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Taxes, education, marriage, and labor supply

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Taxes, Education, Marriage, and Labor Supply

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Abstract

This paper analyzes the impact of income tax policy on household labor supply through two key life-cycle choices: education and marriage/divorce. To this end, I construct a quantitative life-cycle model to study the effects of changes in the degree of tax progressivity and in the unit of taxation on household labor supply. The model is calibrated to match key statistics in the United States economy, and then I analyze the impact of several tax reforms on labor supply. I find that when the unit of taxation is changed from the family to the individual this reduces the tax burden on secondary earners, which increases women's education and labor supply, but has a negligible effects on men. Further, I find that small reductions in the progressivity of the tax schedule increase college enrollment and labor supply. To drive these results, the marriage/divorce decision is important because it amplifies the effect of tax reforms on labor supply and education. My experiments demonstrate that one underestimates the impact of income tax reforms on labor supply if life-cycle choices are ignored.

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1 Introduction

This paper studies two features of the United States income tax system: the degree of tax progressivity and the choice of the family as the unit of taxation. A tax system with these two characteristics is not *marriage neutral*, meaning that changes in marital status affect individuals federal income tax obligation. In particular, primary earners face a lower marginal tax rate after marriage, while secondary earners face a higher marginal tax rate. These changes in taxation encourage specialization within households. More precisely, after marriage primary earners have more incentives to work in the market, while secondary earners have fewer incentives to work in the market and more incentives to work at home.

A second aspect of the U.S. tax system is that the unit of taxation is the family. This structure was adopted in 1948, when 90% of families were traditional one-earner families,[1] consisting of a breadwinner husband and a stay-at-home wife. Specialization within the household was the norm, and the change in the unit of taxation reinforced it. Today, the majority of families have two earners, and 72% of secondary earners are women (as of 2003). This state is the result of important changes beginning in 1950's: female labor force participation has more than doubled, they make up the majority of college students and study towards a more career-oriented degree.[2] Despite these large changes, the current income tax system is still very similar to the original 1950's implementation. Secondary earners are still penalized with an increased marginal tax rate after marriage; consequently, married women still have an incentive to reduce their labor supply or even to leave the labor force.

With females' responses in mind, this paper investigates the impact of changing the unit of taxation and the progressivity of the tax schedule on household labor supply. To fully account for these effects, I include two key life-cycle choices: college education and marriage/divorce. This paper main contribution is to quantify the impact of tax reforms on labor supply, while considering the impact on educational choice and household formation. A model with such endogenous choices is not only more realistic, but also offers a more precise evaluation of the *long-run* impact of tax reforms on household labor supply.

[1] For more information on 1948 tax reform, see the work of McCaffery (1999)
[2] For an overview on female transformation, the work of Goldin (2006)

Both of these features clearly can affect the decision of potential workers to invest in college education. They can do so through two main channels: the average return on and the riskiness of the investiment. College is costly both in terms of tuition and forgone earnings. However, the investment also grants access to better wages and to a higher probability of marrying a college-educated spouse. These benefits are skewed by taxes that decrease the average income tax of primary earners, while increasing the tax liability to secondary earners. Because the majority of secondary earners are women, separating their tax liability from their spouse increases their return on college education, while it reduces the return for men. Furthermore, the progressivity of the tax code reduces the risk of investing in college, because it reduces the variance of after-tax wages. Female earners have less income variation than males, so reducing progressivity affects men to a greater extent than women, which leads to a relative increase in females's education. These changes in education have a sizable effect on labor supply, because college educated men and women supply more labor on average than women and men who don't have a college degree.

The U.S. income tax system distorts marital decisions by its asymmetric treatment of families and individuals. For a broad range of incomes, one-earner families receive a tax benefit, while high income two-earner families pay a tax penalty. Eliminating these tax distortions can impact marriage and divorce rates and assortative matching patterns, both of which are quantitatively important when assessing the effect of taxes on labor supply. Marriage and divorce rates affect labor supply, because, on average, married men work more than single men and married women work less than single women. The effect of assortative matching is the result of an increase in marriage among college-educated individuals, which leads to an increase in the individual return on investing in a college degree.

In order to analyze the impact of tax reforms on household labor supply, I construct a quantitative life-cycle model. When young, agents decide once whether to enroll in college. After college, agents are heterogeneous in wealth and wages. Then, they meet other singles and decide whether to marry. In each period, married agents face a divorce decision and everyone decides on their labor supply, which depends on marital status, wages, and wealth. In addition, I allow labor supply to vary along both intensive and extensive margins. The model is calibrated to match key statistics of the U.S. economy in 2003, and then I substitute the U.S. current tax schedule with four experimental tax schedules. These new tax schedules alter the degree of the tax

progressivity and the unit of taxation.

In my first tax reform, *separate filing*, I change the unit of taxation by treating everyone according to the U.S. tax schedule of single individuals. Sweden, Canada and the U.K. are examples of countries that also consider the individual as the unit of taxation. The main implication of this tax reform is that now secondary earners' marginal tax rate does not increase after marriage. Consequently, this tax reform affects women more than men, because women are the majority of secondary earners. Particularly, females' hours increase by 4.1%, while males' increase by 1.3%. Regarding education, 2.3% more women enroll in college, while male college education increases by 1%.

In my second tax reform, *splitting of total income*,[3] I apply the single individual's tax schedule to the average family income. This tax schedule preserves the family as the unit of taxation, but minimizes changes in marginal tax rates due to marriage. This tax reform is similar to the French and German income tax system (though it can be criticized, because it generates a considerable tax benefit for married couples whose incomes are very disparate). In the U.S., the first two tax brackets by 2003 schedules are unaffected by this reform, because the joint filing is equivalent to the splitting of total income tax reform in these two brackets. Consequently, just a small fraction of the population is affected by this reform. Individuals change their education level in the same direction but to a lesser degree than with separate filing; female college education increases by 0.5% and male college education increases by 0.1%. Females' hours increase by 3.7% and males' hours increase by 5.11%.

In my third tax reform, *flat tax*, I eliminate the progressivity of the tax code, consequently all individuals pay the same income tax rate. This is the only reform that is both marriage neutral and treats families equally, meaning families with the same total income pay the same amount of taxes. However, because the flat tax eliminates the progressivity of the tax schedule, it increases the risk of investing in college education. Men, facing a higher risk in investing in college education than women, reduce their college enrollment by 0.3%, while female college enrollment increases by 5.6%. Overall males' hours increase by 9.7% and females' hours increase by 11.1%.

In my last tax reform, *the two-brackets tax reform*, I simplify the tax code to two income tax brackets. The marginal tax rates and the size of the brackets are chosen to maximize total welfare. This reform is based on Hall and Rabushka (1996), which

[3]The split of total income is the 1948 original implementation of the family as the unit of taxation.

proposed a flat tax to replace the current U.S. income tax system with a tax exemption for low earners. The idea of this tax reform is to simplify the tax schedule without dramatically increasing the tax rate on low income individuals. It thereby maintains some of the insurance that the currently income tax system provides to low income individuals. As a consequence, in this tax reform both males' and females' education increase; females college education increases by 9.9% and male college education increases by 3.7%. Females' hours increase by 17.3% and males' hours by 12.8%.

My work here is closely related to that of Chade and Ventura (2002), who study the impact of income tax reforms in the U.S. tax system on household labor supply and marriage formation. Also in a similar vein, Guner, Kaygusuz, and Ventura (2008) analyzes the effect of tax reforms on household labor supply, focusing on married females' extensive margin. In this paper, the authors preserve the current U.S. demographics distribution meaning that it does not consider long-run effects on household formation. In the empirical literature, Kaygusuz (2010) analyzes the impact of the Tax Reform Act of 1981 and the Tax Reform Act of 1986 on female labor supply. Kaygusuz (2010) finds that changes in the tax structure introduces by theses laws can explain 20% of the increase in married female labor force participation between 1980 and 1990. Reinforcing this finding, Eissa (1995) concludes that the labor supply from high-income married women increased in response to the Tax Reform Act of 1986.

This paper is organized as follows. In Section 2, I describe the model. In Section 3, I discuss the calibrated model and its quantitative properties. My main findings are presented in Section 5, where I evaluate and explain the effects of the four tax reforms. Section 6 concludes the paper

2 The Economic Environment

The economy is populated by a continuum of males and females, each sex with a unit mass. Individuals live for T periods. They are born single and their first decision is whether to enroll in college. When born agents are heterogeneous in their psychic cost θ_i, which captures the non-monetary cost of enrolling in college. In addition to the psychic cost, agents that decide to enroll in college pay a monetary cost κ that is homogeneous across agents. Agents are born with no wealth; consequently, college

students borrow to pay for their college expenses. There are two direct returns on attending college: (i) drawing a lifetime wage from the college-educated distribution $F_g^c(\cdot)$, which is gender-specific g; and (ii) being more likely to meet a college educated spouse. During college, agents, that decide not enroll in college, draw a lifetime wage from the non-college-educated distribution $F_g^{nc}(\cdot)$ and work. After agents turn 2 years old, they enter the marriage market.

In the marriage market agents are matched randomly, with the exemption of the first marriage market, where randon matched is restricted to education group. In this first marriage market college-educated females are matched randomly with college-educated males, while non-college educated females only match non-college educated males. After this special marriage market, agents that did not marry participate again in the marriage market, that is now completely random. The marriage market is restricted to single agents of the same cohort. Every period, matched agents learn their potential spouse's wage and their wealth, and the couple's match quality b, then they decide whether to marry. The match quality b is identically and independently distributed. After marriage, the match quality evolves by following a first-order autoregressive process. At the beginning of each period married agents learn their current match quality, and they face a unilateral divorce decision. At the end of each period, with the exception of college students at age 1, agents make their labor supply choice. For simplicity, there is no remarriage, and the only borrowing and lending in the economy is for college enrollment.

2.1 College Decision

There are two costs to enroll in college: a uniform monetary cost κ and an agent-specific psychic cost θ_i. The psychic cost is independently and identically distributed with cumulative distribution $\Theta(\cdot)$. The benefits of attending college are two: (i) Drawing a lifetime wage from the college-educated distribution $F_g^c(\cdot)$; and (ii) matching only singles with college education, after the graduation. All college students study full-time, therefore, they do not work. Since agents are born with zero wealth, college students borrow to pay their college expenses and to consume during this period. There is no default on college loans. The sequence of college payments a_t is determined by problem (4) in the following section.

Agents who decide to not enroll college draw a lifetime wage from the non-college-educated distribution $F_g^{nc}(\cdot)$ and they work while the college students study. After college age, agents are characterized by a vector $x_g = \{w, d, m, t\}$, where g indicates the agent's gender, w is the agent's lifetime wage, d is the agent's wealth, m is the agent's marital status and t is the agent's age. Agents that do not enroll in college have zero wealth d.

Let θ_g^* be the psychic cost at which an agent of gender g is indifferent about attending college or not. In this case, θ_g^* is defined by

$$\theta_g^* = E_c V_g(w, d, s, 1) - E_{nc} V_g(w, 0, s, 1),$$

where the expectation is taken with respect to the college-educated c and non-college-educated nc wage distribution and s indicates that the agent is single. The decision of enrolling in college is characterized by a threshold. Agents of gender g with a psychic cost less than θ_g^*, enroll in college and agents with a psychic cost greater than θ_g^* do not enroll. The following indicator function $I^E(\cdot)$ characterizes the education choice:

$$I^E(g, \theta_i) = \begin{cases} 1 & \text{if } \theta_i \leq \theta_g^* \\ 0 & \text{if } \theta_i > \theta_g^*. \end{cases} \tag{1}$$

2.2 Marriage Decision

After the college period, agents enter in the marriage market, where single agents of the opposite sex are matched. They learn their potential spouse wage, wealth, and the couples' match quality b. The match quality b is normally distributed $N(\mu_b, \sigma_b^2)$, with mean μ_b and variance σ_b^2. The match quality follows a first order autoregressive process AR(1):

$$b = \varrho + \rho b_{-1} + \epsilon, \quad \text{with} \quad \epsilon \sim N(0, \sigma_{div}^2),$$

where ϱ is a constant, ρ is the coefficient of autocorrelation and ϵ is the error term,

which is normally distributed with mean zero and variance σ^2_{div}. Let the match quality conditional distribution be represented by $M(b|b_{-1})$.

After agents learn their potential spouse wage, wealth and the couple' match quality, they deide wheter to marry. Marriage is consensual, so both agetns must agree to marry. A matched couple is characterized by a pair of vectors $\{x_m, x_f, b\}$, where x_m summarizes the male characteristics, x_f summarizes the female characteristics and b is the couple's current match quality. Let $W_m(x_m, x_f, b)$ be the value to the potential husband of marrying a women with characteristics x_f when the couples's match quality is b. Respectively, let $W_f(x_m, x_f, b)$ be the value to the potential wife. Let $V(x_g)$ be the value of being single for agent $\{x_g\}$. The matched couple $\{x_m, x_f, b\}$ will marry if both spouse have higher utility being married than single, this condition is summarized in the Table 1 below .

Table 1: Marriage Decision

Husband accepts	$W_m(x_m, x_f, b)$	$\geq$	$V(x_m)$
Wife accepts	$W_f(x_m, x_f, b)$	$\geq$	$V(x_f)$

We can caracterized the decision of marry by a threshold $b(x_m, x_f)$, which is the maximum between the match quality at which the potential husband is indifferent about marriage and the one at which the potential wife is also indifferent. Therefore, for any match quality b above this threshold, agents marry, and for any match quality below it, they do not. The marriage decision is characterized by the indicator function below:

$$I^M(x_m, x_f, b) = \begin{cases} 1 & \text{if } b \geq b(x_m, x_f) \\ 0 & \text{if } b < b(x_m, x_f). \end{cases} \tag{2}$$

2.2.1 Married Agents

Now we can define the value of being married for a spouse of gender g that enjoys a current match quality b.

$$W_g(x_m, x_f, b) = u(x_m, x_f, b) + \beta \int_{-\infty}^{\infty} \max\{W_g(x'_m, x'_f, b'), H(x'_g)\} dM(b'|b)$$

where $u(x_m, x_f, b)$ is the solution of the household maximization problem, and $H(x'_g)$ is the value of being divorced next period to spouse x_g. The discount factor is β and the prime indicates the age dependence. As the bellman equation above shows, a couple that decides to get married or to stay married enjoys a common utility $u(x_m, x_f, b)$ in the current period. Then next period, the married couple will observe their new match quality b', and will decide wether to stay married, this decision is represented by the max operator in the bellman equation.

2.2.2 Single Agents

The value of being single agent depends on the distribution of single agents of the opposite sex. The value of being single female at the state $\{x_f\}$ is given by:

$$\begin{aligned} V(x_f) &= u(x_f) + \beta\lambda_m(c, t+1) \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \max\{W_f(x'_m, x'_f, b), V(x'_f)\} dS(b) dF^c(x'_m) \\ & \quad \lambda_m(nc, t+1) \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \max\{W_f(x'_m, x'_f, b), V(x_f)\} dS(b) dF^{nc}(x'_m) \end{aligned}$$

where $u(x_f)$ is the solution of the single household maximization problem for agent $\{x_f\}$, $\lambda(e, t+1)$ is the distribution of single male agents at period $t+1$ with education e. The bellman equation above shows the value of being single for an agent that did not marry in the current period. This agent enjoys utility $u(x_g)$ today, and in the next period he will have a new chance of getting married. It is important to note also that the value of being single today depends on the next period distribution of single agents which is represented by $\lambda(e, t+1)$.

2.3 Divorce Decision

Divorce is unilateral. At the beginning of each period, married agents learn their current match quality b, and they decide to stay married or to divorce. Let $H(x_g)$ be the value of being divorced for an agent $\{x_g\}$. A married couple $\{x_m, x_f, b\}$ divorce if at least one of the inequalities in table 2 holds:

Table 2: Divorce Decision

Husband divorces	$W_m(x_m, x_f, b)$	$<$	$H(x_m)$
Wife divorces	$W_f(x_m, x_f, b)$	$<$	$H(x_f)$

Because the value of being married $W_g(x_m, x_f, \cdot)$ is increasing in the match quality b, the divorce decision is also characterized by a threshold $d(x_m, x_f)$, at which at least one of the spouses wants to divorce. The divorce decision is characterized by the indicator function below:

$$I^D(x_m, x_f, b) = \begin{cases} 0 & \text{if } b \geq d(x_m, x_f) \\ 1 & \text{if } b < d(x_m, x_f). \end{cases} \tag{3}$$

2.4 Household Labor Supply Problem

At the end of each age, with the exception of college students, agents make their labor supply choice. Each individual is endowed with one unit of time that can be allocated to market work l_1, home production l_2, and leisure $(1 - l_1 - l_2)$. Following Becker (1965), I assume that there is a home production function that uses market goods c_M and home production time l_2 to produce a final consumption good c_T. The home production function is of the constant of elasticity of substitution type and the parameter η determines the elasticity of substitution between market goods and home time in the home production and the parameter ψ is the share of market goods and $1 - \psi$ is the share of home production time. The productivity of labor in the home production θ_g is gender-specific.

Market goods c_M are purchased with labor l_1. Wages are fixed and do not vary over time; they are lifetime wages. Agents pay income taxes $T(\cdot)$ and each tax reform im-

plies a different tax function. Agents maximize their total consumption and leisure, the parameter α measures the weight in the utility function that is given to consumption and $1-\alpha$ is the weight to leisure. The parameter σ determines the elasticity of labor supply. Agents discount their future total consumption and leisure, with a discount factor β.

Now it is possible to define the student debt problem. College students borrow to pay their college expenses and tuition cost during college. They have access to college loans, in which they pay a fixed interest rate r and they commit to a fixed sequence of payment for the rest of their life. The payment scheme is characterized by the solution of the following maximization problem

$$\begin{aligned}
\max_{\{c_{T,t},c_{M,t},l_{1,t},l_{2,t},a_t\}_{t=1}^{T}} \quad & E\sum_{t=1}^{T}\beta^t \quad \alpha\log(c_{T,t}) + (1-\alpha)\frac{(1-l_{1,t}-l_{2,t})^{1-\sigma}}{1-\sigma} \\
\text{s.t.} \quad & \\
& c_{M,1} + a_1 \leq \kappa \\
& c_{M,t} + a_{t+1} \leq wl_1 - T(wvl_{1,t}) + (1+r)a_t \\
& c_{T,t} = (\psi c_{M,t}^{\eta} + (1-\psi)(\theta_g l_{2,t})^{\eta})^{\frac{1}{\eta}} \\
& l_{1,t} + l_{2,t} \leq 1 \\
& l_{1,t} \geq 0, \quad l_{2,t} \geq 0 \quad , a_{T+1} = 0,
\end{aligned} \tag{4}$$

where the expectation is taken with respect to the wage distribution of college-educated agents. The wage distribution depends only on education and gender, individuals of the same gender that decide to enroll in college face the same wage distribution, and consequently the same maximization problem. Because there is a unique solution for the college debt problem, agents of the same gender have the same optimal sequence of debt payments and it is sufficient to keep track of the agents gender and age to characterize fully the sequence of payment. Let $d(g,t) = a_{t+1} - (1+t)a_t$ be the net payment made by an agent of gender g at age t.

Single and Divorced Households Singles and divorced agents solve the same maxi-

mization problem. After college, all agents learn their life-time wage, when single and divorced they solve the following household maximization problem. The sequence of payment is determined before agents know their future wages. After college, single and divorced households solve the following maximization problem:

$$
\begin{aligned}
\max_{c_{M,t}, c_{T,t}, l_{1,t}, l_{2,t}} \quad & \alpha \log(c_{T,t}) + (1-\alpha)\frac{(1-l_{1,t}-l_{2,t})^{1-\sigma}}{1-\sigma} \\
\text{s.t.} \quad & \\
& c_{M,t} \leq w l_{1,t} - T(w l_{1,t}) - d_t^g 1_{\{e=college\}} \\
& c_{T,t} = \left(\psi c_{M,t}^{\eta} + (1-\psi)(\theta^g l_{2,t})^{\eta}\right)^{\frac{1}{\eta}} \\
& l_{1,t} + l_{2,t} \leq 1 \\
& l_{1,t} \geq 0, \quad l_{2,t} \geq 0,
\end{aligned}
$$

where $T(\cdot)$ is a tax function that changes according to the tax experiment. The indicator function for college debt is equal to 1 for agents who have enrolled in college and 0 otherwise.

Married Households A married couple, as an single individual, choose how many hours each spouse work at the market, l_m^1 and l_f^1, where m indicates the husband hours and f the wife, and how many hours each spouse work at home, l_m^2 and l_f^2, and last how many hours each spouse enjoy of leisure. The utility function of an married couple combined a traditional and a modern view of marriage. The traditional part is the specialization within the household, which is captured by the perfect substitution between the wife and the husband time in the home production. The modern part is the couple's leisure, which is a combination of the husband's leisure and the wife's leisure. The parameter ζ measures the elasticity of substitution between the wife's and the husband's leisure in the family utility function. In addition, married couples enjoy a return of scale ϕ in consumption and leisure. The couple's income is taxed $T(\cdot)$ and the taxes function depends on the tax reform. The match quality b enters additively in the couples' utility function and can be either positive or negative. The household problem for a married couple $\{x_m, x_f, b\}$ with current match quality b is

given by:

$$\max_{c_{T,t},c_{M,t},l^1_m,l^f_{1,t},l^m_{2,t},l^f_{2,t}} \quad \alpha \log\left(\frac{c_{T,t}}{2^\phi}\right) + \frac{(1-\alpha)}{1-\sigma}\left(\frac{(1-l^m_{1,t}-l^f_{1,t})^\zeta + (1-l^m_{2,t}-l^f_{2,t})^\zeta}{2^\phi}\right)^{\frac{1-\sigma}{\zeta}} + b$$

s.t.

$$c_{M,t} \leq w^m l^m_{1,t} + w^f l^f_{1,t} - T(w^m l^m_{1,t}, w^f l^f_{1,t}) - d^m_t 1_{\{e=college\}} - d^f_t 1_{\{e=college\}}$$
$$c_{T,t} = (\psi c^\eta_{M,t} + (1-\psi)(\theta_m l^m_{2,t} + \theta^f l^f_{2,t})^\eta)^{\frac{1}{\eta}}$$
$$l^m_{1,t} + l^m_{2,t} \leq 1$$
$$l^f_{1,t} + l^f_{2,t} \leq 1$$
$$l^m_{1,t} \geq 0, \quad l^m_{2,t} \geq 0, \quad l^f_{1,t} \geq 0, \quad l^f_{2,t} \geq 0$$

The indicator function is for each spouse and it is equal to 1 if the spouse enrolled in college and 0 otherwise.

2.5 Matching Process

After college single agents are matched at the beginning of each period. Matching is restricted to single agents of the same cohort. The first marriage market for each agent is limited to single agents of the same education group. After this special marriage market, single agents of the same cohort meet at the beginning of each period. Now, we can define the the matching process, let $\lambda_g(e,t)$ be the probability of meeting a single agent of gender g, with education e, and age t. Let $\eta_g(e,t)$ be the proportion of single agents of gender g, with education e, and age t. Then, we can compute the proportion of $(t+1)$-year-old single college-educated men by

$$\eta_m(c,t+1) = \eta_m(c,t) \quad \{\lambda_f(c,t)\int_{-\infty}^{b(x_m,x_f)} dS(b)dF^c_m(w)dF^c_f(w) \\ \lambda_f(nc,t)\int_{-\infty}^{b(x_m,x_f)} dS(b)dF^c_m(w)dF^{nc}_f(w)\}$$

where the proportions for the other gender and education groups are defined similarly. The law of motion of the matching probability $\lambda(g,e,t+1)$ is just a normalization

of the proportion of singles in each education group.

$$\lambda_g(e, t+1) \quad = \quad \frac{\eta_g(e, t+1)}{\eta_g(e, t) + \eta_g(e', t)}$$

where e indicates the education group, for which the proportion is being calculate and e' indicates the other education group.

2.6 Equilibrium

Agents differ in the size of the psychic cost θ_i of attending college. The psychic cost is normally distributed, $N(\mu_{edu}, \sigma^2_{edu})$, with mean μ_{edu} and variance σ^2_{edu}. Let the cumulative distribution of the psychic cost be represented by $\Theta(\cdot)$. In equilibrium, agents perfectly foresee the fraction of agents of each gender who will enroll college. The following equation summarize the equilibrium condition:

$$\begin{aligned}
\theta^*_m &= E_c V_m(w, d, s) \left(\Theta(\theta^*_m), \Theta(\theta^*_f)\right) - E_{nc} V_m(w, 0, s) \left(\Theta(\theta^*_m), \Theta(\theta^*_f)\right) \\
\theta^*_f &= E_c V_f(w, d, s) \left(\Theta(\theta^*_m), \Theta(\theta^*_f)\right) - E_{nc} V_f(w, 0, s) \left(\Theta(\theta^*_m), \Theta(\theta^*_f)\right)
\end{aligned}$$

where $\{\theta^*_f, \theta^*_m\}$ is the fraction of females and males that enroll in college in equilibrium. The equilibrium equation guarantees that the forecast of the fraction of college-educated agents of each gender is the same as the actual fraction of college-educated agents that choose to enroll in college. Now I can define the equilibrium of the model.

Definition 1 *An equilibrium is a set of allocations for single and divorced households* $\{c^i_{T,t}, c^i_{M,t}, l^i_{1,t}, l^i_{2,t}, a^i_t\}_{t=1:n, i \in I_g, g \in \{m,f\}}$ *and a set of allocations for married households* $\{c^{ij}_{T,t}, c^{ij}_{M,t}, l^i_{1,t}, l^j_{1,t}, l^i_{2,t}, l^j_{2,t}, a^i_t, a^j_t\}_{t=1:n, i \in I_m, j \in I_f}$ *and a set of decision rules: (i) marriage decisions* $\{I^{Mij}_t\}_{t=2:n, i \in I_m, j \in I_f}$*; (ii) divorce decisions* $\{I^{Dij}_t\}_{t=3:n, i \in I_m, j \in I_f}$*; and (iii) education decisions* $\{I^{E_i}, I^{E_j}\}_{i \in I_m, j \in I_f}$.

1. *Debt Payment Optimality: Given a tax system $\{T(\cdot)\}$, college tuition cost κ and interest rates r, the college payment scheme $\{a_t\}_{t=1,n}$ is optimal*

2. *Allocation Optimality: Given wages $\{w_i, w_j\}_{i\in I_m, j\in I_f}$, a tax system $\{T(\cdot)\}$ and college payment scheme $\{a_t\}_{t=1,n}$, allocations solve the household problem. Government budget constraint is satisfied.*

3. *Marriage and Divorce Decision Optimality: Given $\{\theta_f^*, \theta_m^*\}$ and the agents' optimal allocations, the agents' marriage $\{I_t^{Mij}\}_{t=2:n, i\in I_m, j\in I_f}$ and divorce $\{I_t^{Dij}\}_{t=3:n, i\in I_m, j\in I_f}$ decisions are optimal.*

4. *Education Optimality: Given the agents' allocations and marriage and divorce decisions, agents' education decisions $\{I^{E_i}, I^{E_j}\}_{i\in I_m, j\in I_f}$ are optimal, and $\{\theta_f^*, \theta_m^*\}$ satisfies the education equilibrium condition.*

3 Data

The stationary equilibrium is calibrated to the U.S. data in the year of 2003. Agents live for nine periods, $T = 9$; each period corresponds to five years. All Agents are from 20 to 65 years old. All the data from the Current Population Survey is from the Integrated Public Use Microdata Series - Current Population Survey (IPUMS-CPS) and the year is 2003. The definition used to college-educated agents is individuals with at least 3 years of college attendance and to non-college-educated agents are individuals with less than 3 years of college attendance.

College The psychic cost of attending college θ_i is assumed to have a normal distribution and is the same across gender. The mean μ_{edu} and the variance σ_{edu} of the psychic cost are calibrated to match the fractions of college-educated males (0.29) and college-educated females (0.28) in the 2003 IPUMS-CPS, using the definition above of college-educated and non-college educated agents. College tuition κ is from the College Board and based on four years public and private not for profit universities. The college tuition is an annual estimation of the tuition paid, which is the full tuition price minus the amount of financial aid received. The final monetary cost is $\$4580$ in 2003 dollars. The interest rate on college loans is assumed to be 4% annually. Studying time during college is calibrated to match 32.5 hours per week, which is from the American Time Use Survey.

Demographics The match quality distribution and its autoregressive process are calibrated to match marriage rates by education group and the fraction of divorced agents. There are four education groups: (i) both spouses have a college education, (ii) only the wife has, (iii) only the husband has, and (iv) neither one has. The data is from the 2003 IPUMS-CPS and the match quality initial distribution is normal, with mean μ_b and variance σ_b. The first-order autoregressive process has a constant ϱ, the autocorrelation coefficient ρ, and an error term with a mean of zero and a variance σ_{div}. Table 5 summarizes the values found and the statistics targeted.

Preferences The time discount factor β is equal to 0.81, which corresponds to a discount factor of 0.96 annually. There are three utility function parameters to be calibrated: (i) the elasticity of labor supply σ, (ii) the elasticity of substitution ζ between wife leisure and husband leisure, and (iii) the household weight α on leisure and consumption. The preference parameters are calibrated to match the average hours worked per female, which is 27.94 and the average hours worked by males, which is 39.35. Both are average hours worked per person of each gender and they are from the 2003 IPUMS-CPS, with the population restricted from 25 to 65 years old. The other moment is the fraction of two-earner households among married households. This moments is very important to measure the impact of separate filing and the splitting of total income tax reforms on labor supply. It is also calculated from the 2003 IPUMS-CPS for the same age group.

Home Production The elasticity of substitution between market goods and home production time η is from the work of McGrattan, Rogerson, and Wright (1997). The difference in home productivity θ and the weight on market goods and home time ψ on the home production are calibrated to match the average time on home production for males (9.1) and females (17.34) from the American Time Use Survey in 2003. The return of scale on consumption ϕ for married households is from the Organization for Economic Co-operation and Development (OECD) and it is equal to 0.77.

Wages Wages are from the CPS in 2003 and are lifetime wages. They are hourly-wages[4] and restricted to those in the civilian labor force who make at least half of the minimum wage and to those who worked at least 10 hours per week. Hourly wages are assumed to have a log-normal distribution. There are four wage distributions, one for each education and gender group. Table 3 summarizes the mean and variance for

[4]Mean hourly wage = $\frac{\text{Income Wage}}{\text{Usual Hours Worked*Weeks Worked}}$.

each education and gender group.

Table 3: Wage Distribution

Category	Parameter Values	
Female College	$\mu_{f,c} = 2.94$	$\sigma_{f,c} = 0.33$
Male College	$\mu_{m,c} = 3.25$	$\sigma_{m,c} = 0.46$
Female Non-College	$\mu_{f,nc} = 2.45$	$\sigma_{f,nc} = 0.27$
Male Non-College	$\mu_{m,nc} = 2.72$	$\sigma_{m,nc} = 0.36$

Taxes The income tax schedule is estimated from OECD data and includes the federal income tax, the earned income tax credit (EITC), the state tax from Michigan, and the city tax from Detroit. Two tax schedules are estimated, one for singles individuals and one for married individuals. The average tax function ($t(\cdot)$) is estimated in terms of average income, *AI*, which in 2003 was $\$36,084$. The average income tax functions for singles (s) and for married (m) are:

$$t^S(income) = -1.3059 - 0.0050\left(\frac{income}{AI}\right) - \frac{0.0097}{1-0.9382}\left(\frac{income}{AI}\right)^{1-0.9382}$$
$$t^M(income) = -0.3920 - 0.0052\left(\frac{income}{AI}\right) - \frac{0.8944}{1-0.8293}\left(\frac{income}{AI}\right)^{1-0.8293}.$$

The social security tax function ($t_{ssc}(\cdot)$) is estimated separately. It is equal to a flat tax of 0.0765 for an income less than $\$87,000$ in 2003 dollars. Above this upper limit the social security tax function is estimated as:

$$t_{ssc}(income) = 0.0145 + \frac{5,349}{income}.$$

The total tax function for singles is the sum of their average income tax and the social security tax rate times their income. For couples, the total tax function is the couple's income multiplied by their income tax, and for spouses who participate in the labor force, their individual social security contributions are added. The social security contribution is equal to the social security rate multiplied by the spouse's income.

Table 4 summarizes all the parameters calibrated in the model.

Table 4: Parameter Values

Category	Parameter Values	Source
Preferences	$\beta = 0.81$	Prior Information
	$\alpha = 0.48$, $\zeta = -1.36$	Calibrated
	$\sigma = 0.86$	Calibrated
Home Production	$\eta = 0.45$, $\phi = 0.77$	Prior Information
	$\psi = 0.38$, $\theta = 0.46$	Calibrated
College	$\kappa = 4,580$, $l_{edu} = 32.5$	Prior Information
	$\mu_{edu} = -2.79$, $\sigma_{edu} = 1.71$	Calibrated
Marital	$\mu_b = 1.13$, $\sigma_b = 1.82$	Calibrated
	$\varrho = 0.40$, $\rho = 0.64$	Calibrated
	$\sigma_{div} = 1.80$	Calibrated

4 The Benchmark Economy

Before proceeding to investigate the impact of income tax reforms on labor supply, I must investigate how well the benchmark model performs with the parameters selected and calibrated. Table 5 summarizes the performance of the model compared to the statistics targeted. The model does very well. The objective of the tax reform exercise is to quantify the effect of taxes not only on labor supply, but also on education, marriage, and divorce. To assess the effect of tax reform on labor supply correctly, I consider a potential two-earner household model in which the household maximizes the time devoted to working outside and inside the home -labor supply and home production- and leisure. By allowing the household to do home production the model generates changes in both the intensive and extensive margins. In the data, both average hours worked and home production for both males and females are targeted, and the model comes close to both targets.

In the calibration, neither labor force participation nor hours worked per education group were targeted, yet the benchmark model's steady states value match both moments very well. Hours worked and labor force participation by education group are very important to my analysis, since an increase in education does not only affect

Table 5: Benchmark Calibration Results

	Data	Model
College Females	0.28	0.28
College Males	0.29	0.30
College Husband, College Wife	0.15	0.16
College Husband, Non-College Wife	0.08	0.08
Non-College Husband, College Wife	0.06	0.08
Non-College Husband, Non-College Wife	0.39	0.39
Divorced	0.14	0.14
Average Hours Worked Females	27.96	27.86
Average Hours Worked Males	38.95	39.46
Average Home Production Females	17.40	17.54
Average Home Production Males	9.60	9.55
Proportion of Two-Earner Married Agents	0.62	0.63

productivity, but also in general generates an increase in hours worked. Table 6 compares hours worked and labor force participation of married individuals generated by the model to the value in the data for each gender and education group. All the data is from IPUMS-CPS for individuals from 25 to 65 years old.

Table 6: Benchmark Calibration Results: Labor Supply by Education

	Hours Worked		LFP (Married Individuals)	
	Data	Model	Data	Model
College Females	32.05	32.51	0.77	0.77
College Males	42.15	41.82	0.94	0.93
Non-College Females	26.27	25.57	0.69	0.69
Non-College Males	37.16	36.54	0.89	0.89

The education choice is crucial to the model, and as presented before, is carefully modeled. Investing in education is risky, because there is uncertainty on future wages. This uncertainty comes from the wage distribution that is estimated from the data. The fact that college-educated males have higher variance in their future wages will play an important role when the progressivity of the tax schedule is modified. There are two returns on attending college: wages and marriage. Marriage and divorce decisions amplify the effect of taxes on education. In order to assess correctly the return on college from the marriage market, the marriage composition among educa-

tion groups is targeted. By targeting the marriage composition, the model captures the fact in the data that individuals with a college education are more likely to marry a college-educated spouse than a non-college-educated spouse.

A key feature needed in order to quantify the effects of taxes on labor supply, education, and total welfare is the fraction of two-earner families. This feature is fundamental to all tax reforms, because the change in the unit of taxation from the family to the individual results in one-earner families no longer receiving tax benefits and two-earner families no longer paying a tax penalty. Consequently, by targeting the fraction of two-earner families and one-earner families, I have the correct composition of the current family types. This feature of the calibration allows me to estimate the impact of tax reforms on both short-run, when the demographics characteristics are fixed, and in the long-run, when agents are allowed to adjust both marriage/divorce and education decisions.

5 Results

After calibrating the model to the current U.S. income tax system. I impose, sequentially, four tax reforms on my model: (i) a splitting of total income, (ii) a separate filing, (iii) a flat tax, and (iv) a two-bracket tax code. The first two reforms maintain the progressivity of the tax code and the last three tax reforms are marriage-neutral. All tax reforms are revenue-neutral. To make the splitting of total income and separate filing reforms revenue neutral, I have all households potentially receiving a subsidy or paying a tax from the government that is proportional to their total income, from the estimation I find that in both cases households receive a subsidy.

The analysis is a steady-state comparison. I impose each tax reform on the benchmark model, and then I find the new steady-states, which is compared with that of the benchmark model. In addition, in the most interesting cases, I quantify the importance of each life-cycle choice to the tax reform. Consequently, I analyze the same tax reforms in a model with only education, with only marriage/divorce, [5] and with the demographics distribution fixed and only labor supply varying with taxes.

[5] In the exercise agents' marriage and divorce decisions are the same as those in the benchmark model, but also they are myopic with respect to the proportion of college students.

5.1 Splitting of Total Income

The reform of splitting income for tax purposes is based on the original 1948 U.S. income tax implementation. There is a unique tax schedule, which is the tax schedule for single individuals. Married individuals' tax rate is given by applying single individual tax schedule to the couple average income. In this tax system, there is no marriage tax penalty and individuals can only receive a tax benefit from getting married. As a consequence of the increase in the tax benefit from marriage, marriage increases by 0.5% and divorce per married couple decreases by -1.2%. An increase in marriage and a reduction in divorce generates an increase in male labor supply and a decrease in female labor supply, because as in the data a married man work more than a single man and a married woman work more than a single man. Overall, female college enrollment increases by 0.5% and male college enrollment increase by 0.1%. Female hours worked increases by 3.7% and male hours worked increase by 5.1%.

Only a small fraction of the population is affected by this tax reform, because the current U.S. tax system allows it for middle- and low-income households. The main groups that are affected by this tax reform are the high-income, two-earner households and the very poor-households. The high-income, two-earner households used to pay a marriage penalty; with the tax reform, they can receive a marriage benefit. As a result, in two-earner families the wife's labor supply increases by 6.5% and the husband's labor supply increases by 5.0%. The poorest families have more access to the earned income tax credit after the tax reform. As a result, their labor supply increases considerably. The labor supply of poor males increases by 15.0% and that of poor females by 6.0%.

5.2 Separate Filing

The separate filing tax reform eliminates marriage as a factor in tax calculations. Therefore, changes in marital status do not affect individuals' income taxes. The main effects of this tax reform are to reduce the marginal tax rate on secondary earners, and to increase it on primary earners. Females are the majority of secondary earners, and secondary earners' tax burden is an increasing function of primary earners'

income. Because college-educated females are more likely to marry high income primary earner, they benefit more from the separate filing tax reform. As a result, the sperate filling tax reforms increases the return from college education for females. Overall female college education increases by 2.3%.

Another benefit of separate filing to college-educated females is from marriage. After this tax reform, the income of the secondary earner becomes a larger fraction of after-tax total income. Consequently the value of marrying a high-income secondary earner increases. In Table 7, I compare the value of the separate filing tax reform with three special cases of the model, one without the marriage decision and one without the education decision and the last one where the only decision is labor supply. In this last case there is no change in the demographics composition. In the model without the marriage decision, female college attendance increases, but less than in the model with all three life-cycle choices. In Table 7, we can see that changes in both decisions are important to explain the increase in female labor supply. In a model without any life-cycle choice, female labor supply increases by 2.41%, which is lower than in any other model. In particular, it almost half than the increase in labor supply from the full model which is 4.13%.

Table 7: Separate Filing Reform

	Percentage Change From The Benchmark			
	Full Model	Only Marital	Only Education	Constant
Married	-0.33%	0.01%	-0.01%	0.0%
Divorced/Married	-0.59%	-0.72%	-0.46%	0.0%
College Females	2.26%	0.0%	1.88%	0.0%
College Males	1.03%	0.0%	0.42%	0.0%
Average Hours per Females	4.13%	4.02%	3.67%	2.41%
Average Hours per Males	1.30%	1.07%	1.38%	1.41%
Average Home Prod Females	-6.58%	-6.42%	-5.89%	-5.40%
Average Home Prod Males	-8.53%	-8.33%	-9.44%	-9.50%
Total Welfare	0.71%	0.67%	0.67%	0.65%

Males hours worked patterns' are different than females. First, overall males labor supply increases by 1.3%, although on average they face a higher marginal income tax. The main reason for this result is that married men labor supply depends on his spouse labor force participation. On average, after the tax reform, a man married with a wife that participates in the labor force reduces his hours worked, while she

increases it, and the couple consumes more leisure. However, a man married with a stay at home wife increases his hours worked, while she increases her home production, and on average they consume less leisure. Because the response of men on one-earner families is stronger than men in two-earner families, on average man hours worked increases. Overall, in the separating filing tax reform, male hours worked increases by 1.3% and male education by 1.0%.

5.3 Flat Tax

The flat tax reform eliminates the progressivity of the tax code, which increases the risk of acquiring a college education. College-educated males expect a higher variance in their future wages than do college-educated females; as a result they face more risk in investing in college education after the tax reform. Male college education decreases by 0.3%, while female college education increases by 5.6%. In this environment, the progressivity of the tax code and marriage are the only mechanisms that reduces the risk of acquiring education.

Table 8: Flat Tax Reform

	Percentage Change From The Benchmark			
	Full Model	Only Marital	Only Education	Constant
Married	-0.63%	-0.19%	-0.53%	0.00%
Divorced/Married	0.30%	-0.33%	0.01%	0.00%
College Females	5.57%	0.00%	5.35%	0.00%
College Males	-0.29%	0.00%	-1.13%	0.00%
Average Hours per Female	11.07%	10.74%	10.85%	9.01%
Average Hours per Males	9.69%	9.07%	8.86%	9.56%
Average Home Prod Females	-6.10%	-5.62%	-5.89%	-5.72%
Average Home Prod Males	-11.24%	-11.14%	-10.54%	-9.64%
Total Welfare	0.49%	0.40%	0.42%	0.40%

The flat tax reform eliminates any marriage tax benefit and penalty, which can make marriage more or less attractive. Before this reform more couples receive a marriage benefit than a marriage penalty, so overall the flat tax reform decreases marriage and increases divorce. With this reform individuals become more selective in choosing their future spouse; as a result, marriage among the college-educated agents increases by 2%, which amplifies the effect of taxes on education. After the flat tax reform,

females not only experience an increase in the value of attending college, but an increase in the value of marrying a college-educated spouse. The impact of taxes on the marriage decision creates an amplification effect on education. Table 8 compares the value of the tax reform for four cases of the model: one with all endogenous decisions, one with only education decision, one with only marriage and divorce decisions, and the last one with only labor supply, in which the demographics distribution is fixed. Female labor supply increases by 11.07% and both the reduction in marriage and the increase in education are important to explain that increase.

Males labor supply also increases with this tax reform, most of the increase in male labor supply is driven by poor males who face a much higher tax rate after marriage. Table 9 indicates the change in labor supply by income group. These groups are the richest quarter, poorest quarter, and the half in between, or the middle class. This table shows that the poorest males are responsible for the sizable fraction of the increase in male labor supply under a flat tax.

Meanwhile, most of the increase in female labor supply with the flat tax reform is from middle-class females. The increase in female education generates an increase in female income; as a consequence in the middle class, many females who were secondary earners become primary earners in one-earner and two-earner families. This helps explain the 13.6% increase in the middle-class female labor supply that results with this reform.

Table 9: Flat Tax Reform Income Distribution

	Benchmark		Flat Tax	
	Market Hours Worked	Home Hours Worked	Market Hours Worked	Home Hours Worked
Rich Females	46.19	3.97	49.40	3.40
Rich Males	51.20	1.03	54.56	0.74
Middle Females	27.70	17.04	31.57	14.05
Middle Males	42.59	6.20	46.37	6.00
Poor Females	10.05	30.62	10.94	32.30
Poor Males	16.00	26.67	19.83	22.45

5.4 Two Brackets

In this tax reform, I simplify the tax code to two income tax brackets. The marginal tax rates and the size of the brackets are chosen to maximize total welfare. In this tax reform, although the top bracket has a higher marginal tax rate than with the flat tax, both male and female education increase more than with that reform. This is because the progressivity of the two-brackets tax reform reduces the risk of acquiring a college education. Females' college education increases by 9.9% and males' college education increases by 3.67%.

Two-brackets tax reform generates the biggest increase in labor supply, for both males and females. Female labor supply increases by 17.32% and male labor supply by 12.82%. Because in the two brackets tax reform, the marginal tax rate on the rich is higher, this income group labor supply is lower than in the flat tax. However, for all the other income groups the labor supply is higher. In the two brackets tax code, middle-class females are the group most affected by this tax reform in both the intensive and the extensive margins. Female labor force participation increases by 11.05%. Differently from the flat tax where most of the increase in male labor supply comes from the poor, in this tax reform, middle-class males are responsible for an important fraction of the increase in male labor supply, as Table 10 indicates.

Table 10: Two Brackets Tax Code Income Distribution

	Benchmark		Flat Tax	
	Market Hours Worked	Home Hours Worked	Market Hours Worked	Home Hours Worked
Rich Females	46.19	3.97	47.72	3.76
Rich Males	51.20	1.03	54.01	0.85
Middle Females	27.70	17.04	35.11	12.15
Middle Males	42.59	6.20	48.15	5.00
Poor Females	10.05	30.62	11.85	30.20
Poor Males	16.00	26.67	21.53	23.27

6 Conclusion

The inclusion of the three life-cycle choices in the analysis of tax reforms is fundamental to correctly assessing their impact on labor supply. The education choice brings

a new perspective to the importance of the degree of progressivity in the tax code, which affects the risk of investing in college education. This relationship emerges when we compare the outcome of the flat tax with the outcome the two-brackets tax reform. In the flat tax, only female college education increases, while in the two-brackets tax reform both male and female college education increases. This result demonstrates the importance of some degree of progressivity as insurance for investment in college education.

The separate filing and the splitting of total income tax reforms do not alter the degree of progresssivity of the tax code, but they modify the marginal tax rate on secondary earners and primary earners. These two tax reforms indicate that the gains from a reduction in the secondary earner marginal tax rates is sizable. In both tax reforms not only female labor supply increases, but also female education, which is fundamental to measure the gains in total welfare from the tax reform for current and future generations.[6] In addition, when comparing the separate filing tax reform with the splitting of total income, we can conclude that a more dramatic reduction in the marginal tax rate of the secondary earner, which occurs in the separate filing tax reform, can lead to bigger gains in total welfare.

[6]It is a well know fact in the literature that mothers education has an important impact on children performance, Carneiro, Meghir, and Parey (2007)

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