int_A a\psi^M(a, x, z, q)da + \sum_z \int_A a\psi_m^S(a, z)da + \sum_x \int_A a\psi_f^S(a, x)da \\ &\quad + \int_A a\psi^{M,r}(a)da + \int_A a\psi_m^{S,r}(a)da + \int_A a\psi_f^{S,r}(a)da, \end{aligned}$$

and

$$\begin{aligned} L &= \sum_{x,\ z,\ q} \int_A (xl_f^M(a, x, z, q) + zl_m^M(a, x, z, q))\psi^M(a, x, z, q)da + \\ &\quad \sum_z \int_A zl_m^S(a, z)\psi_m^S(a, z)da + \sum_x \int_A xl_f^S(a, x)\psi_f^S(a, x)da. \end{aligned}$$

In addition, factor prices are competitive so $w = F_2(K, L)$, $R = F_1(K, L)$, and $r = R - \delta_k$. In the 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 cross-sectional, aggregate as well as demographic data. As a first step in this process, we start by defining the length of a period to be a year.

Demographics and Endowments We assume that agents are workers for forty years, corresponding to ages 25 to 64, and set $\rho = 1/40$ accordingly. Absent population growth in the model, we set δ so that the model is consistent with the observed fraction of retired individuals (65 years and above), as a fraction of the population 25 years and older. From the 2000 Census, we calculate that this fraction was 0.203. Hence, given the value assumed for ρ, we set δ equal to 0.0982 in order to reproduce the same age structure in the benchmark economy.

We set the number of productivity types (labor endowments) to five. Each productivity type corresponds to an educational attainment level: less than high school ($<$ hs), high school (hs), some college (sc), college (col) and post-college education ($>$ col). We use data from the Consumer Population Survey (CPS) to calculate efficiency levels for all types of agents. Efficiency levels correspond to mean hourly wage rates within an education group, which we construct using annual wage and salary income, weeks worked, and usual hours worked data.[5] We include in the sample household heads and spouses between 25 and 64, and exclude those who are self-employed or unpaid workers. Table 1 shows the estimated efficiency levels for the corresponding types, where wage rates for each type and gender are normalized by the overall mean hourly wages in the sample. The Table also reports the observed gender gap in hourly wage rates for each educational group; the gap is roughly constant across educational categories, averaging about 72%.

We subsequently determine the distribution of individuals by productivity types for each gender, i.e. $\Omega(z)$ and $\Phi(x)$, using the 2000 Census. For this purpose, we assume an underlying stationary demographic data, and *assume* that the distribution of retired agents by educational attainment is the same as the observed distribution of agents prior to retirement. Given this assumption, we consider all household heads or spouses who are between ages 25

[5]We find the mean hourly wages as $\frac{\text{annual wage and salary income}}{\text{(usual hours worked)(number of weeks worked)}}$.

and 64 and for each gender 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 2. Consistent with positive assortative matching by education, the largest entries in each row and column in Table 2 are located along the diagonal.

Finally, given the fractions of individuals in each education group, $\Phi(x)$ and $\Omega(z)$, and the fractions of married working households, $M(x, z)$, in the data, we calculate the implied fractions of single working households, $\omega(z)$ and $\phi(x)$, reported in Table 3. About 74% of households in the benchmark economy consists married households, while the rest (about 26%) are single-person ones. This table also shows $\omega(z)$ and $\phi(x)$ that we construct from the 2000 Census. The mismatch between implied and actual values of $\omega(z)$ and $\phi(x)$ is quite small, suggesting that stationary population structure is not an unrealistic assumption.

Technology We specify the production function as Cobb-Douglas with capital share equal to 0.317. In the absence of population growth and growth in labor efficiency, we set the depreciation rate equal to 0.07. These values are consistent with a notion of capital that excludes residential capital, consumer durables and government owned capital for the period 1960-2000. The corresponding notion of output is then GDP accounted for by the business sector. Altogether, this implies a capital to output ratio of about 2.325.[6]

Taxation To construct income tax functions for married and single individuals, we estimate *effective taxes* paid by married and single households as a function of their reported income. We use tabulated data from the Internal Revenue Service by income brackets.[7] For each income bracket, total income taxes paid, total income earned, number of taxable returns and number of returns data are publicly available. Using these, we find the mean income and the average tax rate corresponding to every income bracket. We calculate the average tax rates as

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

[6]See Guner, Ventura and Yi (2005) for details.

[7]Source: Internal Revenue Service (2000), Statistic of Income Division, Individual Income Tax Returns Bulletin (Publication 1304). See Kaygusuz (2006a) for further details.

We then estimate the effective tax functions both for married and single households. In particular, we fit the following equation to the data,

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

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 4 shows the estimates of the coefficients for married and single households.

Given these estimates, we specify the tax functions in the benchmark model as

$$T^M(\textit{income}) = [0.1023 + 0.0733 \log(\textit{income})]\textit{income},$$

and

$$T^S(\textit{income}) = [0.1547 + 0.0497 \log(\textit{income})]\textit{income}.$$

Figures 2 and 3 display estimated average and marginal tax rates for different multiples of household income. Our estimates imply that a single person with twice mean household income in 2000 faces an average tax rate of about 18.9% and a marginal tax rate equal to about 23.9%. The corresponding rates for a married household with the same income are about 15.3% and 22.6%.

Finally, we need to assign a value for the (flat) capital income tax rate τ_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 $\tau_k = 0.124$. In the benchmark economy total taxes, income taxes on labor and capital and the additional tax on capital, amount to 13.1% of aggregate output.

Social Security We start by estimating the payroll tax from data. 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.[8]

[8] 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.

Using Social Security Beneficiary Data, we calculate that during this same period a retired single woman obtained old-age benefits of about 0.77 of a single retired male, while a retired couple averaged benefits of about 1.5 times those of a retired single male. Thus, given the payroll tax rate, the value of the benefit for a single retired male, b_m^S, balances the budget for the social security system.

Preferences There are two utility functions parameters, the intertemporal elasticity of labor supply (γ) and the parameter governing the disutility of market work (B). We consider two values for γ: 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 more 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 and Floden (2006) results are based upon estimates for married males that control for the bias emerging from borrowing constraints.[9] 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 ($\gamma = 0.2$). Given γ, we select the parameter B to reproduce average market hours per worker observed in the data. These average hours per worker amounted to about 40.8% of available time in 2000.[10]

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

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

where $\Gamma(.)$ is the Gamma function. By proceeding in this way, we exploit the information contained in the *changes* in the labor force participation of married females as their own wage rate increases with education, for a given husband type. We emphasize that this allows us to control the slope of the distribution of utility costs. As we argued in section 2, the

[9] Rupert, Rogerson and Wright (2000) provide estimates within a similar range in the presence of a home production margin. Heathcote, Storesletten and Violante (2007) report an estimate of 0.2, using a model with incomplete markets.

[10] The numbers are for people between ages 25 and 55 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. Married males work 2294 hours per year, and married females work 1741 hours per year. We assume that each person has an available time of 5000 hours per year. Our target for hours corresponds to 2040 hours per-year.

shape of the distribution of utility costs is potentially critical 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 55, for each of the educational categories defined earlier.[11] Table 5 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 69.4%, and it increase from 44.8% for the lowest education group to 82.5% 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 (five entries) in Table 5 as closely as possible. Altogether, this process requires estimating 10 parameters (i.e. a pair (θ, k) for each husband educational category).

Finally, we choose the remaining preference parameter, the discount factor β, so that the steady-state capital to output ratio matches the value in the data consistent with our choice of the technology parameters (2.325).

Table 6 summarizes our parameter choices. Table 7 shows the performance of the benchmark model in terms of the targets we impose for B and β, i.e. labor hours per-worker and capital output ratio. The table also shows how well the benchmark calibration matches the labor force participation of married females. Although, as we explained above, our calibration strategy is to match each row of Table 5, it is more instructive to look at the aggregate participation rate of married females and the labor force participation of married females by their educational level. The model has no problem in reproducing jointly these observations as the table demonstrates.

5 Tax Reforms

We now consider three hypothetical reforms to the current U.S. tax structure: a proportional consumption tax, a proportional income tax and a progressive consumption tax. The first reform flattens the current income tax schedule and changes the tax base from income to *consumption*, effectively eliminating the taxation of capital income built into the income tax. The second reform only flattens the tax schedule while keeping income as the tax base. Finally, the third reform reintroduces progressivity into a consumption tax system.

[11] We consider all individuals who are *not* in armed forces

The findings we report are based on steady state comparisons of pre and post-reform economies. In all reforms, we keep the additional tax rate on capital income (τ_k) and the social security system unchanged.[12] The exercises are in all cases *revenue neutral*, as a single tax rate is found in order to match the benchmark steady state tax revenues.

A Proportional Consumption Tax The first reform replaces current income taxes with a proportional consumption tax, which makes marginal and average tax rates equal for all households. For a better understanding of the results, the reader should bear in mind that a consumption tax still distorts labor choices, but by construction eliminates the distortions on capital accumulation created by the income tax.

Table 8 reports key findings from this exercise. In line with the existing literature, the effects of a consumption tax on aggregates are dramatic. Aggregate output increases by about 11.2%. As a result, a flat consumption tax of 17.8% is all that is needed to generate revenue neutrality. The long-run rise in output is fueled by significant rises in factor inputs. The capital-to-output ratio increases by about 15% in the post-reform steady state. Total (raw) hours in turn increase by 4.7%, while labor supply (hours adjusted by efficiency units) increases by 4.2%. Despite the rise in labor supply, as a result of higher capital stock in post-reform economy, the wage rate increases by 6.5% as well.

Our economy allows us to identify and quantify *differential* responses in labor supply to tax changes that takes place at the intensive margin for both males and females, as well as at the extensive margin for married females. Recall that the benchmark economy, the tax structure generates non-trivial disincentives to work since marginal tax rates increase with incomes. In particular, 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, in conjunction with the partial removal of capital income taxation, the change in labor supply of married females is substantially larger than the aggregate change in hours. The introduction of a consumption tax implies that the labor force participation of married females increases by 7.3%, while hours per worker rise by about 2.6% for females, and about 2.8% for males. Due to changes along the intensive and the extensive margin, total hours for married females increase by more than 10.5%. This is a dramatic rise and is more than *three times* the change in total male hours. These results are especially worth noting as the parameter governing

[12] Results when the tax rate on capital income is also eliminated are available upon request.

intertemporal substitution of labor is the *same* for males and females. Summing up, there are substantial changes in hours of different groups of different magnitudes underlying the aggregate hour changes.

A Proportional Income Tax The second reform is similar to the first one but introduces a proportional income tax instead of a proportional consumption tax. The consequences of this reform could then be viewed as the consequences of simply flattening-out the current income tax schedule.

The key finding from this exercise is that the resulting rise in labor supply is smaller but similar to the one in the consumption tax case, 4.7% versus 4.3%. This suggests that the main contribution to changes in the labor input comes from the flattening of the tax schedule. Hours per worker, both for males and females, increase by about 2.5% and 2.3%, respectively, and total hours increase by about 4.3%. Again, the rise in total hours by married females is very pronounced, of about 9.3%, and again more than *three times* the change in total male hours.

In relation to the case with a proportional consumption tax, the effects on capital accumulation are now less pronounced. This is expected: an income tax, differently from a consumption tax, still distorts asset accumulation decisions. Consequently, the capital-to-output ratio increases by just 4.5%. Overall, as a result of smaller rises in both labor and capital inputs, the effects on aggregate output (although still substantial) are smaller than under a proportional consumption tax. Note that in the current case the change in output amounts to about 5.9%, whereas under proportional consumption taxes the effects are almost twice as big: 11.2%.

A Progressive Consumption Tax In our third exercise we consider a progressive consumption tax, which consists of an exemption level below which agents do not pay taxes, and a proportional tax on household consumption applied above this level. To illustrate the consequences of different exemption levels, we consider a 'high' exemption case and a 'low' exemption case. The 'high' exemption amounts to 1/3 of mean consumption in our benchmark economy for single households, and 1/2 of mean consumption in our benchmark economy for married ones. The 'low' exemption equals 1/4 of mean consumption in our benchmark economy for single households, and 1/6 of aggregate consumption in our benchmark economy for married ones.[13] We emphasize that these exemption levels are defined as multiples of consumption in the benchmark case; as a result, they do *not* vary when consumption changes (increases) as a result of the reform in question.

Results are reported in Table 9. Under a high exemption, the reform requires a tax rate of 27.5% whereas under a low exemption the required rate is 21.5%; the corresponding rate under a proportional consumption tax was 17.8%. A comparison between proportional and progressive consumption tax reforms (Tables 8 and 9) is quite revealing. The effects on capital intensity are comparable under both types of reforms. This should not be surprising since the bulk of capital is owned by households who are above the exemption levels and they are affected in a similar way in these reforms; both reforms eliminate the distorting effects of income taxes on their asset accumulation decisions. The effect on aggregate output in the long run, however, is lower than under a proportional consumption tax and declines steeply with increases in exemption levels. This is clearly due to the smaller increases in the labor input. Note that hours and the labor input increase by about 1.5% with the high exemption level and 3.6-3.2% with the low one, whereas the increase is of about 4.7% and 4.2%, respectively, under a proportional consumption tax.

It is important to understand the channels that lead to a much smaller rise in aggregate labor under a progressive consumption tax than under a proportional one. We start by noting that for households at the top of the skill distribution and therefore above the exemption threshold, the relevant marginal tax distorting labor choices is larger than under a proportional consumption tax. This high marginal tax rate, in conjunction with the implicit transfer associated to a progressive tax, results in a lower response from these households in terms of work hours. In turn, the effect on households at the top has an important effect on aggregate labor in efficiency units, as these households have a disproportionate contribution to this variable. A progressive consumption tax reform also discourages labor supply at the bottom of skill distribution as these households have incentives to stay below the exemption level. These phenomena are present in previous studies with heterogeneity, such as Altig et al (2001), Conesa and Krueger (2006), Nishiyama and Smetters (2005) and Ventura (1999).

The current framework, however, allows us to uncover the differential effects of a progressive consumption tax on the labor force participation of married females, which increases

[13] In 2005, consumption per-person 25 years old and above was about \$45,110. Thus, the value of the high (low) exemption for a married couple is approximately \$22,555 (\$11,253).

much *less* with a progressive consumption-tax reform. Consider first the case of high exemption level. The rise in labor force participation in this case is less than half of the rise under a proportional consumption tax (3.2% versus 7.3%). This is a central result regarding the expected effects of a tax reform of this sort. The key for this finding is the structure of progressive consumption tax, which combines an exemption level *and* a common marginal tax rate above it. The interplay of these features discourages changes in labor force participation in married households with relatively less skilled members. When females in such households enter the labor force, some of these households face a positive (rather than zero) marginal tax rate. Therefore, the bulk of them choose not to enter the labor force. It turns out that these households were the ones that respond the most under proportional tax reforms; as we discuss in detail below. When we lower the exemption level, the number of households that face this trade-off becomes smaller, and the results look more similar to the ones obtained under a proportional consumption tax reform.

The analysis so far reveals several important insights that a single-agent framework would fail to capture. Notice that female labor force participation plays a significant role in all of the reforms we have considered. Under proportional taxes, the overall rise in married female hours is more than three times the rise in male hours, and fueled by a significant increase in the extensive margin. Furthermore, the structure of reforms interact in a nontrivial way with the labor force participation of married females. The increases in the labor force participation, as well as aggregate hours of married females, under a progressive consumption tax reform can be much lower than those under a proportional consumption tax reform. Overall, these findings motivate us to explicitly quantify the relative importance of married females for our results. We do this in the next section.

6 The Role of Married Females

We now discuss in detail the 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. Although the aggregate effects on labor supply are smaller under progressive consumption tax relative to a proportional one, the rise in married females's labor supply becomes a much more important component of the overall rise in labor supply (i.e. labor in efficiency units). Table 10 makes this point 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 consumption and income taxes, the contribution of married females to changes in total hours is around 58-59%. Nevertheless, the contribution of married females to changes in total hours is much higher under a progressive consumption tax: about 65% and 80% for the low and high exemption values, respectively. This occurs as changes in labor supply for other groups are of smaller or negative magnitude under a progressive consumption tax.[14] The contributions of married females to total labor supply follow a similar pattern, but the magnitudes are smaller. This occurs since females on average are less skilled than men, and since the rise in female labor supply is concentrated among low skilled ones, an issue that we elaborate below. The results in Table 10 indicate that married females account for about 49-50% of the changes in labor supply under proportional taxes, and about 55% and 65% of the changes under a progressive consumption tax. We conclude that the overall contribution of married females is substantial; they contribute disproportionately to changes in labor supply given their share of the working age population (about 37.5%).

In the bottom panel of Table 10 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 calculate the role of extensive margin, we count both the hours worked by married females who enter the labor market, as well as by those who stop participating. The latter is necessary as some married females, in particular those with low skills after a progressive consumption tax reform, prefer *not* to work in the post-reform economy. Concretely, for each (x, z, a, q)-type married woman, we first determine if labor force participation for this type is different between pre and post reform economies. If the change in participation is positive and a married woman enters the labor force after a reform, we weigh the change in participation by the hours she works (or the total labor she supplies) under the new tax system. Summing up over all such households gives us the total rise in hours (or in labor supply) due to extensive margin. If, on the other hand, the change is negative and a married woman stops working, we weigh the change in participation by the hours she worked (or total labor she supplied) in the

[14] The interplay of high marginal tax rates and an exemption value, dictates that the bulk of single individuals decrease hours worked after the reform in the high exemption case. For single females, only those with college education increase hours (0.2%). For single males, an increase in hours takes place for those with college education or above (0.6% and 0.8%, respectively).

benchmark economy. The difference between these two sums gives us the *net* change in hours (or total labor supply) due to the extensive margin. Using this measure, the extensive margin contributes about 49-51% of the changes in total hours under proportional taxes, and about 57% and 71% of the changes under progressive taxes. For changes in labor supply, the contributions are 41-43% and about 47% and 55%, 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 in the extensive margin.

A central finding emerging from our proportional tax exercises is that the increase in labor force participation of married females becomes larger as we move towards the bottom of the distribution of skills. Table 11 illustrates this point. In the table, households are arranged according to the skill type of the female member (from high school education or less to post-college education), and the resulting change in the labor force participation of married females is displayed. Both with a proportional consumption tax and a proportional income tax, the rise in female labor force participation for the lowest educational category is remarkable. These females increase their labor force participation by 22.5% under a proportional consumption tax system and by nearly 20% under a proportional income tax system. Under both reforms, the percentage increase in labor force participation *decreases* monotonically; from about 22.5% to about 2.7% under a proportional consumption tax system and from about 20% to about 1.6% under a proportional income tax system. Thus, the bulk of the changes along the extensive margin take place in households with relatively less skilled members.

The results with a progressive consumption tax are different. With the high exemption level, the labor force participation of the lowest skill types is *only* about 1% higher than in the benchmark economy. The behavior of married females is affected significantly here: a higher labor force participation can move these households above the exemption threshold and change their marginal tax rate from zero to about 21.5% and 27.5%. This clearly generates disincentives for labor force participation. Once we move to households with a female member who has more than high school education, the pattern is similar to what we observe with proportional income or consumption taxes. With the low exemption level, as the number of married household below the threshold is reduced, the results are similar to ones obtained by the proportional consumption tax reform.

According to Table 10, married females and in particular their labor force participation decisions play a key role in the overall rise in aggregate hours and labor supply. We conclude this section by performing a simple exercise. We ask: what would the effects of these three reforms be if we keep the labor decision rules of married females at their benchmark values? In particular, if a married female in a type (x, z, a, q) household was *not* participating in the benchmark economy, we force her not to participate in the post-reform economy. On the other hand, if a married female in a type (x, z, a, q) household *was* participating in the benchmark economy, we force her to work exactly the same hours in the post-reform economy. All households can still react to these reforms by changing the labor supply (hours) of the male members as well as changing their savings behavior. In this experiment, household solve a single person decision problem taking labor force participation and working hours of their partners as given.

These exercises reinforce our conclusions regarding the importance of the labor supply of married females. As expected, when we fix female labor supply at its benchmark values, male hours per worker increases quite more. Males now work more by 4.2% with a proportional consumption tax. When we allow females to adjust their labor supply freely (Table 8), the rise in male hours was only 2.8%, about 50% lower. The magnitudes are similar under a proportional income tax. With a progressive consumption tax, males now increase their hours by 2.1%, which is more than twice the rise when we allow females to adjust their labor supply freely (Table 9.) This is in line with our previous results demonstrating the relative importance of female labor supply behavior under a progressive consumption tax reform. Fueled by the large response in male hours, aggregate output increases, but quite less than it did with the original reforms. In the cases of proportional consumption and income tax reforms, the rises in aggregate output is in the order of 68% and 50% of the original increases, while it is about 58% of the original rise with a progressive consumption tax reform.

7 The Importance of the Intertemporal Elasticity

We now turn our attention to the role of the preference parameter γ; 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. In particular, we recover new parameters for the distribution of utility costs so as to reproduce the facts on labor force participation.

Our results are summarized in Table 12. The key finding is that the importance of married females for the aggregate effects of tax reforms increases. As the table demonstrates, the contribution of married females to changes in labor hours and labor supply goes up substantially. For instance, the contribution to changes in hours now ranges from about 76% to 96% across experiments, while under the higher value, $\gamma = 0.4$, the contribution ranged from 50% to 71%.

These results are driven by the behavior of labor force participation under the low elasticity value. Note that changes in hours per-worker are much smaller than under $\gamma = 0.4$, but changes in labor force participation are larger. Since adjusting along the intensive margin is costlier under $\gamma = 0.2$, married households find optimal to adjust hours worked largely along the extensive margin. This, in conjunction with the fact that the model under $\gamma = 0.2$ has still to respect current data on labor force participation, renders the substantial response of married females displayed in Table 12. In other words, a lower value of the labor supply elasticity implies a *higher* aggregate labor supply response from married females in tax reforms.

An implication of these findings on labor supply is that the impact of reforms on output is not too different across the two values of γ. This is especially clear for the case of an income tax reform, where changes in labor supply are central to long-run output gains. With $\gamma = 0.4$, output gains amount to 5.9%, whereas under $\gamma = 0.2$, the output gains amount to 5.4%. We conclude from these findings that for the current environment the precise value for this parameter is of second-order importance for understanding the aggregate effects of tax reforms.

8 Comparisons with a Standard Macro Framework

How do our results compare to those emerging from standard macroeconomic setup with heterogenous agents? To answer this question, we consider an economy with only single earner households, and eliminate all gender-based differences in wage rates and social security transfers. We use data on males to calibrate wage rates and the relative sizes of productivity groups, and impose the tax functions pertaining to married households. Altogether, these assumptions render a macroeconomic model with heterogenous agents consistent with those in the literature; e.g. Conesa and Krueger (2006), Ventura (1999).

Results are displayed in Table 13 in the case of a consumption tax, for two values of the elasticity γ. The results show that for the high value of γ, the standard framework captures only about 89% of the output gains under the current framework, and about 83% of the changes in aggregate labor supply. For the low value of γ, the fractions captured by the standard framework of output and labor supply is smaller, not surprisingly; about 85% and 51%, respectively. It is worth noting that in these results, male hours respond *more* in the standard framework than in the current one; this follows as in the current framework, married households adjust labor supply of both spouses.

An important implication from these findings is that tax reform exercises can be misleading if a 'standard' framework is used with low labor supply elasticities. The results in Table 13 provide a careful, model-based and quantitative argument for the use of high labor supply elasticities in the context of tax reforms.

9 Concluding Remarks

In this paper we study the aggregate effects of tax reforms for the US economy, taking seriously into account the labor supply decisions of married females and the underlying structure of household heterogeneity. For these purposes, and differently from the existing literature, our model economy consists of one and two-earner households, and two-earner households face explicit labor supply decisions along both intensive and extensive margins.

We find that tax changes can lead to large effects across steady states on aggregate variables. We quantify the relative importance of changes in the labor supply of different groups, and find that married females play a critical role in these changes. We find that when current taxes are replaced by proportional taxes, married females account for around 49-50% of the total increase in labor hours, and about 58-59% of the aggregate increase in labor in efficiency units. When current taxes are replaced by progressive consumption taxes, married females contribute even more to changes in hours and labor supply depending on the exemption value (65% and 55% in the low case, and 80% and 65% in the high). We also calculate that the bulk of the changes accounted for by married females can be attributed to movements along the extensive margin.

We also find that when preferences are consistent with an elasticity of labor supply on the low side of the available estimates, the labor supply behavior of married females becomes even *more* important. In this case, married females account for at least 76% of the changes in hours in a tax reform. We conclude from these exercises that the value of this preference parameter is of second-order importance in understanding the effects on output and labor supply associated to tax reforms. Finally, reforms in a standard version of the model, populated only by single agents, result in output gains that are up to 15% lower than our benchmark economy.

9.1 Appendix: Definition of Equilibrium

Let $\psi^M(B, x, z, q)$ denote the number of married individuals with assets $a \in B$, when the female is of type x, the male is of type z, and the household faces a utility cost q of joint work. This function (measure) is defined for all Borel sets $B \in \mathcal{A}$, all $x, z, q \in X \times Z \times Q$. The measures $\psi_f^S(B, x)$ (single females), $\psi_m^S(B, z)$ (single males), $\psi^{M,r}(B)$ (retired married couples), $\psi_f^{S,r}(B, x)$ (retired single females) and $\psi_m^{S,r}(B, x)$ (retired single males) are defined in similar way.

Let $\chi\{.\}$ denote the indicator function. The measures defined above obey the following recursions:

Married working agents:

$$\begin{aligned} \psi^M(B, x, z, q) &= (1-\rho) \int \psi^M(a, x, z, q)\chi\{a^M(a, x, z, q) \in B\}da \\ &+ \delta M^r(x, z)\zeta(q|z)\chi\{0 \in B\}, \end{aligned}$$

Single working agents:

$$\psi_f^S(B, x) = (1-\rho) \int \psi_f^S(a, x)\chi\{a_f^S(a, x) \in B\}da + \delta\phi^r(x)\chi(a')\chi\{0 \in B\},$$

$$\psi_m^S(B, z) = (1-\rho) \int \psi_m^S(a, z)\chi\{a_m^S(a, x) \in B\}da + \delta\omega^r(x)\chi\{0 \in B\}.$$

Married retired agents:

$$\psi^{M,r}(B) = (1-\delta) \int \psi^{M,r}(a)\chi\{a^{M,r}(a) \in B\}da + \rho \sum_{x,z,q} \int \psi^M(a, x, z, q)\chi\{a^M(a, x, z, q) \in B\}da,$$

Single retired agents:

$$\psi_f^{S,r}(B) = (1-\delta) \int \psi_f^{S,r}(a)\chi\{a_f^{S,r}(a) \in B\}da + \rho \sum_x \int \psi_f^S(x, a)\chi\{a_f^S(a, x) \in B\}da,$$

$$\psi_m^{S,r}(B) = (1-\delta) \int \psi_m^{S,r}(a)\chi\{a_m^{S,r}(a) \in B\}da + \rho \sum_z \int \psi_m^S(a, z)\chi\{a_m^S(a, z) \in B\}da.$$

Equilibrium Definition: For a given government consumption level G, social security tax benefits b^M, b^S_f and b^S_m, tax functions $T^S(.)$, $T^M(.)$, a payroll tax rate τ_p, a capital tax rate τ_k, and an exogenous demographic structure represented by $\Omega(z)$, $\Phi(x)$, $M(x,z)$, a *stationary equilibrium* consists of prices r and w, aggregate capital (K) and labor (L), household decision rules $l^M_f(a,x,z,q)$, $l^M_m(a,x,z,q)$, $l^S_m(a,z)$, $l^S_f(a,x)$, $a^M(a,x,z,q)$, $a^S_m(a,z)$, $a^S_f(a,x)$, $a^{M,r}(a)$, $a^{S,r}_m(a)$, and $a^{S,r}_f(a)$, and measures ψ^M, ψ^S_f, $\psi^S_m, \psi^{M,r}$, $\psi^{S,r}_f$ and $\psi^{S,r}_m$ such that

1. Given tax rules and factor prices, the decision rules of households are optimal.

2. Factor prices are competitively determined; i.e. $w = F_2(K,L)$, and $r = F_1(K,L) - \delta_k$.

3. Factor markets clear; i.e.,

$$\begin{aligned} K &= \sum_{x,\ z,\ q} \int_A a\psi^M(a,x,z,q)da + \sum_z \int_A a\psi^S_m(a,z)da + \sum_x \int_A a\psi^S_f(a,x)da \\ &\quad + \int_A a\psi^{M,r}(a)da + \int_A a\psi^{S,r}_m(a)da + \int_A a\psi^{S,r}_f(a)da, \end{aligned}$$

$$\begin{aligned} L &= \sum_{x,\ z,\ q} \int_A (xl^M_f(a,x,z,q) + zl^M_m(a,x,z,q))\psi^M(a,x,z,q)da + \\ & \sum_z \int_A zl^S_m(a,z)\psi^S_m(a,z)da + \sum_x \int_A xl^S_f(a,x)\psi^S_f(a,x)da. \end{aligned}$$

4. The measures ψ^M, ψ^S_f, $\psi^S_m, \psi^{M,r}$, $\psi^{S,r}_f$ and $\psi^{S,r}_m$ are consistent with individual decisions.

5. The Government Budget and Social Security Budgets are Balanced; i.e.,

$$\begin{aligned} G &= \sum_{x,z,q} \int_A T^M(.)\psi^M(a,x,z,q)da + \sum_z \int_A T^S(.)\psi^S_m(a,z)da \\ &+ \sum_x \int_A T^S(.)\psi^S_f(a,x)da + \tau_k K, \end{aligned}$$

$$\int_A b^M\psi^{M,r}(a)da + \int_A b^S_f\psi^{S,r}_f(a)da + \int_A b^S_m\psi^{S,r}_m(a)da = \tau_p wL$$

Table 1: Productivity Levels, by Type, by Gender

	Males (z)	Females (x)	x/z
<hs	0.709	0.505	0.712
hs	0.920	0.669	0.727
sc	1.113	0.799	0.718
col	1.447	1.052	0.727
>col	1.809	1.326	0.733

Note: Entries are the productivity levels of males and females, using 2000 data from the Consumer Population Survey. These levels are constructed as hourly wages for each type, ages 25-64 –see text for details.

Table 2: Distribution of Married Working Households by Type, %

	Female				
Male	<hs	hs	sc	col	>col
<hs	6.76	4.24	2.32	0.39	0.17
hs	3.15	13.49	7.29	1.83	0.68
sc	1.75	7.44	13.51	4.32	1.56
col	0.39	2.36	5.76	7.58	2.61
>col	0.17	0.90	2.63	4.42	4.27

Note: Entries show the fractions of the total married pool, by wife and husband educational categories. The data used is from the U.S. 2000 Census –see text for details.

Table 3: Fraction of Agents By Type, By Gender, and Marital Status

	Males				Females			
	All	Married	Singles	Singles (data)	All	Married	Singles	Singles (data)
<hs	0.1439	0.1028	0.0411	0.0386	0.1360	0.0904	0.0456	0.0403
hs	0.2659	0.1958	0.0701	0.0703	0.2793	0.2105	0.0688	0.0679
sc	0.2891	0.2115	0.0776	0.0773	0.3159	0.2331	0.0828	0.0848
col	0.1858	0.1384	0.0474	0.0488	0.1760	0.1373	0.0387	0.0423
>col	0.1153	0.0915	0.0238	0.0250	0.0928	0.0687	0.0241	0.0247
Total:	1.0000	0.74	0.26	0.26	1.0000	0.74	0.26	0.26

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. The last column in each panel shows the corresponding values in U.S. 2000 Census data.

Table 4: Tax Parameters

	$\widehat{\eta}_1$	$\widehat{\eta}_2$
Married	0.1023	0.0733
R^2		0.99
Single	0.1547	0.0497
R^2		0.93

Note: Entries show the parameter estimates for the postulated tax function. These result from regressing effective average tax rates against household income, using 2000 data from the U.S. Internal Revenue Service – see text for details.

Table 5: Labor Force Participation of Married Females (%

Male	Female <hs	hs	sc	col	>col
<hs	41.1	62.5	72.1	77.4	70.9
hs	49.1	67.7	77.6	84.3	86.6
sc	50.1	68.1	74.9	82.9	88.9
col	49.5	64.4	68.8	73.4	83.7
>col	45.8	58.4	62.8	64.1	79.1
Total	44.8	66.5	73.2	74.6	82.5

Note: Each entry shows the labor force participation of married females, calculated from 2000 data from the Consumer Population Survey –see text for details. The outer rows show the weighted average for a fixed male or female type.

Table 6: Parameter Values

Parameter	Value	Comments
Discount Factor (β)	0.973	Calibrated - matches K/Y
Intertemporal Elasticity (Labor Supply) (γ)	0.4	Literature estimates.
Disutility of Market Work (B)	6	Calibrated - matches hours per worker
Capital Share (α)	0.317	Calibrated - see text.
Depreciation Rate (δ_k)	0.07	Calibrated - see text.
Probability of Retirement	1/40	Calibrated - implies average working life of 40 years
Mortality rate (δ)	0.0982	Calibrated - implies fraction of retired people in data.
Payroll Tax Rate (τ_p)	0.086	Calibrated - balances budget
Capital Income Tax Rate (τ_k)	0.124	Calibrated - Matches corporate tax collections
Distribution of utility costs $\zeta(.\|z)$	–	Gamma Distribution - matches LFP by education conditional on husband's type

Table 7: Model and Data

Statistic	Data	Model
Capital Output Ratio	2.325	2.321
Labor Hours Per-Worker	0.408	0.408
Participation rate of Married Females(%)		
Less than High School	44.8	45.0
High School	66.5	66.1
Less than College	73.2	72.3
College	74.6	77.5
More than College	82.5	81.6
Total	69.4	69.2

Note: Entries summarizes the performance of the benchmark model in terms of the stated targets.

Table 8: Proportional Taxes (% change)

	Consumption Tax	Income Tax
Labor Force Participation	7.3	6.2
Aggregate Hours	4.7	4.3
Aggregate Hours (Married Females)	10.6	9.3
Hours per worker (female)	2.6	2.3
Hours per worker (male)	2.8	2.6
Labor Input	4.2	3.8
Capital/Output	15.0	4.5
Aggregate Output	11.2	5.9
Wage rate	6.5	2.0
Flat tax rate (%)	17.8	12.7

Table 9: Progressive Consumption Tax (% change)

	High Exemption	Low Exemption
Labor Force Participation	3.2	6.3
Aggregate Hours	1.5	3.6
Aggregate Hours (Married Females)	4.4	8.7
Hours per worker (female)	0.3	1.5
Hours per worker (male)	0.9	2.1
Labor Input	1.4	3.2
Capital/Output	14.4	14.2
Aggregate Output	8.0	9.8
Wage	6.3	6.3
Tax rate (%)	27.5	21.5

NOTE: These results in Table 9 pertain to the revenue-neutral replacement of the income tax system by a progressive consumption tax. The latter consists of an exemption level and a common tax rate applied above this level. The 'high' exemption level corresponds to 1/3 mean consumption for single individuals, and 1/2 mean consumption for married households in the benchmark economy. The 'low' exemption level corresponds to 1/6 mean consumption for single individuals, and 1/4 mean consumption for married households in the benchmark economy.

Table 10: Contribution of Married Females to Changes in Labor Supply (%)

	Proportional Consumption	Proportional Income	Progressive Consumption (high exemption)	Progressive Consumption (low exemption)
Panel A: Total Changes				
Δ in Married Female Hours (% of Total Δ in Hours)	59.3	58.1	80.1	64.9
Δ in Married Female Labor (% of Total Δ in Labor)	50.5	49.4	65.2	55.0
Panel B: Extensive Margin				
Δ in Married Female Hours (% of Total Δ in Hours)	51.5	49.6	71.0	56.8
Δ in Married Female Labor (% of Total Δ in Labor)	42.7	40.7	55.4	46.7

NOTE: The 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 value for the elasticity of intertemporal substitution is 0.4. The top panel shows the contribution of total changes. The bottom panel shows only the contribution of changes along the extensive margin. The progressive consumption tax considered is the high exemption level case.

Table 11: Changes in Labor Force Participation

Female Type	Proportional Consumption	Proportional Income	Progressive Consumption (high exemption)	Progressive Consumption (low exemption)
<hs	22.5	20.0	0.9	18.7
hs	9.1	6.2	6.1	7.6
sc	5.4	6.1	2.6	5.3
col	4.5	3.5	2.9	3.7
>col	2.7	1.6	1.0	2.2

NOTE: The entries show the percentage changes in labor force participation, arranged by the female type, for all reforms considered. The value for the elasticity of intertemporal substitution is 0.4. The progressive consumption tax considered is the high exemption level case.

Table 12: Low Intertemporal Elasticity (% change)

	Proportional Consumption	Proportional Income	Progressive Consumption (high exemption)
Labor Force Participation	11.0	8.3	5.0
Total Hours	4.6	3.9	1.7
Total Hours (Married Fem.)	13.0	10.7	5.8
Hours per worker (female)	1.7	1.5	0.2
Hours per worker (male)	1.4	1.2	0.2
Labor Input	3.8	3.2	1.4
Aggregate output	10.3	5.4	8.0
Δ in Married Female Hours (% of Total Δ in Hours)	79.0	76.3	96.3
Δ in Married Female Labor (% of Total Δ in Labor)	71.2	68.4	86.2

NOTE: Results in Table 12 show the aggregate consequences of tax reforms under a low value of the intertemporal elasticity parameter ($\gamma = 0.2$). The 'high' exemption level for a progressive consumption tax corresponds to 1/3 mean consumption for single individuals, and 1/2 mean consumption for married households in the benchmark economy.

Table 13: Comparison with Standard Framework

	High Elasticity ($\gamma = 0.4$)		High Elasticity ($\gamma = 0.2$)	
	Current Framework	Standard Framework	Current Framework	Standard Framework
Aggregate Hours	4.7	3.4	4.6	1.9
Labor Input	4.2	3.5	3.8	1.9
Aggregate Output	11.2	10.0	10.3	8.8
Hours per worker (male)	2.8	3.5	1.7	2.0

NOTE: The results in the Table show aggregate effects of a consumption tax under the framework developed in this paper, and under a version of a standard macroeconomic model with a single earner as described in the text.

Figure 1: Taxes and Labor Force Participation of Secondary Earners

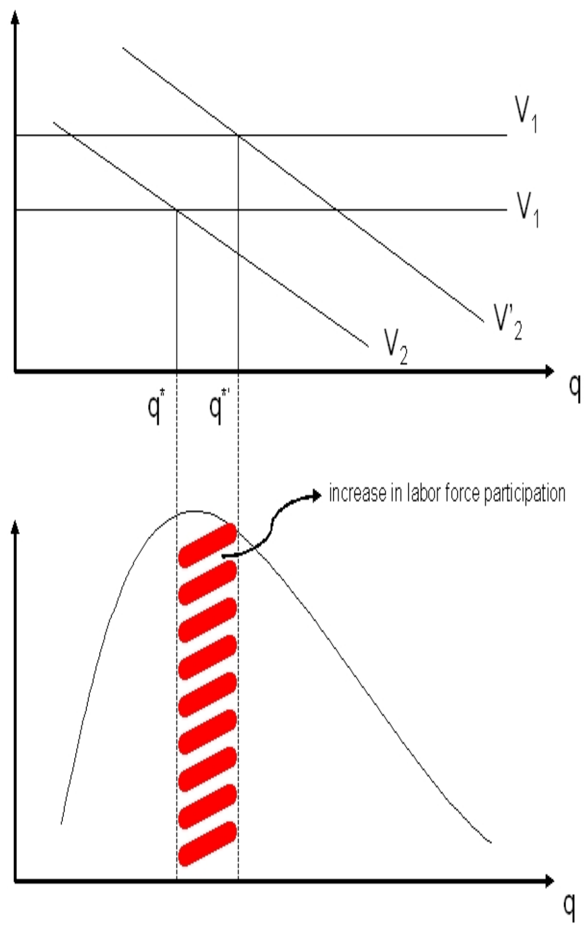


FIG. 2: AVERAGE TAX RATES

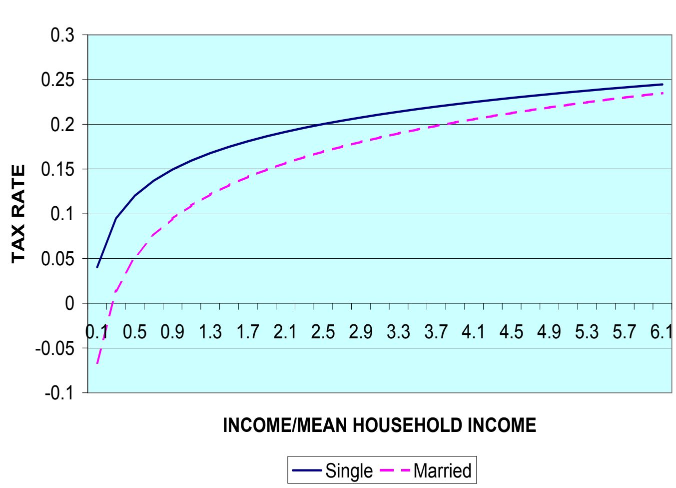
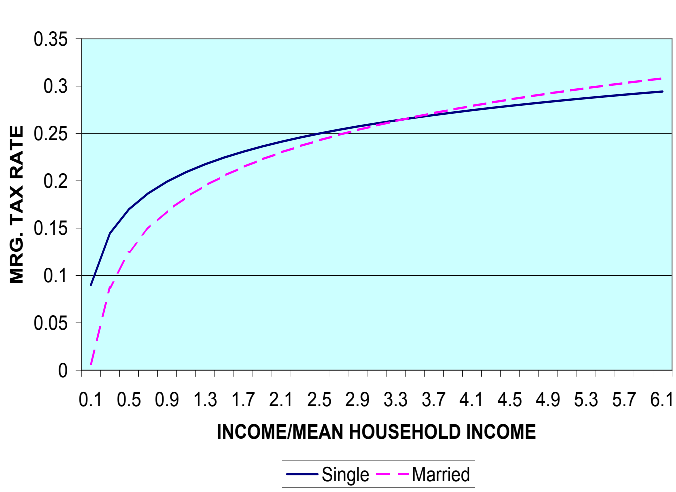


FIG. 3: MARGINAL TAX RATES



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