Taxation, Aggregates and the Household

Nezih Guner, Remzi Kaygusuz and Gustavo Ventura*

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Abstract

We quantitatively explore tax reforms in a dynamic setup with married and single households, and with an operative extensive margin in labor supply. Our model is restricted to be consistent with observations on gender and skill premia across schooling groups, labor force participation and the structure of marital sorting, under a tax structure that resembles the current one in the United States. We then use this framework to evaluate hypothetical reforms to the U.S. tax system. Our preliminary findings indicate that tax reforms can lead to large effects across steady states on aggregate variables, and that the labor supply behavior of different groups is key. Replacing current income taxes by a flat consumption tax increases steady-state output by about 14.9%. This increase is accompanied by differential effects on labor supply: while total hours work increase by 8.1%, the labor force participation of secondary earners increases by 8.9% and married females increase total hours by 12.4%. Married females account for about 43.1% of the total increase in labor hours. When current income taxes are replaced by a progressive consumption tax, married females account for a much larger (73.8%) share of the total increase in labor hours. Our results also show that the extent of the labor force participation by secondary earners, the wage structure (gender gap and skill premium), as well as the marital composition of population (who is married with whom) in the pre-reform economy affect aggregate outcomes in fundamental ways.

*Guner, Department of Economics, Universidad Carlos III de Madrid, Calle Madrid 126, Getafe (Madrid), 28903, Spain, and CEPR; Kaygusuz and Ventura, Department of Economics, Pennsylvania State University, Kern Graduate Building, University Park, PA 16802-3306. We thank participants in 2006 FEDEA Dynamic General Equilibrium Macroeconomics Workshop in Santiago de Compostella, 2006 NBER Summer Institute, 2006 SED Annual Meeting in Vancouver, 2006 Midwest Macro Conference in St. Louis, and the 2006 LACEA Meetings in Mexico City for helpful comments. We thank for the support by the Population Research Institute at Penn State.

1 Introduction

Tax reforms have been at the center of numerous debates among academic economists and policy makers. These debates have been fueled by concerns on the equity and efficiency of the current tax structure, by theoretical results establishing that taxing capital income is not efficient, and by the fact that the current U.S. tax structure is complicated and distortionary. Not surprisingly then, there have been calls for fundamental tax reforms that would simplify the tax code, broaden and/or change the tax base, and adopt a more uniform marginal tax rate structure.[1] There is no consensus, however, on what the *quantitative* effects of alternative forms of taxation would be. This lack of consensus partly reflects how individuals weigh equity and efficiency of alternative forms of taxation differently, and such differences might be hard to resolve. Yet, differences that originate from the implications of different models should be easier to deal with, as we learn from existing models and try to build better ones. This has been a challenge for economists in recent years.

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, the current household structure in the U.S. should force us to think beyond single-earner household paradigm. Consider how different U.S. households look today compared to 1960. To begin with, a much smaller proportion of the adult population is married. More than 80% of women between ages 25 and 64 were married then whereas about 65% of them are today. Second, married women devote a much larger fraction of their available time to work outside the home. Using Current Population Survey (CPS) data, we calculate that the labor force participation of secondary earners in married households was about 43% in 1960 while it is about 74% today. Third, earnings per-hour of females relative to males (gender gap) have grown considerably; from around 40% in 1960 to about 73% nowadays. Overall, these changes resulted in a major shift in the structure of a typical U.S. household; a shift away from households with a bread-winner husband and house-maker wife. The macroeconomic consequences of this transformation are arguably of first-order importance. We clearly live in a different world.

Our aim is twofold. We study tax reforms in dynamic economies with an operative

[1] Among such fundamental reform proposals, one can list Hall and Rabushka's (1995) flat tax, Bradford's (1986) X-tax, a simple proportional income tax or a proportional consumption tax – see Auerbach and Hassett (2005).

extensive margin in labor supply and a demographic structure in line with data. This is novel in the literature. In addition, we evaluate the importance of each of these non-standard features to quantify the long-run consequences of such reforms.

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 affects critically the 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 greatly 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. Two recent major tax reforms, i.e. Economic Recovery Tax Act of 1981 (ERTA) and Tax Reform Act of 1986 (TRA), have been shown to affect female labor supply behavior significantly, but have relatively small effects on males (Burtless (1991), 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)). Furthermore, recent studies also highlight the significant role that taxes play in accounting for cross-country differences in labor supply behavior, and the long-run effects in labor supply associated to tax changes (Prescott (2004)). If households react to taxes much more than previously thought, the potential effects of tax reforms can be much more significant.

The model economy we consider is populated with males and females who differ in their potential earnings, and who exhibit life-cycle behavior. They are born as workers and stochastically transit into retirement, and once retired, into death. At any point in time agents are either married or single. Hence, in the model agents differ along their gender, earnings, and marital status. Each period, single agents are exogenously matched according to probabilities that depend on individual types and assets, and form two-person households. Similarly, each period married agents divorce according to an exogenous process, and become single. Singles decide how much to work, and how much to save out of their total after-tax income. Married agents' decisions are more involved. They decide whether both or only one of the household members should work, and if so, how much. If both agents work in a married household, they face a utility cost, which represent the additional difficulty originating from the need to better coordinate household activities, potential child-care costs, etc. As a result, it is possible that one of the agents in a married couple household may choose not to work at all. This is a key aspect of the environment as it permits to model the labor supply of a married household along the extensive margin (whether to work or not). Like singles, married agents also decide how much to save out of their after-tax total income. Finally, there is a simple pay-as-you-go social security system that taxes workers labor income and provide benefits to retired.

A few features of this model are important to highlight here. First, we model explicitly the participation decision of secondary earners in married households. This is novel in dynamic models with heterogeneity. It is also key, since the structure of taxation affects the participation decision of individuals, and available evidence suggests that it does so significantly. The model thus allows us to separate changes in labor supply that take place at both extensive and intensive margins. Second, since we aim at a realistic picture of U.S. households, the model is developed so that it can reproduce *exactly* who is married to whom in the data. This feature is key for our purposes, since different households face different marginal tax rates, and reactions of different households to a tax reform are potentially not the same. Third, the fact that in the model agents save and accumulate assets allows us to capture the effects of tax reforms on the aggregate capital stock. This is obviously in order since the federal government in the United States taxes both labor and capital income, and capital income is taxed further via the corporate income tax. Thus, comprehensive tax reforms will affect the marginal tax rates on both types of income and the incentives to accumulate capital.

We restrict model parameters so that our benchmark economy is consistent with key aggregate and cross-sectional features of the U.S. economy. 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 households incomes and taxes in a parsimonious way. Second, we construct our benchmark economy to be consistent with the data on the labor force participation of secondary earners. In particular, since each married household in the model economy is characterized by the labor market productivity levels of its two members, we select parameter values so that the labor force participation of secondary earners for each household type is in line with the data. Third, the demographic structure of the model is tightly mapped to U.S. demographics. In the model, agents face exogenous demographic transitions. Most importantly, individuals face exogenous marital transitions during their working-age years. The structure of our model allows us to select these marital transitions so that marital structure of the benchmark economy (who is single, who is married, and who is married with whom) matches exactly the structure observed in the U.S. economy. Altogether, our framework is then a rich, yet still tractable model of household formation and dissolution.

Our preliminary findings indicate that tax reforms can lead to large effects across steady states on aggregate variables, and that the labor supply behavior of different groups is key. Replacing current income taxes by a flat consumption (income) tax results in an increase in aggregate output of about 14.9% (8.9%). This output increase is accompanied by differential effects on labor supply: while total hours work increase by 8.1% (7.8%), the labor force participation of secondary earners increases by 8.9% (7.6%) and married females increase total hours by 12.4% (12.8%). Overall, married females account for about 43% (46%) of the total increase in labor hours.

If instead tax reforms are represented by a common marginal tax rate and an exemption level, aggregate effects are more moderate and the positive effects on labor force participation are much less pronounced. Replacing current income taxes by a consumption tax with these properties, results in an increase in aggregate output of about 8.3% across steady states and a change in labor force participation of only 3.1%. Interestingly, the contribution of married females to the total increase in labor hours is much more significant with a progressive consumption tax (75%).

Related Literature The current paper is related to three literatures. First, our evaluation of tax reforms using dynamic models with heterogenous agents is related to the work by Altig et al (2001), Diaz-Jimenez and Pijoan-Mas (2005), 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. 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. Finally, the current paper is related to papers that studied the macroeconomic effects of changes in labor supply along the extensive margin; Cho and Rogerson (1988), Cho and Cooley (1994), Mulligan (2001), Chang and Kim (2006) and Kaygusuz (2006b) are examples. Kleven and Kreiner (2006) study optimal taxation of two-person households when households face an explicit labor force participation decision.

2 The Economic Environment

Background The economy we investigate is 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 Blanchard (1985) individuals have finite lives, and as in Gertler (1999) their lives have 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 $1/\delta$.

Each agent is endowed with one unit of time, which can be divided between market work and leisure. Each agent is also indexed by a labor market productivity level (type), which remains constant throughout his/her life. Agents also differ by their marital status: they can be single or married. Marital status of agents change *exogenously* in the way we detail below. For simplicity, we assume that 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), if both members of a married household supply positive amounts of market work, then members incur a utility cost. This utility cost is drawn once and for all from a given distribution when the household is formed and remains constant until the household either breaks up or their members retire. Households save in the form of a one-period, risk-free asset. If a household breaks up, each member gets half of the total household assets. Retired agents are not allowed to work, so their only decision is about their savings. There is a pay-as-you-go social security system in place that provides social security payments to households. We assume that there are three levels of social security benefits, one for retired married, one for retired single female, and one for retired single male households. Retired individuals who die are replaced by *single* workers with the same productivity level and zero assets. We assume for simplicity that assets of the deceased are not distributed among the surviving population.

A representative firm rents capital and labor services to produce a single consumption good, and pays a wage rate per effective unit of labor and a rental rate for capital. Finally, there is a government that taxes labor and capital income each period, and consumes the aggregate amount G and runs the social security system. There are three different taxes in this economy: a progressive household income tax on labor and capital incomes, an additional flat tax on capital incomes, and a flat payroll tax on labor earnings. Taxation is the only source of government revenue, and is used to finance G as well as social security payments. Progressive taxes on capital and labor income and the flat capital income tax are used to finance G, while payroll taxes on labor earnings are used to finance social security transfers.

$>$From the previous assumptions, at any point in time the economy is populated by single and married households who differ by their labor market status, market productivity of their member(s), asset levels, and the utility cost of joint work (if married and working). The state for a household in this economy consists of its assets, productivity of its members (if working) and per period utility cost of joint work (if married and working). The aggregate state for this economy consists of distribution of households by their types and asset levels. We describe in detail below a stationary environment in which these distributions and factor prices are constant. We provide a formal definition of equilibria in the Appendix.

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 of gender $i = \{f, m\}$ is given by

$$U_i^S(c, l) = U_i(c, 1 - l),$$

where c is consumption and $1 - l$ is leisure. It is assumed here that $U_i^S$is continuous, strictly increasing in each argument, differentiable and strictly concave.

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

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

where c is aggregate consumption of the household. We assume that consumption is a public good subject to congestion and let $0.5 \leq \gamma \leq 1$ capture the economies of scale at the household level, so that per capita consumption is given by γc. Households are assumed to maximize sum of their members utilities. We assume that when both members of a married household work, the household incurs a utility costs q, and let $\chi(l_i, l_j)$ be an indicator function for joint work, i.e.

$$\chi(l_i, l_j) = \begin{cases} 1, \text{ if } l_i l_j > 0 \\ 0, \text{ otherwise} \end{cases}.$$

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 household members. Let $\zeta(q|x, z)$ denote the probability that the cost of joint work is q, with $\sum_{q \in Q} \zeta(q|x, z) = 1$ for all x and z, for a household with productivity levels x and z. When a married household is formed, the household draws its q, which remains constant until the marriage ends. We assume that each member of the household incurs half of this total utility cost.

Incomes and Taxation Let w be the wage rate per effective units of labor and r be the rental rate of capital. 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 $a + ar + wzl$. 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 Each period agents from each gender are either single or married. 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

$$\Phi(x) \equiv \sum_z M(x, z) + \phi(x) + \sum_z M^r(x, z) + \phi^r(x), \tag{1}$$

and

$$\Omega(z) \equiv \sum_x M(x, z) + \omega(z) + \sum_x M^r(x, z) + \omega^r(z), \tag{2}$$

hold by construction.

Each agent is born as a single worker with zero assets, and his/her marital status changes exogenously as long as he/she remains a worker. We assume that each period agents first face retirement shocks and then, if they do not retire, experience marriage and divorce shocks. Once retired, marital status of agents remain constant until he/she dies.

In particular, each period working single agents match with other single workers of opposite sex according to exogenous probabilities. To this end, let $\pi_m(z)$ be the probability that a single male worker of type z is matched with a female worker, and $\pi_f(x)$ denote the probability that a single female worker of type x matches with another male worker. Given that a single type-z male is matched, let $P_m(x|z)$ be the conditional probability that his match is type-x. Similarly, let $P_f(z|x)$ be the conditional probability that a single female of type x is matched with a type-z male. Each period working married households, independent of their members' types, face an exogenous divorce probability denoted by λ. Divorced agents have to remain single one period before they match with other singles.

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 $\psi^M(x, z, a, q)$ be the number of working married households of type (x, z, a, q), $\psi_f^S(x, a)$ be the number of working single females of type (x, a), and similarly let $\psi_m^S(z, a)$ be the number of single working males of type (z, a). 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

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

and

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

Finally, note that given $\psi_f^S(x, a)$ and $\psi_m^S(z, a)$, the probability that a random type-x single female worker has assets a, and a random type-z single male worker has assets a are given by

$$\varphi_f(a|x) = \frac{\psi_f^S(x, a)}{\phi(x)}, \tag{3}$$

and

$$\varphi_m(a|z) = \frac{\psi_m^S(z, z)}{\omega(z)}. \tag{4}$$

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

2.1 The Problem of a Single Household

We are now ready to define the problem of single and married households. 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

$$V_m^{S,r}(a) = \max_{a'}\{U_m^s(c,0) + (1-\delta)\beta V_m^{S,r}(a')\}, \tag{5}$$

subject to

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

The value of being a single retired female of type a, $V_f^{S,r}(a)$, is defined in a similar way.

Consider now the problem of a single male worker of type (z, a). A single male worker decides how much to work, l_m^S, and how much to save for the future, a'. If he remains a worker, which happens with probability $1-\rho$, he can become married or remain single next period. Let $V_m^M(x, z, a, q)$ denote the expected lifetime utility of being married for a male worker, which will be defined below. Then, the problem of a single male worker is given by

$$\begin{aligned} V_m^S(z,a) = \max_{a',\, l_m^S}\{&U_m^S(c, l_m^S) + \\ &(1-\rho)\beta[\pi_m(z)\sum_{q,\, x}\zeta(q|x,z)P_m(x|z)\int_A V_m^M(x,z,a'+a,q)\varphi_f(a|x)da \\ &+ (1-\pi_m(z))V_m^S(z,a')] + \rho\beta V_m^{S,r}(a')\}, \end{aligned} \tag{6}$$

subject to

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

and

$$l_m^S \in [0,1],\ a' \geq 0.$$

A single worker of type-(z, a) decides how much to work and how to save. If he does not retire at the start of the next period, which happens with probability $1-\rho$, then he gets married with probability $\pi_m(z)$. In that event, agent is matched with a female of type (x, a') with some probability and the newly-married couple draw a value for q from $\zeta(q|x, z)$; forming a type-$(x, z, a + a', q)$ married household. The value of being a single female worker $V_f^S(x, a)$ can be defined in a similar fashion.

2.2 The Problem of a Married Household

Again first consider the problem of a retired couple of type a. Their problem is given by

$$\max_{a'}\{U_m^M(\gamma c, 0, 0, q) + U_f^M(\gamma c, 0, 0, q) + (1-\delta)\beta(V_m^{M,r}(a') + V_f^{M,r}(a')\}, \tag{7}$$

subject to

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

Hence, if $\widehat{a}'$ and $\widehat{c}$ denote the optimal decision in this problem, then

$$V_m^{M,r}(a) = U_m^M(\gamma\widehat{c}, 0, 0, q) + (1-\delta)\beta V_m^{M,r}(\widehat{a}),$$

and

$$V_f^{M,r}(a) = U_f^M(\gamma\widehat{c}, 0, 0, q) + (1-\delta)\beta V_f^{M,r}(\widehat{a}).$$

Consider now the problem of a married working household of type (x, z, a, q). A married working household solves a joint maximization problem given by

$$\begin{aligned}
\max_{a',\, l_f^M,\, l_m^M,\, c} &\{[U_m^M(\gamma c, l_m^M, l_f^M, q) + U_f^M(\gamma c, l_m^M, l_f^M, q)] \\
&+(1-\rho)\beta[\lambda V_m^S(z, a'/2) + (1-\lambda)V_m^M(x, z, a', q) \\
&+(\lambda V_f^S(x, a'/2) + (1-\lambda)V_f^M(x, z, a', q)] \\
&+\rho\beta[V_m^{M,r}(a') + V_f^{M,r}(a')]\},
\end{aligned} \tag{8}$$

subject to

$$\begin{aligned}
c + a' &= a + wzl_m^M + wxl_f^M + ra - \tau_p wzl_m^M - \tau_p wxl_f^M \\
&\quad -T^M(wzl_m^M + wxl_f^M + ra) - \tau_k ra,
\end{aligned}$$

and

$$l_m^M \in [0,1], \quad l_f^M \in [0,1], \; a' \geq 0.$$

Like singles a married couple decides how much to work and how much to save. Unlike singles, however, they might choose zero hours for one of the members. This will happen if q is too high, given their market productivity levels. If they do not retire at the start of the next period, the couple faces an exogenous probability of divorce. If divorce occurs, then the household splits their assets equally and becomes single households next period.

Let $\hat{l}_m^M$, $\hat{l}_f^M$, $\hat{c}$, and $\hat{a}'$ be the optimal decisions associated with problem (8). Then, the lifetime utility of being married, $V_m^M(x,z,a,q)$ and $V_f^M(x,z,a,q)$, are given by

$$\begin{aligned} V_f^M(x,z,a,q) &\equiv U_f^M(\gamma\hat{c},\hat{l}_m^M,\hat{l}_f^M,q) + (1-\rho)\beta[\lambda V_f^S(x,\hat{a}'/2) + (1-\lambda)V_f^M(x,z,\hat{a}',q)] \\ &\quad +\rho\beta V_f^{M,r}(\widehat{a}'), \end{aligned}$$

and

$$\begin{aligned} V_m^M(x,z,a,q) &\equiv U_m^M(\gamma\hat{c},\hat{l}_m^M,\hat{l}_f^M,q) + (1-\rho)\beta[\lambda V_m^S(z,\hat{a}'/2) + (1-\lambda)V_m^M(x,z,\hat{a}',q)] \\ &\quad +\rho\beta V_m^{M,r}(\widehat{a}'). \end{aligned}$$

2.3 Marriage Accounting

In order to solve households' dynamic programming problems, it is necessary to specify exogenous marriage transitions. These exogenous transitions consists of the probabilities that single agents get married, $\pi_m(z)$ and $\pi_f(x)$, the chances that they meet a particular type from the opposite sex if they get married, $P_m(x|z)$, and $P_f(z|x)$, and a probability of divorce for married agents, i.e. λ. We next show that if we assume a *stationary population structure*, then, for a given divorce rate, the exogenous transitions for singles can be constructed in a straightforward way.

A stationary population puts some structure on the relationship between the number of individuals of a given type by gender, $\Phi(x)$ and $\Omega(z)$, the number of marriages of working age by type, $M(x,z)$, and the distribution of singles, $\phi(x)$ and $\omega(z)$. First, given that retired agents' marital status does not change over time, we have

$$M^{r\prime}(x,z) = (1-\delta)M^r(x,z) + \rho M(x,z), \tag{9}$$

which implies the following steady state condition

$$\delta M^r(x,z) = \rho M(x,z). \tag{10}$$

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

$$\delta\phi^r(x) = \rho\phi(x), \tag{11}$$

and

$$\delta\omega^r(z) = \rho\omega(z). \tag{12}$$

Using the steady state restrictions implied by equations (10), (11) and (12), we can rewrite equation (1) as

$$\Phi(x) = \sum_z M(x,z) + \frac{\rho}{\delta}\sum_z M(x,z) + \phi(x) + \frac{\rho}{\delta}\phi(x). \tag{13}$$

This equation restricts how $\Phi(x)$, $M(x,z)$, and $\phi(x)$ are related. Needless to say, there is a similar restriction on $\Omega(z)$, $M(x,z)$, and $\omega(z)$ resulting from the steady state version of equation (2) given by

$$\Omega(z)(x) = \sum_z M(x,z) + \frac{\rho}{\delta}\sum_z M(x,z) + \omega(x) + \frac{\rho}{\delta}\omega(x). \tag{14}$$

These two equations allow us to pin down $\phi(x)$ and $\omega(z)$ given the data on $\Phi(x)$, $\Omega(z)$, and $M(x,z)$. Hence, 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.

We are now ready to construct the exogenous marriage transitions. To this end, first remember that each period married working couples who do not retire divorce with probability λ. Hence, out of $M(x,z)$ marriages between type-x females and type-z males, $(1-\rho)(1-\lambda)M(x,z)$ survives to the next period. There are also new marriages that are formed between type-x females and type-z males. In particular, given our assumptions on the formation and dissolution of households, each period there will be an exogenous fraction $\theta_m(x,z)$ of type-z single males marrying type-x single females, and an exogenous fraction $\theta_f(x,z)$ of type-x single females marrying type-z single males. Then, the following equations characterize the law of motion for the mass of married households

$$M'(x,z) = (1-\rho)(1-\lambda)M(x,z) + \theta_f(x,z)(1-\rho)\phi(x), \tag{15}$$

or

$$M'(x,z) = (1-\rho)(1-\lambda)M(x,z) + \theta_m(x,z)(1-\rho)\omega(z). \tag{16}$$

In a steady state the measure of a given type of married household is constant over time, i.e., $M'(x,z) = M(x,z)$. The steady state versions of these conditions then determine $\theta_m(x,z)$ and $\theta_f(x,z)$ in terms of $M(x,z)$, $\phi(x)$ and $\omega(z)$ as

$$M(x,z) = \frac{\theta_m(x,z)(1-\rho)\omega(z)}{1-(1-\rho)(1-\lambda)}, \tag{17}$$

and

$$M(x,z) = \frac{\theta_f(x,z)(1-\rho)\phi(x)}{1-(1-\rho)(1-\lambda)}. \tag{18}$$

Note that given $M(x,z)$, $\omega(z)$, $\phi(x)$, λ, and ρ, equations (17) and (18) determine $\theta_m(x,z)$ and $\theta_f(x,z)$. Furthermore, $\theta_m(x,z)$ and $\theta_f(x,z)$ are all we need to determine the exogenous transition probabilities for singles. In particular, we can find the probability of marriage for a type x female with a type z male conditional on the event of marriage, $P_f(z|x)$, given by

$$P_f(z|x) = \frac{\theta_f(x,z)\phi(x)}{\sum_z \theta_f(x,z)\phi(x)} = \frac{\theta_f(x,z)}{\sum_z \theta_f(x,z)} \tag{19}$$

Similarly, $P_m(x|z)$ will be

$$P_m(x|z) = \frac{\theta_m(x,z)\omega(z)}{\sum_x \theta_m(x,z)\omega(z)} = \frac{\theta_m(x,z)}{\sum_x \theta_m(x,z)}. \tag{20}$$

The probability of getting married and the probability of remaining single for any type of individual can also be expressed in terms of $\theta_f(x,z)$ and $\theta_m(x,z)$. The probability of marriage for a type x single female, $\pi_f(x)$, is the ratio of the total number of single females of type x who get married to the number of single females of type x. This is given as

$$\pi_f(x) = \frac{\sum_z \theta_f(x,z)\phi(x)}{\phi(x)} = \sum_z \theta_f(x,z). \tag{21}$$

Moreover, the probability of remaining single for a given type of single female is $1-\pi_f(x)$. The corresponding probabilities for a single male are defined in a similar fashion as

$$\pi_m(z) = \frac{\sum_x \theta_m(x,z)\omega(z)}{\omega(z)} = \sum_x \theta_m(x,z). \tag{22}$$

2.3.1 Discussion

It is important to point out that we take the rates at which individuals transit from singlehood to marriage, $\theta_i(x,z)$, $i=f,m$, as *exogenous*. This is the simplifying assumption we make in relation to how households are formed. This allows us to write the law of motion for the stock of married people $M(x,z)$ in a simple way, as shown in equations (15) and (16).

The stationary environment we consider further allows us to tightly map the model to demographic data, since there is a trivial mapping between the flows into marriage and the number of married households by type, given the exogenous transition rates ρ and λ, as shown by equations (17) and (18). Therefore, we can nicely calibrate the model by *reverse-engineering*: we observe who is married-with-whom by type and recover the rates at which individuals transit into marriage in a stationary environment.

More specifically, we observe the number of individuals of a given type by gender, $\Phi(x)$ and $\Omega(z)$, as well as the number of marriages of working age by type, $M(x, z)$. We subsequently calculate the number of single individuals using the basic accounting identities in Equations (13) and (14). Using the resulting number of single workers, $\phi(x)$ and $\omega(z)$, and the life-cycle transition probabilities, ρ and δ, we then back out the rates $\theta_i(x, z)$, $i = f, m$ using Equations (17) and (18). Once we construct $\theta_i(x, z)$, we have enough structure to pin down the exogenous probabilities of household formation.

2.4 Production

There is a single firm in the economy that operates a constant returns to scale technology. This firm rents capital and labor services from households. Using aggregate capital, K, and aggregate labor, L, the firm produces $F(K, L)$ units of consumption good. We assume that the capital depreciates at rate δ_k.

3 Parameter Values

We now proceed to assign parameter values to the endowment, preferences and technology parameters of our benchmark economy. 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 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.

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.[2] 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, and also reports the observed gender gap in hourly wage rates for each educational group. Wage rates for each type and gender are normalized by the overall mean hourly wages in the sample.

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 equals the observed distribution of agents prior to retirement. We consider all household heads or spouses who are between ages 25 and 64 and for each gender calculate the fraction of people 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. Finally, given the fractions of individuals, $\Phi(x)$ 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. This table also shows $\omega(z)$ and $\phi(x)$ that we construct from 2000 data. The mismatch between implied and actual values of $\omega(z)$ and $\phi(x)$ are really small, suggesting that stationary population structure is not an unrealistic assumption.

We set the divorce probability in order to match the divorce rates for married individuals for this age group. We estimate this probability as the divorce rate for married households aged between 25 and 64. Using data from the National Center for Health Statistics, we calculate that this rate was 2.1% in the 2000. Thus, we set $\lambda = 0.021$.

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

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

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.[3]

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 Data by income brackets.[4] 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 find the average tax rates as

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

We follow Gouveia and Strauss (1994) and estimate the effective tax functions both for married and single households. In particular, we fit the following equation to the data,

$$average\ tax\ (income) = \gamma_1 + \gamma_2 \log(income) + \varepsilon,$$

where *average tax* (*income*) is the average tax rate that applies when income equals *income*. We normalize mean income with mean household income in 2000 to find *income*. 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

$$\begin{aligned} T^M(income) &= [0.1023 + 0.0733 \log(income)]income \\ T^S(income) &= [0.1547 + 0.0497 \log(income)]income. \end{aligned}$$

Figures 1 and 2 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 equal to 15.3% and a marginal tax rate equal to about 26.0%. The corresponding rates for a married household with the same income are about 18.7% and 23.6%.

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

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

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

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 $\tau_k = 0.161$.

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.[5]

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 We assume that individuals value current consumption and leisure streams according to

$$U_i^S(c,l) = \frac{\left[c^{\mu_i}(1-l)^{1-\mu_i}\right]^{1-\sigma} - 1}{1-\sigma}.$$

for $i = f, m$. We set σ equal to 4.[6] Given σ, we select the gender-specific parameters μ to reproduce average market hours per worker by males and females observed in the data. These average hours amounted to 36.2% of the available time for females and 45.1% for males in 2000.[7]

We assume that the utility cost parameter q is exponentially distributed with mean $1/\bar{q}(x,z)$. We choose $\bar{q}(x,z)$ so that the labor force participation of secondary earners in the benchmark economy is consistent with data. Both in the data and in the model, we label an individual as a secondary earner if his/her hourly wage is less than his/her partner. Using

[5] 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.

[6] The value of this parameter is critical as it governs the elasticity of intertemporal substitution in consumption and leisure.

[7] The numbers are for people between ages 25 and 55 and are based on CPS. We find mean yearly hours worked by 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.

CPS, we calculate that the employment-population ratio of secondary earners is 73.75% for married individuals between ages 25 and 55.[8] Table 5 shows the distribution of secondary earner's labor force participation by productivities of husbands and wives for married households. Our strategy is select 25 values of $\bar{q}(x, z)$ to match 25 entries in Table 5 as closely as possible. Table 6 shows the labor force participation of secondary earners in the model economy.

We select the level of economies of scale in married households (γ) based on available estimates. Following Cutler and Katz (1992), we set $1/\gamma = 1.4142$ as an intermediate estimate in the existing literature. This value implies a two person household needs only 41% more resources than a single person household to enjoy the same per capita consumption.[9] This is slightly less than the recent estimates by Hong and Rios-Rull (2004) who find that the second adult costs only 32% of the first one.

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 7 summarizes our parameter choices. Table 8 shows the performance of the model in terms of the targets we impose for μ_f, μ_m, and β, and the aggregate participation rate of secondary earners. The model has no problem in reproducing jointly these observations as the table demonstrates.

4 Tax Reforms

We now consider three hypothetical revenue-neutral reforms to the current U.S. tax structure: a proportional consumption tax reform, a proportional income tax reform and a progressive consumption tax reform. For each reform we study two cases. A *complete* reform replaces both federal income taxes and the additional proportional tax on capital income. A *partial* reform, on the other hand, only replaces federal income taxes and keeps the additional proportional capital income tax intact. These partial experiments are relevant since elimination

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

[9] Usually equivalence scales are measured in following way. Consider a family with p adults and k children. Let C be total spending on consumption, then per capita consumption is given by $c = C/E(p.k)$ with $E(p, k)$ representing the family size in adult equivalence. A standard functional form is $E(p, k) = (p + ck)^e$. An intermediate value in the literature for e, according to Cutler and Katz (1992), is 0.5, corresponding to $1/\gamma = 1.4142$ in our formulation.

of additional tax on capital, which is meant to capture corporate income taxes, might not easily be a part of a reform that aims to change the current structure of income taxation. Furthermore, this experiment highlights the separate role that this tax play on capital accumulation. In all reforms we keep the social security system unchanged. The results reported below based on steady state comparisons of pre and post reform economies.

A Proportional Consumption Tax The first reform replaces current income taxes (partially or fully) with a proportional consumption tax. We select this new tax rate so that tax collections are the same in the new steady state as in the in pre-reform economy. Table 9 reports the results from this reform. The effects of this reform are quite dramatic. With a partial reform, aggregate output increases by about 15%. As a result, a flat consumption tax of 18.9% is all that is needed to generate revenue neutrality. The rise in total output is fueled by significant rises in factor inputs, with the capital-to-output ratio increasing by about 15% in the post-reform steady state. There is also a large effect on labor supply, both at the extensive and the intensive margins. The tax structure in the benchmark economy generates significant disincentives to work since marginal tax rates increase with incomes, and secondary earners who decide to enter the labor force are taxed at their partner's current marginal tax rate. With the elimination of these disincentives, labor force participation of secondary earners increase by nearly 9%. At the same time hours per worker also rise by about 6%, both for males and for females. Movements in both margins generate together an 8% increase in total hours. The effect on females turns out to be more significant than that on males. Since bulk of secondary earners are women, the total hours for married females increase by more than 12%.

The aggregate effects of a complete reform are more pronounced since the elimination of additional 16.1% flat tax on capital provides additional incentives for capital accumulation. Aggregate output now increases by 17.5% and capital-to-output ratio by more than 20%. Despite the rising incomes the labor supply effects of the complete reform are slightly larger than the partial one. This is partly due to larger increase in wages that comes with capital accumulation. While the wage rate increases by 6.8% with the partial reform, it increases by almost 9.5% with the complete reform.

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.

Results from this reform are reported in Table 10. Unlike the case with a proportional consumption tax, the effects on capital accumulation are now less significant. This is expected: an income tax, differently from a consumption tax, still affects capital accumulation decisions. Consequently, the capital-to-output ratio increases by just 3.6% with the partial reform and by 11.3% with the complete reform. This results in a lower increase in aggregate output since effects on labor supply, at least for partial reforms, are quite comparable to results from a proportional consumption tax.

A Progressive Consumption Tax The final reform introduces a progressive consumption tax. The progressive consumption tax consists of an exemption level below which agents do not pay taxes and a proportional tax rate applied above this level. We set the exemption level as 1/3 of aggregate consumption in our benchmark economy for singe households, and 1/2 of aggregate consumption in our benchmark economy for married ones. The results from a partial reform are reported in Table 11. Now a partial reform requires a marginal tax rate of 28.2%, versus 18.9% with the proportional consumption tax.

A comparison between proportional and progressive consumption tax reforms (Tables 9 and 11) is quite revealing. The effects on the capital stock are comparable under both reforms. This should not be surprising since most of capital is owned by households who are above the exemption levels and they are affected in a similar way in both reforms; both reforms eliminate the effects of income taxes on their decisions on asset accumulation. The effect on aggregate output, however, is smaller. This is due to smaller rise in labor input.

Why does labor force participation of secondary earners increase less with a progressive consumption-tax reform? The key for this finding is the structure of taxes we introduce, which combines an exemption level *and* a common marginal tax rate above it. The interplay of these two features discourages changes in labor force participation in married households with less skilled members. It turns out that these households were the ones that respond the most under proportional tax reforms.

The Role of Married Females Although the aggregate effects on labor supply is now 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. Table 12 makes this point clear. In this table we report the contribution of married female hours to changes in total hours. In each reform, except with progressive consumption tax, the contribution of married females is around 40-45%. However, the contribution of married females is much higher under the progressive consumption tax, about 75.2%. These results suggest that effects of tax reforms can depend critically on *who* increases labor supply. These results also suggest that the wage structure (gender gap and skill premia), the skill distribution as well as marital sorting (who is married with whom) play important roles, since they affect households' labor supply along both intensive and extensive margins.

5 The Role of New Features: Tax Reforms in Different Economies

In this section, we conduct a simple but illuminating exercise. We focus on one partial reform, a progressive consumption tax, and analyze how (i) labor force participation of secondary earners, (ii) wage structure, and (iii) skill and marital distribution of agents in pre-reform economy affect reform outcomes. This allows us to isolate the contribution of different aspects of the environment on the effects of tax reforms. To accomplish this, we recalibrate our model using past data. As a result, the exercises shed light on the differential effects of potential tax reforms in the U.S. in the past. Perhaps more interestingly, they also shed light on the effects of tax reforms for economies that are different from today's U.S. economy but look more like (in terms of labor force participation of secondary earners, wage structure and marital sorting) the U.S. in the past.

We proceed as follows. We unbundle our 2000 benchmark economy piece-by-piece so that it looks more and more like the U.S. economy in 1960. We first set labor force participation of secondary earners to their 1960 values. We keep all other exogenous variables (e.g. taxes, distribution of agents across skill types etc.) intact, and recalibrate the benchmark economy to match labor force participation of secondary earners in 1960. We label this *Case I.* Second, we change both the labor force participation of secondary earners and wages to their 1960 values and recalibrate our economy again. This is *Case II.* Finally, on top of previous changes we introduce the productivity distribution and the structure of marital sorting from 1960 and then recalibrate our benchmark economy. This is *Case III*, the 1960 economy. For each of these three cases, we reform the tax system and replace existing income taxes with a progressive consumption tax.

How different was the 1960 economy? Table 13 shows the labor force participation of secondary earners in 1960. As expected, they are much lower than 2000 values. The average labor force participation of secondary earners is 43.4% while it was 74.75% in 2000. Table 14 shows productivity levels in 1960. In 1960 wages were much more compressed across education categories. The gender gap was also higher (except the highest skill level which is most probably due to small sample size we have). Finally, Table 15 shows the distribution of married agents across skill types. There were much more low skilled agents in 1960. Indeed, almost 70% of all households were composed of partners who either had less than high school education or only a high school degree.

Table 16 shows the effects of a progressive consumption tax reform for these three cases and compares its effects with those on 2000 benchmark. With only 1960 labor force participation, the effects of the reform are quite larger than they were for 2000 economy. Output now grows by 12% (instead of 8,3%), mainly fuelled by larger increases in labor force participation and aggregate hours. Intuitively, the effects on married females' labor supply is now much larger since there is much more room to increase labor force participation for all skill types in 1960 economy.

Once we introduce 1960 wages, however, the effects become much smaller. With 1960 wages, wage distribution is much more concentrated. Therefore, there are only few agents benefiting from reductions in high marginal tax rates. Furthermore, the gender gap is much larger across the board, and this reduces the incentives for females to enter the labor force. Both low skill premium and high gender gap lowers the labor supply incentives generated by this reform. The effects are once again more significant when we adjust the skill and marital distributions. Once we move to skill and marital distributions to 1960, Case III, two things are worth mentioning.[10] First, there is much more married people, 89.3% in 1960 vs. 74% in 2000. Second, the population is much less skilled. Both forces contribute to

[10] Note that given our procedure to calculate marriage formation rates, when we change the underlying skill distribution and marital sorting, i.e. when we change $\Omega(z)$, $\Phi(x)$, and $M(x, z)$, the economy is characterized by new matching rates.

get a larger effect on labor supply. With a larger married population, married female labor force participation decisions now play a greater role for the aggregates. Second, since the population is less skilled, it is concentrated in skill groups that have substantial more room to increase their labor supply (see Table 13). Overall, our results indicate that replacing current taxes by a progressive consumption tax in a 1960 economy leads to larger effects on labor force participation and labor supply of married females (relative to the 2000 economy). However, the resulting changes in output are of smaller magnitude.

6 Conclusions

In this paper we study aggregate and cross-sectional effects fundamental tax reforms for the US economy. In contrast to the existing literature, our model economy consists of one and two-earner households, and two-earner households face explicit labor force participation decisions. Our preliminary findings indicate that tax changes can lead to large effects across steady states on aggregate variables, and that the labor supply behavior of two-earner households is key. Furthermore, structure of pre-reform economy play a critical role. Economies that differ in terms of labor force participation of secondary earners, wages, and marital composition react quite differently to the reforms we consider.

6.1 Appendix: Definition of Equilibrium

For a given government consumption level G, social security tax benefits b^M, b_f^S and b_m^S, 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 $\Omega(z)$, $\Phi(x)$, $M(x,z)$ and implied matching rates $\theta_f(x,z)$, $\theta_m(x,z)$, a *stationary equilibrium* consists of factor prices r and w, aggregate capital (K) and labor (L) inputs, decision rules for labor supply and asset holdings of married and single households $l_f^M(x,z,a,q)$, $l_m^M(x,z,a,q)$, $l_m^S(z,a)$, $l_f^S(x,a)$, $a^M(x,z,a,q)$, $a_m^S(z,a)$, $a_f^S(x,a)$, $a^{M,r}(a)$, $a_m^{S,r}(a)$, and $a_f^{S,r}(a)$ and measures $\psi^M(x,z,a,q)$, $\psi_f^S(x,a)$, $\psi_m^S(x,a)$, $\psi^{M,r}(a)$, $\psi_f^{S,r}(a)$ and $\psi_m^{S,r}(a)$ such that

1. Given tax rules, the demographic structure, and factor prices w and r, the decision rules of households solve the corresponding dynamic problems.

2. Factor prices are determined by the profit maximization problem of the representative firm; i.e.,

$$w = F_2(K,L),$$

and

$$r = F_1(K,L) - \delta_k.$$

3. Factor markets clear; i.e.,

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

and

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

4. The measures $\psi^M(x,z,a,q)$, $\psi_f^S(x,a)$, $\psi_m^S(x,a)$, $\psi^{M,r}(a)$, $\psi_f^{S,r}(a)$ and $\psi_m^{S,r}(a)$ are consistent with individual decisions.

   <u>Married working agents:</u> for any $a' \in A$

$$
\begin{aligned}
\psi^M(x,z,a',q) &= (1-\rho)(1-\lambda)\int_{\mathcal{A}} \psi^M(x,z,a,q)da \\
&\quad +(1-\rho)\zeta(q|x,z)\int_{\mathcal{B}} \theta_m(x,z)\varphi_f(a_2|x)\psi_m^S(a_1,z)da_2da_1,
\end{aligned}
$$

   where $\mathcal{A} = \{a : a^M(x,z,a,q) = a'\}$, and $\mathcal{B} = \{a_1, a_2 : a_m^S(z,a_1) + a_f^S(x,a_2) = a'\}$

   <u>Single working agents:</u> if $a' \neq 0$,

$$
\psi_f^S(x,a') = (1-\rho)\lambda \sum_{q,\,z} \int_{\mathcal{C}} \psi^M(x,z,a,q)da + (1-\rho)(1-\pi_f(x))\int_{\mathcal{D}} \psi_f^S(x,a)da,
$$

   and

$$
\psi_m^S(z,a') = (1-\rho)\lambda \sum_{q,\,x} \int_{\mathcal{C}} \psi^M(x,z,a,q)da + (1-\rho)(1-\pi_m(z))\int_{\mathcal{E}} \psi_m^S(z,a)da,
$$

   <u>Single working agents:</u> if $a' = 0$,

$$
\begin{aligned}
\psi_f^S(x,0) &= (1-\rho)\lambda \sum_{q,\,z} \int_{\mathcal{C}} \psi^M(x,z,a,q)da \\
&\quad +(1-\rho)(1-\pi_f(x))\int_{\mathcal{D}} \psi_f^S(x,a)da + \delta(\phi^r(x) + M^r(x,z))
\end{aligned}
$$

   and

$$\begin{aligned}\psi_m^S(z,0) &= (1-\rho)\lambda\sum_{q,\,x}\int_{\mathcal{C}}\psi^M(x,z,a,q)da \\ &+(1-\rho)(1-\pi_m(z))\int_{\mathcal{E}}\psi_m^S(z,a)da+\delta(\omega^r(z)+M^r(x,z)),\end{aligned}$$

where $\mathcal{C}=\{a:a'=\frac{g^M(x,z,a,q)}{2}\}$, $\mathcal{D}=\{a:a'=a_f^S(x,a)\}$ and $\mathcal{E}=\{a:a'=a_m^S(z,a)\}$.

Married retired agents: for any $a'\in A$

$$\psi^{M,r}(a')=(1-\delta)\int_{\mathcal{F}}\psi^{M,r}(a)da+\rho\sum_{x,z,q}\int_{\mathcal{A}}\psi^M(x,z,a,q)da,$$

where $\mathcal{F}=\{a:a^{M,r}(a)=a'\}$ and $\mathcal{A}=\{a:a^M(x,z,a,q)=a'\}$.

Single retired agents:

$$\psi_f^{S,r}(a')=(1-\delta)\int_{\mathcal{G}}\psi_f^{S,r}(a)da+\rho\sum_{x}\int_{\mathcal{D}}\psi_f^S(x,a)da,$$

and

$$\psi_m^{S,r}(a')=(1-\delta)\int_{\mathcal{I}}\psi_m^{S,r}(a)da+\rho\sum_{z}\int_{\mathcal{E}}\psi_m^S(z,a)da,$$

where $\mathcal{G}=\{a:a_f^{S,r}(a)=a'\}$, $\mathcal{I}=\{a:a_m^{S,r}(a)=a'\}$, $\mathcal{D}=\{a:a'=a_f^S(x,a)\}$ and $\mathcal{E}=\{a:a'=a_m^S(z,a)\}$.

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

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

$$\begin{aligned}\int_A b^M\psi^{M,r}(a)da &+ \int_A b_f^S\psi_f^{S,r}(a)da+\int_A b_m^S\psi_m^{S,r}(a)da \\ &= \tau_p(wL)\end{aligned}$$

Remarks A few comments are in order regarding the definition of equilibria. Note that the law of motion for the measure of married working agents, $\psi^M(.)$ reflects the fact that upon forming a married household, individuals combine their assets. In similar fashion, the laws of motion for the measures of single working individuals, $\psi_i^S(.)$, $i = m, f$, reflect the assumption made previously that upon dissolving a married household, assets are divided equally between spouses. Finally, in the case of singles, note that when next period assets are zero, we include the terms $\delta(\phi^r(x) + M^r(x,z))$ and $\delta(\omega^r(z) + M^r(x,z))$. These terms amount to the number of retired males and females who die per period. Thus, the addition reflects the assumption that when single or married retired individuals die, they are replaced by identical *single* agents with zero assets.

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

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

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

Table 4: Tax Parameters Estimates

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

Table 5: Labor Force Participation of Secondary Earners, Data, %

	Female					
Male	<hs	hs	sc	col	>col	Total
<hs	51.82	65.17	70.08	82.46	71.43	59.14
hs	55.61	73.55	79.78	87.61	89.17	75.18
sc	53.53	72.09	77.35	85.03	86.41	76.59
col	57.69	67.67	69.07	78.63	85.81	75.19
>col	60.00	68.12	73.35	72.22	81.07	75.30
Total	53.29	71.60	75.78	79.78	83.83	73.75

Table 6: Labor Force Participation of Secondary Earners, Model, %

	Female					
Male	<hs	hs	sc	col	>col	Total
<hs	49.57	66.34	67.44	80.36	69.36	58.82
hs	55.29	74.50	82.59	86.29	86.37	75.54
sc	51.73	70.56	77.01	87.23	85.70	75.78
col	56.31	69.92	70.20	77.52	85.01	74.90
>col	62.00	68.52	71.15	72.80	81.03	74.83
Total	51.75	71.68%	75.86	79.59	83.10	73.07

Table 7: Parameter Values

Intertemporal Elasticity of Substitution ($1/\sigma$)	0.25
Discount Factor (β)	0.981
Male Consumption Share (μ_m)	0.485
Female Consumption Share (μ_f)	0.395
Household Economies of Scale ($1/\gamma$)	1.4142
Capital Share (α)	0.317
Depreciation Rate (δ_k)	0.07
Probability of Retirement	1/40
Mortality rate (δ)	0.0982
Divorce Rate (λ)	0.021
Payroll Tax Rate (τ_p)	0.086
Capital Income Tax Rate (τ_k)	0.161

Table 8: Model and Data

Statistic	Data	Model
Capital Output Ratio	2.325	2.339
Labor Hours Per-Worker (males)	0.451	0.453
Labor Hours Per-Worker (females)	0.362	0.357
Participation rate of Secondary Earners (%)	73.75	73.07

Table 9: Proportional Consumption Tax (% change)

	Partial Reform	Complete Reform
Participation of Secondary Earner	8.95	9.28
Total Hours	8.08	8.29
Total Hours (Married Females)	12.42	13.12
Hours per worker (female)	5.88	6.16
Hours per worker (male)	5.52	5.74
Capital/Output	15.48	20.82
Aggregate output	14.88	17.47
Wage rate	6.82	9.45
Flat tax rate (%)	18.9	22.9

NOTE: The results for a "complete reform" pertain to the revenue-neutral replacement of both income and capital income taxes by a proportional consumption tax. The results for a "partial reform" pertain to the revenue-neutral replacement of only the income tax system by a proportional consumption tax.

Table 10: Proportional Income Tax (% change)

	Partial Reform	Complete Reform
Participation of Secondary Earner	7.62	4.61
Total Hours	7.77	5.95
Total Hours (Married Females)	12.80	8.84
Hours per worker (female)	6.16	5.32
Hours per worker (male)	5.30	5.32
Capital/Output	3.63	11.33
Aggregate output	8.85	10.85
Wage rate	1.68	5.34
Flat tax rate (%)	12.1	14.9

NOTE: The results for a "complete reform" pertain to the revenue-neutral replacement of both income and capital income taxes by a proportional income tax. The results for a "partial reform" pertain to the revenue-neutral replacement of only the income tax system by a proportional income tax.

Table 11: Progressive Consumption Tax (% change)

	Partial Reform
Participation of Secondary Earner	3.09
Total Hours	1.75
Total Hours (Married Females)	4.70
Hours per worker (female)	0.00
Hours per worker (male)	1.55
Capital/Output	13.64
Aggregate output	8.32
Wage rate	6.40
Flat tax rate (%)	28.2

NOTE: The results for a "partial reform" pertain to the revenue-neutral replacement of only 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 exemption levels correspond to 1/3 aggregate consumption for single individuals, and 1/2 mean consumption for married households.

Table 12: Contribution of Married Female Hours to Changes in Total Hours (%)

	Flat Cons. (Complete)	Flat Cons. (Partial)	Flat Inc. (Complete)	Flat Inc. (Partial)	Prog. Cons. (Partial)
Δ in Mar. Fem. Hours (relative to Δ in Tot. Hours)	44.4	43.1	41.6	46.2	75.2

Table 13: Labor Force Participation of Secondary Earners in 1960, Data, (%)

	Female					
Male	<hs	hs	sc	col	>col	Total
<hs	40.15	46.23	55.50	74.51	82.35	42.58
hs	40.21	44.09	53.46	61.43	72.73	44.63
sc	39.66	43.04	46.67	49.41	60.00	44.10
col	25.00	29.92	32.12	45.78	77.42	35.72
>col	35.00	31.54	42.61	50.00	68.09	44.70
Total	39.97	43.18	46.60	52.47	70.65	43.39

Table 14: Productivity Levels, by Type, by Gender in 1960

	Males (z)	Females (x)	x/z
<hs	0.990	0.582	0.587
hs	1.120	0.743	0.663
sc	1.235	0.811	0.657
col	1.551	0.969	0.624
>col	1.489	1.418	0.953

Table 15: Distribution of Married Working Households by Type in 1960, (%)

	Female				
Male	<hs	hs	sc	col	>col
<hs	40.34	12.82	2.2.6	0.49	0.15
hs	6.97	13.46	2.40	0.67	0.18
sc	1.85	4.27	2.35	0.70	0.19
col	0.51	2.18	1.61	1.42	0.23
>col	0.3	1.31	1.40	1.26	0.70

Table 16: Progressive Consumption Tax Reform in Different Economies (% change)

	2000. Economy	Case I.	Case II	Case III
Aggregate Output	8.3	11.7	6.5	7.4
Participation of Secondary Earner	3.1	5.6	1.7	7.3
Aggregate Hours	1.8	4.2	3.3	4.7
Aggregate Hours (Married Females)	4.7	8.1	5.2	10.7

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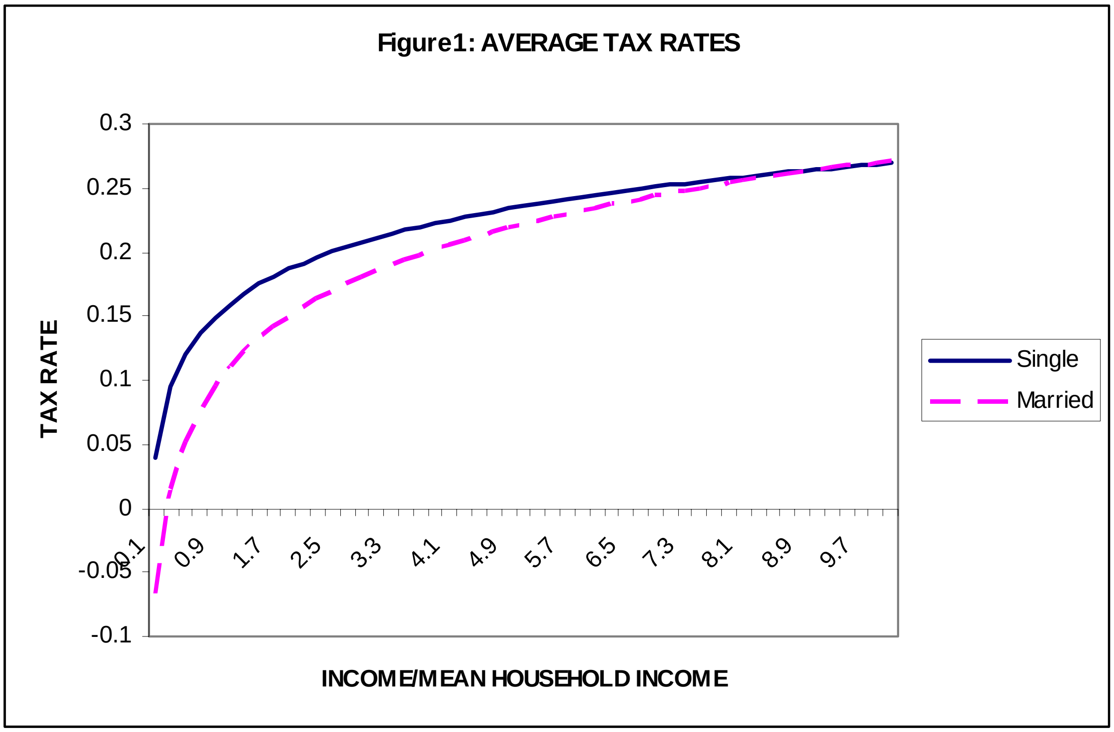
Figure1: AVERAGE TAX RATES
TAX RATE
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0.1
0.9
1.7
2.5
3.3
4.1
4.9
5.7
6.5
7.3
8.1
8.9
9.7
INCOME/MEAN HOUSEHOLD INCOME
Single
Married

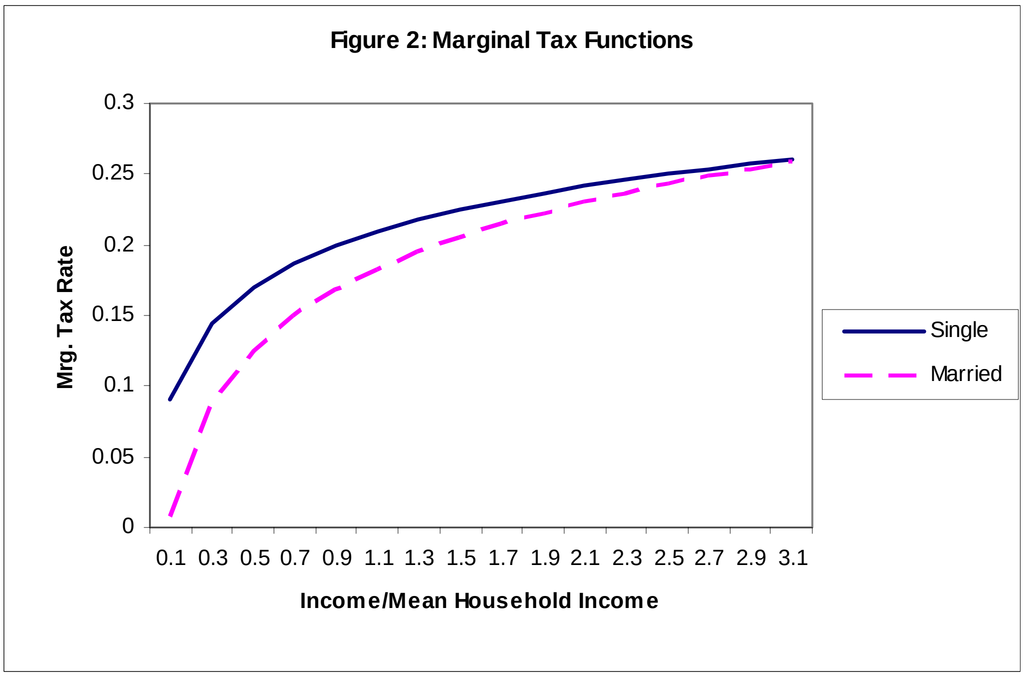
Figure 2: Marginal Tax Functions
Mrg. Tax Rate
0
0.05
0.1
0.15
0.2
0.25
0.3
0.1 0.3 0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9 3.1
Income/Mean Household Income
Single
Married