Taxation and Household Decisions: an Intertemporal Analysis*

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February 2021

Abstract

How do different income taxation systems – for instance individual vs. joint – affect people's decisions and welfare? We provide an answer to this question in three steps. We document that taxing married households jointly, as in the U.S., generates substantial disincentives for secondary earners to supply labor, and that secondary earners respond to these disincentives. Next, we develop a lifecycle model in which single and married individuals make decisions about labor supply, household production, human capital accumulation, consumption, savings, marriage, and divorce. We estimate the model using variation from past tax reforms in the U.S., as well as auxiliary time use and expenditure data. Lastly, we use the model to evaluate the effect of three sets of tax and transfer policies on individual decisions and welfare. We first analyze policies that reduce tax rates on secondary earner's income. We then study alternative systems for determining eligibility of married households for means-tested programs. Finally, we evaluate the interaction between income taxation and government programs designed to increase female labor supply, such as child care subsidies. We find that both individual taxation and secondary earner deductions are on average welfare-improving, with substantial effects on female labor supply, human capital accumulation, intra-household specialization, and marital sorting based on earnings potential. When studying eligibility for means-tested programs, we find that secondary earner deductions generate overall welfare improvements, and are preferred over individual treatment of income for program eligibility. Lastly, we find that childcare subsidies are about 30% more effective in increasing female labor supply under an individual tax system, indicating that there is substantial scope for improving tax and transfer efficiency in countries that have implemented policies targeting female labor supply.

*We are grateful to participants at various seminars and conferences for helpful comments.
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1 Introduction

Income taxation differs significantly across countries, most prominently for individuals in married households. For example, countries with individual tax systems, like Canada and Sweden, consider neither spousal earnings nor marital status when determining an individual's tax schedule. By contrast, joint tax systems, like those in the U.S. and Germany, consider only pooled earnings of the couple when determining married individuals' tax rates and tax liability. Finally, a number of countries, like France and the U.K., have hybrid systems that borrow elements from both joint and individual schemes.

The choice of a tax system affects primary and secondary earners' respective tax schedules, their contribution to after-tax household income, and correspondingly their incentives to work and save. Thus, it can produce potentially sizable short- and long-run effects on individual decisions, economic outcomes, and welfare (Bick and Fuchs-Schündeln (2017)). The objective of this paper is to estimate these effects, with emphasis on long-run consequences. The paper is divided into three parts. First, we provide evidence about households' labor supply responses to the disincentives embedded in joint tax systems. Second, we develop and estimate a dynamic model of individual decisions that accounts for the fact that most households are composed of a primary and a secondary earner that make joint decisions. Lastly, we evaluate the performance of different taxation schemes using the estimated model.

The first part of the paper provides evidence about four main facts. First, secondary earners face higher marginal and average tax rates under a joint tax system than under an individual one. The opposite is true for primary earners. Second, in the U.S., a married woman's average tax rate, as predicted by the earnings of her husband, is strongly correlated with her probability of employment. In Canada, however, which has an individual tax system, married women's employment varies little with husband's income. Third, under a joint tax system, married single-earner households enjoy larger take-home incomes than under the individual system, whereas the opposite is true for married couples with relatively equal earnings. These three facts suggests that joint taxation creates incentives for married couples to have one spouse specialize in labor market activities and one in household activities. Lastly, we document that changes in tax rates generated by past U.S. tax reforms produce significant changes in labor force participation for one group of individuals: married women. We estimate that a 10 percentage-point decline in married women's average tax rate, as predicted based on her husband's earnings, is associated with percentage point increases in their labor force participation that are between 1.75 and 3 in the short run. The response is about twice as large for married women with young children.

In the second part, we use the evidence above to develop and estimate a dynamic model of household decisions. The facts indicate that, to credibly evaluate a tax reform, one should properly model primary and secondary earners, their interactions, and the possible selection in the way they match. Our evidence also makes clear that reduced-form methods are useful to document short-run effects of tax reforms. Assessing their long-run consequences requires a model that accounts for the dynamic aspects of tax reforms. To that end, we develop an intertemporal model with the following features. Individuals can be either single or married, where the marriage decision is endogenous. If married, two individuals make joint and efficient decisions, with the limitation that they cannot commit to future allocations of resources. Whether married or single, individuals choose labor supply on the extensive and intensive margins, consumption, savings, and the time and money they invest in the production of a home-produced good. The efficiency of decisions jointly with the existence of the home-produced good allows us to generate intra-household specialization, which is an important feature of the data. Changes in taxation systems have the potential to produce changes in number of marriages, selection into marriage, intra-household specialization, and number of divorces. We consider a model without commitment, because it allows for all types of divorces observed in the data – mutual consent and no fault – and for general changes in the degree of specialization. Individuals in the model accumulate human capital, and human capital depreciates when they do not work, allowing us to capture the long-run effects of changes in the tax system on individual decisions and outcomes. Since the model is estimated using U.S. data, we model in detail the U.S. taxation system by coding the year-on-year changes in tax brackets due to the tax code, to minor tax reforms, and to the three major tax reforms discussed above. Lastly, to account for the fact that the performance of a taxation system depends on the existing welfare system, we model in detail the main components of the U.S. safety net: Social Security Income (SSI) taxes and Medicare taxes, the EITC, the Child Tax Credit (CTC), the Child and Dependent Care Credit

(CDCC), and the Supplemental Nutrition Assistance Program (SNAP).

The model is estimated using as the main source of the variation three important tax reforms that took place in the U.S.: the 1986 Reagan tax reform, the 1993 Earned Income Tax Credit (EITC) expansion, and the 2003 Bush tax cut. Using the estimated model, we evaluate three of the most debated tax reforms: a shift from a joint to an individual taxation system; the introduction of a secondary earner deduction in a joint taxation system; and the addition of child care subsidies to a joint and to an individual taxation system. Our results indicate that the transition from a joint to an individual taxation system has significant effects on choices and welfare, with married households in which only one spouse works being the most affected. We find that the labor force participation of secondary earners increase by as much as 5 percentage points and that the households that are impacted the most are the ones with high marginal tax rates for secondary earners under joint taxation. The move to individual taxation changes also how secondary earners allocate time between market and household activities. We find that they reduce the time they devote to household production and increase the hours spent in the labor market, with the increase in labor hours that is smaller than the decline in household time. The corresponding increase in leisure for secondary earners is explained by a shift in decision power toward women of three percentage points generated by the tax reform. Lastly, using a welfare function that assigns equal weights to each household, we find that the shift to individual taxation produces welfare gains in the aggregate.

Some economists have proposed the introduction of a secondary earner deduction in place of a full transition to an individual taxation system, arguing that a shift to individual taxation is politically infeasible in most countries. Our results indicate that this alternative policy is a good substitute for the more drastic change to individual taxation, as the two policies have similar effects on choices and welfare. Analogously to the first policy we evaluate, the introduction of a $\$20,000$ secondary-earner deduction generates increases in the labor force participation of secondary earners that can be as large as 5 percentage points, produces a shift in the allocation of time from household production to market activities, and increases the overall welfare in the economy.

The last policy we simulate, child care subsidies under the joint and individual taxation systems, has also substantive effects on working decisions. The policy increases the fraction of secondary earners who work and their labor supply at the expenses of time devoted to household production under both the joint and individual taxation system. But the impact is larger under the individual system. For instance, the increase in labor force participation generated by this policy is between 1 and 2 percentage points larger under individual taxation.

Several papers have considered the effect of taxes on household decisions. Apps and Rees (1999b) show theoretically that, in a static collective model of the household, a joint taxation system can never be welfare improving over an individual taxation system, even when household production is taken into account. In as separate paper, Apps and Rees (1999a) argue theoretically, using a static collective model of the household, that tax reforms should be evaluated using a model of the households with multiple members. Guner, Kaygusuz, and Ventura (2012) develop a dynamic equilibrium model in which men and women make labor supply decisions and use it to evaluate the effect of a change from joint to individual taxation on labor force participation and hours of work. Our paper differs in several respect. First, we provide evidence that the individuals affected the most by tax changes are married women with children younger than 6. For this reason, our model account for the presence of children of different ages and for household production. Second, we estimate the model using micro data. This is particularly important because the effect of tax reform depends on the estimated intensive and extensive margin elasticities. Third, we model marriage and divorce decisions, which may play an important role when a country switches from a joint to an individual taxation system. One limitation of our paper relative to Guner, Kaygusuz, and Ventura (2012) is that we do not consider general equilibrium effects, which are captured in their paper. Bick and Fuchs-Schündeln (2017) document that the cross-country correlation of average hours worked of working-age married men and married women is approximately zero. They then develop and simulate a static model of labor supply decisions for married men and women and provide evidence using the simulated data that differences in taxation systems across countries can explain the large differences in the labour supply behaviour of married men and married women across those countries. Gayle and Shephard (2016) develop and estimate a model of marriage and household decisions and use it to find the optimal tax structure for the U.S.. Differently from our model, in Gayle and Shephard (2016) there is no dynamics in household decisions. They can therefore only account for short run effects of changes in the tax structure. Their paper, differently from our, accounts for equilibrium effects in the marriage market. In addition, they provide a formal proof of identification for their model whereas, given the complexity of our model, we can only provide a heuristic discussion of identification. Kleven, Kreiner, and Saez (2009) analyze theoretically the non-linear optimal taxation of couples using a static unitary model in which the primary earner makes only intensive margin labor supply decisions and the secondary earner makes only extensive margin labor supply decisions. Their main result is that the tax rate of secondary earners should decline with the spouse's earnings if their labor force participation is a signal that the couple is better off. Alesina, Ichino, and Karabarbounis (2011) study the gender-based taxation of couples in a static collective model with linear and separable tax rates for the two spouses. Their main insight is that secondary earners should have lower marginal tax rates because they have lower labor supply elasticities. Our finding that individual taxation increases the overall welfare, in a dynamic model with taxation rules that are non-linear and joint for couples, is partially based on the same insight. But we do not have the multidimensional screening problem that characterizes Kleven, Kreiner, and Saez (2009)'s paper. Borella, De Nardi, and Yang (2019) estimate a lifecycle model of labor supply and saving decision of couples and study the effect of the dependence of taxes and social security benefits on marital status on the labor force participation decisions of women. They find that removing the dependence on marital status increases significantly the participation of women, which is consistent with our finding that the design of the taxation system has important effects on the choices of secondary earners.

The paper proceeds as follows. In Section 2, we briefly discuss the data used in the paper. Section 3 provides descriptive evidence of the effect of changes in tax rates on individual labor supply decisions. In Section 4, we document the effects that major tax reforms had on individual decisions. In Section 5, we develop the intertemporal model of the household. Section 6 describes the moments used in the estimation of the model. In Section 7, we report the estimation results, the fit of the model, and we discuss the effects of different taxation policies on household decisions. Section 8 concludes.

2 Data

We use five data sets. We provide descriptive evidence and estimate the response to prior tax cuts using the Panel Studies of Income Dynamic (PSID) (1980-2010), the 2000 Census, and the Current Population Survey (CPS) (2001-2015). These data sets provide information about labor force participation, hours of work, earnings, income, education, and demographic variables for primary and secondary earners. We rely on the PSID and the Current Population Survey (CPS) (1980-2016) for all variables used in the structural estimation, with two exceptions. We use the American Time Use Survey (ATUS) (2000-2011) to compute the time invested in the production of the home-produced good, and the Consumer Expenditure Survey (CEX) (1980-2010) to calculate private consumption and the financial resources invested in the production of the home-produced good.

3 Joint vs Individual Taxation Systems

Existing joint tax systems, such as the one in the US or Germany, are predicted to disincentivize secondary earners' labor supply. As we explain below, the reason for this is that under such systems the married secondary earner typically faces an income tax schedule with significantly higher rates than he or she would as an unmarried individual. However, reliably quantifying how much this feature affects labor supply – of both primary and secondary earners – is difficult for two reasons. While some countries, like the UK and Canada, switched from joint to individual taxation in recent decades, this type of policy change affects their whole population, making it difficult to study it using a quasi-experimental approach such as differences-in-differences or regression discontinuity. Moreover, changes in taxation systems have long-term effects through the accumulation of human capital and changes in the degree of intra-household specialization that are difficult to capture using quasi-experimental methods. An alternative is to use cross-country evidence, as Bick and Fuchs-Schündeln (2017) do. They find a strong correlation between the type of taxation system in a country and the aggregate labor supply of its men and women, driven by substantial negative effects of joint taxation on married women's labor supply. While the evidence they present is convincing, it is nevertheless difficult to ascertain precisely how much of the difference in household behavior across countries is attributable directly to the tax system, since differences in taxation across countries are likely to be correlated with other policies that affect labor supply. A third approach is to use a structural model to quantify effects on household behaviors, as we do in this paper. For this approach to provide credible result, it is important to have reliable estimates of the parameters that govern how people respond to tax rate changes and proper specification tests. In this section, we present descriptive and reduced-form evidence that will be used in the estimation of the model and specification tests.

First, we present a simple example that details the disincentives embedded in a joint system, relative to an individual one. Next, we provide evidence that aggregate labor supply patterns in the US are closely in line with what one would predict based on these described disincentives. Finally, we exploit past tax reforms in the U.S. that affected incentives especially for secondary earners to work, and provide evidence about how workers responded, in the short run. We conclude by discussing how these quantified short-run responses can be used as moments in the estimation and as validation of the dynamic structural model we develop.

3.1 Taxing Married Households: A Simple Example

We start with a simple example that illustrate the main differences between joint and individual tax systems. We will use them to provide evidence on the differential effects of these two taxation rules. The example uses a stylized tax schedule for a progressive, joint tax system, similar to the one adopted by the U.S. (Figure 1). According to the tax schedule, single individuals pay no taxes on the first $10,000; 15% on income between $10,000 and $40,000, and 40% on the remaining income. For married couples, these brackets double.

In Table 1 we consider a hypothetical couple, with $80,000 and $30,000 in pre-tax income. The first three columns of the table show tax rates and take-home pay for this couple when they are taxed individually – i.e., either prior to marrying in the joint tax system described above, or before and after marriage if the system were instead individual. The remaining three columns consider what happens to the couple when married under the joint system. As the first row of Table 1 shows, the primary earner has a marginal tax rate (MTR) of 40%, whether he or she is taxed as an individual with $80,000, or as part of a married household with $110,000 in earnings. By contrast, the secondary earner's MTR increases from 15% to 40% after marrying. This increase in the secondary earner's MTR is a well-understood consequence of joint taxation, and commonly cited disincentive for secondary earner labor supply.

The remainder of Table 1 illustrates two additional effects of joint taxation. The first is a change in the couple's take-home pay after marriage under the joint system, from \$86,500 to \$89,000. This \$2,500 "marriage bonus" generates an additional potential disincentive to work in the form of an income effect. It is explained by the greater share of the couple's pre-tax earnings that are taxed at the lower, 15% rate, after marriage.

The second effect relates to the total after-tax earnings of each individual household member and, relatedly, his or her average tax rate (ATR). For the couple that is taxed jointly in Table 1, we assume that the primary earner's income is the first to be taxed, starting from the lower brackets, and the secondary earner's income is taxed next at higher tax rates. This assumption reflects the decision process of many two-earner households, in which the primary earner works regularly and the secondary earner adjusts his or her labor supply depending on the economic conditions. Under this assumption, the primary earner's after-tax income increases by $\$11,500$ after marrying, to $\$71,000$. By contrast, the secondary earner's contribution to after-tax household income declines by $\$9,000$, to $\$18,000$. This implies an ATR of 40% on the secondary earner's $\$30,000$ of pre-tax income – 30 percentage points higher than it would be under the individual system.

We conclude with two observations. First, the above discussion of income effects, in the form of a marriage bonus, and price effects, in the form of changes in MTR and ATR, concerns work incentives in a joint vs. individual system. However, a change in tax rates even within a joint tax system will similarly alter the income and price effects influencing primary and secondary earner labor supply, as we will show shortly. Therefore, previous U.S. tax reforms can provide useful information about how individuals respond to the incentives and disincentives in the joint system. Second, it is important to distinguish between the two types of price effects for the reason that marginal tax rates are typically thought to influence labor supply on the intensive margin, while average tax rates may be more relevant for decisions about labor force participation, especially in the presence of fixed costs of work. We will refer back to this important issue in the discussion of our model results.

3.2 Descriptive Evidence on the Income and Price Effects

While taxation in the U.S. is more complex than the two tax-bracket system used in our example, in this subsection we document that the income and price effects discussed above are standard features of the U.S. joint tax system.

The joint system is known for the prevalence of marriage bonuses, defined as the difference between total after-tax earnings of a couple who is married and an identical couple who is not. In Figure 2, we plot the marriage bonus as a percent of total household after-tax income, for 2015. We consider three groups of U.S. married households: households with only one earner; households in which one spouse earns 80% of income; and households in which the two spouses earn the same amount of income. The Figure shows that all married U.S. households that are fully specialized and almost all married households that are partially specialized experience a marriage bonus. Additionally, the size of the marriage bonus, which can be as high as 9% of take-home income, increases with the degree of intra-household specialization. This second feature of the joint system has therefore also the potential of encouraging married couples to increase the degree of intra-household specialization.

A second feature of joint taxation is that married secondary earners face higher marginal and average tax rates than they would if they were taxed as an individual (Bick and Fuchs-Schündeln (2017)). The tax rate on the first dollar of an individually taxed worker in the U.S. is close to zero. If the same individual is a married secondary earner in the U.S., his or her effective tax rate on the first dollar of income is on average above 20% and can exceed 50%, depending on state of residence and spousal earnings. To document this fact and the potential disincentive effect on labor supply, we proxy primary and secondary earner status by gender, and plot in Figure 3a three series, all as a function of husband's earnings: the predicted average tax rate (ATR) on a married woman's first $15,000 of income; the share of married women not employed, both as a function of husband's earnings; and the distribution of households. The graph is based on the idea that primary earners work mostly a fixed number of hours and that adjustments in labor force participation are mainly by secondary earners.

The graph shows a striking positive correlation between the fraction of married women not employed and the predicted ATR on their earnings. When the tax rate decreases, due to placement along the tax and EITC schedules, the fraction of married women not working declines. When the ATR increases, the fraction rises. It is noteworthy that in the U.S. the percentage of women not working as a function of their husband's earnings can be as low as 20% for low tax rates and as high as 55% for the highest tax rates. In Figure 3b, we analyze the same patterns for Canada, which has an individual tax system. Since under individual taxation the ATR on the first $15,000 is identical for all secondary earners, we omit that variable. There are two main differences between the U.S. and Canada. As predicted, the variation in women's employment as a function of their husband's earnings is much lower than for U.S. women, only varying from around 20% to around 30%. Second, in Canada, there is no particular relationship between the labor force participation of married women and the husband's earnings. This evidence suggests that the joint tax system introduces disincentives for secondary earners to work.

The previous discussion indicate that a switch to individual taxation could have significant and positive welfare effects on secondary earners by reducing their marginal and average tax rates. Figures 4a and 4b indicate, however, that the gains from such a reform would be unequally distributed, with high-income households benefiting the most and low-income households potentially experiencing welfare loses. Figure 4a suggests that households with husbands earning below $50,000 will generally experience welfare loses, as the gain for secondary earners are offset by the losses of primary and the loss of marriage bonuses. Instead, households at the high end of the income distribution will generally experience large income gains, due to income increases for primary earners that can be as high as 35% and limited losses for secondary earners and from marriage bonuses. Figure 4b documents that the different effect of the policy is a consequence of the heterogeneity in earnings potential for primary and secondary earners along the income distribution, which is measured using the CENSUS occupational earning score. Households are assortatively matched on earnings potentials. They are therefore better off under joint taxation if they are at the low end of the distribution and under individual taxation if at the high end.

To conclude, the U.S. joint tax system generates substantial disincentives for secondary earners, in the form of both income and price effects. Moreover, aggregate labor force participation patterns of secondary earners in the U.S., as proxied by gender, are precisely in line with predicted disincentive effects. To obtain additional evidence, in the next section we consider past tax reforms that altered the set of disincentives facing primary and secondary earners in the U.S., and corresponding behavioral responses.

4 Tax Reforms and Labor Supply Behavior

The evidence provided in the previous section indicates that the choice of a tax system has potentially large effects on individual and household behavior. To evaluate these effects, we will structurally estimate a model of household decisions and use it to evaluate through simulations the performance of different taxation systems. For the results of the model simulations to be credible, it is crucial to have reliable estimates of the parameters that govern the individual response to tax changes. The general consensus among economists is that the best source of variation to identify the responses of women and men to tax changes is represented by tax reforms (Keane (2011)). We will therefore structurally estimate those parameters using the main tax reforms that took place in the U.S. in the last four decades: the Tax Reform Act of 1986 (the Reagan tax cuts), the 1993 EITC expansion as part of Omnimus Budget Reconciliation Act (OBRA), and the Jobs and Growth Tax Relief Reconciliation Act of 2003 (the Bush tax cuts). In this section, we describe the variation in labor supply behaviors generated by the three tax reforms and, hence, the variation we will employ in the structural estimation to identify the model parameters related to the individual labor supply responses.

We start by providing evidence that the three tax reforms generated significant changes to the tax schedule. In Figure 6, we depict the tax schedule for a married couple without dependents before and after the Reagan tax cuts. It reveals that families with pooled income above $\$30,000$ enjoyed significant reductions in marginal tax rates. Figure 7 reports the tax brackets for the same group of households before and after the Bush tax cuts. In this case, the reduction in tax rates was smaller, but still substantial, for most families. But some households, particularly the ones with total income between $\$57,000$ and $\$70,000$, experienced declines of the same order of magnitude as for the Reagan tax cuts. Lastly, in Figure 8 we describe the tax schedules before and after the EITC reform. This reform modified the tax brackets by changing the EITC program. It therefore affected only low-income households, as our Figure documents, with most of them experiencing a significant increase in their marginal tax rates.

We now document the responses to the tax reform using two datasets: the Panel Studies of Income Dynamics (PSID) and the Current Population Survey (CPS) March supplement. The PSID has the advantage of being a panel. This feature enables us to study the labor supply responses of married and single men and women using standard techniques. The main limitation of the PSID is that its sample size is small. It is therefore not possible to estimate the responses for different subgroups. Thus, we also estimate the responses using the CPS, which is not a panel, but has a significantly larger sample size. For reasons that will be clear later in the section, since the CPS is not a panel, using this data set we can only study the response of married women.

4.1 Labor Supply Responses to the Tax Reforms: The PSID

To quantify the effects of tax changes on labor supply decisions, we first use the panel structure of the PSID. We start by documenting the response of married women. We proceed in two steps. First, for each household, we construct the marginal tax rate before and after the tax reform. The change in tax rate reported in the PSID is composed of two parts: the change in rate introduced by the reform; and the movement along the tax schedule produced by the optimal labor supply decision made by a person after the reform. To isolate the first part, we compute the tax rate before and after the reform using in both cases the husband income before the reform took place. In the second step, we compute the labor supply response of married women, by regressing their labor force participation or labor supply on the marginal tax rate described above, household and time fixed effects and control variables.

Formally, we estimate the following fixed effect regression:

$$y_{it} = \alpha_i + \beta_1 \cdot \hat{\tau}_i \cdot post_t + \beta_2 \cdot X_{it} + \gamma_t + \varepsilon_{it}$$

where y_{it} is either the logarithm of work hours in period t or an indicator for whether the married woman works in that period, α_i is a household fixed effect, γ_t is a time fixed effect, $\hat{\tau}_{i,t}$ is the predicted marginal tax rate on the wife's first dollar of income computed using the method described above, $post_t$ is an indicator for being in a post-reform year, and X_{it} is a set of time-varying controls that includes experience, the number of children, whether the households have children younger than 6 at the time of the reform.

The results, reported in Table 2, indicate that married women responded to the Reagan and Bush tax cuts by significantly increasing their labor force participation. We find a 10 percentage points increase in the marginal tax rate is associated with an reduction in labor force participation of 1.75 percentage points in the Reagan reform and 3.13 percentage points in the Bush reform. The response to the EITC reform is larger than the response to the Reagan cuts but it is not statistically significant. When we divide the sample between women with and without young children, we find that women with young children responded the most, with an increase in labor force participation of 2.78 percentage points in the Reagan tax reform and of 5.42 in the Bush tax reform. The reforms had no impact on hours of work of married women.

To study the response of married men and single women and men, we estimate the same fixed-effect regression, except that the change in marginal tax rate is computed using household total income before the reform. Because of this, we can only consider individuals that worked before the response and, thus, only estimate their intensive margin response. Also, the meaning of the coefficient on the change in marginal taxes is less precise, since we can no longer interpret our measure of $\hat{\tau}_{it}$ as the tax rate on the individual's first dollar of income. The estimated coefficients on $\hat{\tau}_{i,t}$ are described in Table 3. We find no statistically significant change in hours of work for married and single men, which should be expected as the majority works full time. But, we estimate significant negative responses to the EITC and Reagan reforms for single women, with a reduction of 11.9 and 2.2 percentage points as the tax rate increases by 10 percentage points.

4.2 Labor Supply Responses to the Tax Reforms: The CPS

Since the PSID has small sample size, the individual responses to tax cuts are not very precisely estimated and we cannot study the responses for different income and demographic groups. For married women, we can address this issues using the CPS. Since in the estimation of the model we only use the Bush tax cuts, we will only presents the results for that reform. The effect of the Reagan and EITC reforms are consistent with the ones documented using the PSID.

Because the CPS is not a panel, we cannot follow the same person over time and estimate directly the response to tax reforms. We can, however, determine the average response to tax changes of individuals that are similar. For married women, we can achieve this by constructing income bins for the husband's income and then estimate the average response to tax cuts, by comparing the labor supply decisions of wives whose husband had an income in a given bin before the reform with the decisions of wives with a husband whose income belonged to the same bin after the reform. By keeping the income bin constant, this approach enable us to isolate the changes in tax rates generated by the reform from the changes that are produced by the optimal labor supply response of women and men to the tax reform. The main limitation of this method is that we can only use it to study married women.

Formally, let inc_k be a dummy variable equal to one if the husband's income falls in quantile k of the income distribution. We can then estimate the following regression:

$$y_{it} = \sum_k \alpha_k inc_k + \sum_k \pi_k inc_k \cdot post_t + \beta_2 X_{it} + \gamma_t + \varepsilon_{it} \tag{1}$$

where the y_{it} is the logarithm of work hours in period t or an indicator for whether the married woman works in that period, $post_t$ is a dummy equal to one if a person is observed after the tax reform, and X_{it} is a set of time-varying controls that includes experience, the number of children, whether the households have children younger than 6 at the time of the reform. The parameter of interest is π_k.

Given the large sample size, we can first document graphically which married women were affected the most by the Bush tax cuts in Figure 5a. Only women with husbands earning between $\$55,000$ and $\$85,000$ experienced large declines in marginal tax rates. Correspondingly, Figure 5b provides evidence that exclusively women in that subgroup responded by significantly increasing their labor force participation.

The results obtained by estimating equation (1), which are described in Table 4, are consistent with the graphical evidence. In the last column, we report the change in marginal tax for different husband's income quintiles and document that all income quintiles experience a large cut in marginal tax rates, with the cuts ranging from 1 percentage points for the income quintile $\$40-50K$ to 8.3 percentage points for the quintile $\$60-70K$. But only married women that experience the largest tax cuts responded by significantly changing their labor force participation, which an increase of 4 percentage points. We then divide the sample in married women with and without college degree and find that both have significant responses, but married women with a college degree are more responsive to the tax cuts. We also divide the sample in women with and without young and document that married women with young children are affected the most by the cuts in marginal tax rates, with increases in labor force participation that, at 6 percentage points, are about twice as as large as the changes for married women without children. We have also estimated the effect of the tax reform on hours of work of married women and, as with the PSID, we find no significant change in this variables.

5 Model

In this section, we develop a model that allows us to evaluate alternative taxation systems. Before describing the model in detail, we begin by outlining its general features. First, to account for the fact that individuals are generally taxed using different rules depending on their marital status, we model the decision about whom and whether to marry and divorce. Second, to allow for lasting effects of changes in tax regimes and to produce a realistic fraction of married and divorced individuals, we consider an intertemporal model in which married couples make efficient decisions with no commitment. Third, we model both labor supply and household production decisions, to account for changes in time allocated to market and home production in response to changes in tax regimes. Fourth, to capture heterogeneous responses to tax reforms by presence of children and education, the model includes fertility events and allows individuals to vary by education. Lastly, to capture long-term effects of tax changes, we allow for human capital accumulation and depreciation. We now describe the model in details.

5.1 Timing

People enter adult life with or without a college degree. Their adult life is divided into a working and retirement stage. During their working stage, each person makes decisions about labor supply, time spent on household production, consumption, savings, marriage, and divorce. If a person enters a period in this stage as single, he or she meets a potential spouse and chooses whether to marry. If instead the person enters the period as married, she or he chooses whether to divorce. At the end of the working life, people enter the retirement stage, in which they only choose consumption and savings.

5.2 Preferences and Technology

Preferences. Individual i has preferences over private consumption c^i, leisure l^i, and a home-produced good Q. If i is married, the preferences depend also on the quality of the marriage θ. They can be characterized using the utility function $u^i(c^i, l^i, Q)$ if single and $u^i(c^i, l^i, Q, \theta)$ if married. Individuals discount the future at a factor β. In the estimation of the model, we assume that the utility function takes the following form for couples:

$$u\left(c^i, l^i, Q, \theta\right) = \frac{\left(c^i\right)^{1-\sigma_c}}{1-\sigma_c} + \gamma_l \frac{\left(l^i\right)^{1-\sigma_l}}{1-\sigma_l} + \gamma_Q^i \log Q + \theta,$$

where we allow the relative taste for public consumption to vary across households depending on whether they have children. Single individuals have the same utility function, except that θ^i is set to zero.

Match quality follows the random walk $\theta_t = \theta_{t-1} + z_t$, where z_t is drawn from a normal distribution with mean 0 and variance σ_z. The first realization of θ at the time of marriage is drawn from a normal distribution with mean μ_θ and variance σ_θ.

Education and Savings. In the model, people differ depending on whether they enter the working stage of their life as college graduates. A college degree has three types of returns. It endows graduates with better wage processes; it makes the time invested in the home-good Q more productive; and it increases the probability of matching with another college graduate in the marriage market. People can save using a risk-free asset with gross return R. We will denote by b_t the amount saved.

Wage Processes and Experience. Conditional on education g and gender j, individual i's wage process takes a standard form that depends on a quadratic term in experience e_{it}, an idiosyncratic shock $\varepsilon_{i,t}$, and ability through an individual fixed effect a_i, i.e.

$$\ln w_{it} = a_i + \beta_0^{g,j} + \beta_1^{g,j} e_{it} + \beta_2^{g,j} e_{it}^2 + \varepsilon_{it}, \tag{2}$$

where $\varepsilon_{it} \sim N(0, \sigma_{\varepsilon}^{ig})$, g is high school or college, and $a_i \sim N(0, \sigma_a^{g,j})$.

Human capital, in the form of labor market experience, evolves according to the following process. If a person works full time in a period, the individual's experience increases by one. If the person works part-time, experience increases by a fraction $\lambda > 0$. If someone does not work in the period, the person's experience declines by $0 \leq \delta \leq 1$, to capture the depreciation of human capital. Thus, the variable experience in the wage process (2) can therefore be characterized using the following equation:

$$e^i = e^i_{FT} + \lambda e^i_{PT} + \delta e^i_{NT},$$

where e^i_{FT} and e^i_{PT} are years of experience accumulated in full-time and part-time jobs, and e^i_{NT} are years spent outside the labor force. The wage process can then be written as follows:

$$\ln w^{g,j} = a^i + \beta_0^{g,j} + \beta_1^{g,j} \left(e^i_{FT} + \lambda e^i_{PT} + \delta e^i_{NT}\right) + \beta_2^{g,j} \left(e^i_{FT} + \lambda e^i_{PT} + \delta e^i_{NT}\right)^2 + \epsilon^{g,i},$$

or equivalently,

$$\begin{aligned} \ln w^{g,j} = {} & a^i + \beta_0^{g,j} + \beta_1^{g,j} e^i_{FT} + \psi_1^{g,j} e^i_{PT} + \psi_2^{g,j} e^i_{NT} + \beta_2^{g,j} \left(e^i_{FT}\right)^2 + \psi_3^{g,j} \left(e^i_{PT}\right)^2 + \psi_4^{g,j} \left(e^i_{NT}\right)^2 \\ & + \psi_5^{g,j} e^i_{FT} e^i_{PT} + \psi_6^{g,j} e^i_{FT} e^i_{NT} + \psi_7^{g,j} e^i_{PT} e^i_{NT} + \epsilon^{g,i}, \end{aligned} \tag{3}$$

where $\psi_1^{g,j} = \beta_1^{g,j}\lambda$, $\psi_2^{g,j} = \beta_1^{g,j}\delta$, $\psi_3^{g,j} = \beta_2^{g,j}\lambda^2$, $\psi_4^{g,j} = \beta_2^{g,j}\delta^2$, $\psi_5^{g,j} = 2\beta_2^{g,j}\lambda$, $\psi_6^{g,j} = 2\beta_2^{g,j}\delta$, and $\psi_7^{g,j} = 2\beta_2^{g,j}\lambda\delta$.

Taxes. The tax schedule is allowed to vary with the tax system and the marital status of an individual. We denote by $\tau^s(w_t h_t)$ the function that determines the income taxes that must be paid by a single individual with earnings equal to $w_t h_t$; and by $\tau^m(w_t^1 h_t^1, w_t^2 h_t^2)$ the taxes levied on a married couple, with the first spouse's earnings equal to $w_t^1 h_t^1$ and the second spouse's to $w_t^2 h_t^2$.

The functions τ^s and τ^m are constructed accounting for the year-on-year changes in tax brackets that are codified in the tax law, other year-on-year changes produced by minor tax reforms, and changes introduced by the Reagan tax cuts, the EITC expansion, and the Bush tax cuts. To solve the model, we have to make assumptions on the beliefs people have on future tax changes. We assume that people anticipate the year-on-year changes in tax brackets generated by the tax code and by minor tax reforms. With regard to the major tax reforms, to keep the model tractable, we can make one of the following assumptions: people have perfect foresight; or people believe that there will be no major reform. We adopt the second assumption, even if it introduces complexity in the model, because it is more realistic.

Changes to the income tax schedule have different effects depending on the social security system adopted by a country. For instance, an increase in marginal tax rates for low-income families should have smaller effects on individual choices and welfare in places with a well-developed food-stamp program. Moreover, economists have argued that the kinks and non-convexities created by the social security system have substantial effects on individual decisions and, hence, on the impact of tax reforms (Saez (2010)). To account for the interactions between the social security and taxation schemes, we model the U.S. social security system by allowing the tax schedules $\tau^s(w_t h_t)$ and $\tau^m(w_t^1 h_t^1, w_t^2 h_t^2)$ to depend on (i) Social Security Income taxes (SSI) and Medicare taxes, (ii) the Earned Income Tax Credit, (iii) the Child Tax Credit, (iv) the Child and Dependent Care Credit, and (v) the Supplemental Nutrition Assistance Program (SNAP), also known as food stamp program.

Household Production Function. The home-produced good Q enters the model to account for the significant amount of time that people allocate to home production and childcare: on average 25 and 12 hours per week, by women and men, respectively. The good Q is produced using as inputs the time spent by each household member in household production, d^i, and market goods, m. The corresponding production function is allowed to vary with the number of children in the household, n.

We assume that the production function has three main characteristics. It allows for substitutability between time and market goods. This feature is essential to match the following two related observed patterns. Women with a college degree have higher labor force participation and hours of work than women with less eduction. Men with higher earnings potential are more likely to marry women with a college degree. A model with a production function without market good m or without a significant degree of substitutability between time and goods would not be able to simultaneously generate both patterns. As a second characteristic, to account for the evidence provided in Guryan, Hurst, and Kearney (2008), in our production function, the productivity of time depends on the number of the children, on whether they are of pre-school age ($age < 6$), and on whether the parents have a college degree. Lastly, for couples, we allow the productivity of time to vary between women and men.

For couples, the three characteristics are incorporate in the following constant elasticity of substitution (CES) production function:

$$Q = f\left(d^1, d^2, m\right) = \left(\eta^{g,n} \cdot \left(\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v\right)^{\frac{\tau}{v}} + (1 - \eta^{g,n}) \cdot m^\tau\right)^{\frac{1}{\tau}},$$

where α^i varies only by gender; $\eta^{g,n}$ varies both by education (col vs. hs) and by child status: (i) no children, (ii) have children < 6, and (iii) have only older children age 6+ . Therefore η_g can take one of 6 values in the equation above. The parameter τ measures the degree of substitutability between time and market goods; η represents the share of time employed in the production of Q relative to market goods; and α^1 and α^2 capture differences in the productivity of time between women and men.

For singles, the production function becomes:

$$Q = f\left(d^1, m\right) = \left(\eta^{g,n} \cdot (\alpha_d^1 d^1)^\tau + (1 - \eta^{g,n}) \cdot m^\tau\right)^{\frac{1}{\tau}}.$$

The sum of the time devoted to household production, labor, and leisure must add up to the total time available to an individual, which we denote by T.

Fertility and Child Care. Married and single women give birth according to a probability function that depends on their marital status, education, age, and current number of children. Individuals can therefore affect the number of children they have, albeit in a simple way, by delaying marriage.

Children younger than 6 require child care if their parents work. A married couple has to purchase a number of child-care hours that is equal to the minimum between the labor hours supplied by the husband and the wife. A single parent must pay for a number of child-hours that corresponds to the number of hours supplied to the market. The price paid for one hour of child care is independent of marital status and denoted by p^c.

The Marriage Market. We model the marriage market using a matching framework with search frictions. Specifically, with some probability, single individuals meet a potential spouse with a given education and ability. The probability depends on own education and ability and declines linearly with age to account for the fact that the number of single individuals decreases as people become older. Single individuals who are divorced and have children incur a re-marriage penalty ψ to account for the observation that they have lower marriage rates.

5.3 Decisions

Single's Decisions. If individual i enters period t as single and decides to remain single, this person chooses labor supply, the time and goods used in household production, private consumption, and savings that solve a standard single-agent problem. Let V_t^{es} be the value function of an individual who enters period t as single and V_t^{ds} the value function of a person who decides to be single in the period. The single-agent problem can then be written as follows:

$$V_t^{ds}\left(b_t, e_t, n_t, a\right) = \max_{h_t, d_t, m_t, c_t, b_{t+1}} u\left(c_t, l_t, Q_t\right) + \beta E_t\left[V_{t+1}^{es}\left(b_{t+1}, e_{t+1}, n_{t+1}, a\right)\right]$$

$$s.t. \qquad c_t + m_t = w_t h_t - \tau^s(w_t h_t) + R b_t - b_{t+1} - p_t^c n_t$$

$$Q_t = f\left(d_t, m_t\right), \quad h_t + d_t + l_t = T, \quad \text{and} \quad w_t = w\left(e_t, a\right),$$

where the transition from n_t children to n_{t+1} children is governed by the fertility probability.

Couples' Decisions. If two individuals enter period t as married and decide to stay married, they make efficient decisions with limited commitment. Efficient decisions means that they solve a Pareto problem. But, since they cannot commit to future allocations, the Pareto weights used to make decisions in period t may differ from the Pareto weights with which the two spouses entered the period. Denote with M_t^1 and M_t^2 the Pareto weights used to make efficient decisions in period t. We will discuss later in this section how they are computed. Also, let $V_t^{em,i}$ be individual i's value function if this person enters period t as married and $V_t^{dm,i}$ the value function if he or she decides to stay married in the period. Then, the couple chooses labor supply, household production time and goods, private consumption, and savings as the solution to the following problem:

$$\max_{\{h_t^i,d_t^i,m_t^i,c_t^i,b_{t+1}\}_{i=1}^2} \sum_{i=1}^{2} M_t^i\{u^i(c_t^i,l_t^i,Q_t,\theta_t)+\beta E_t\left[V_{t+1}^{em,i}\left(b_{t+1},e_{t+1}^1,e_{t+1}^2,n_{t+1},a^1,a^2\right)\right]\}$$

$$s.t. \qquad c_t^1+c_t^2+m_t=w_t^1h_t^1+w_t^2h_t^2-\tau^m(w_t^1h_t^1,w_t^2h_t^2)+Rb_t-b_{t+1}-p_t^cn_t$$

$$Q_t=f\left(d_t^1,d_t^2,m_t\right), \quad h_t^i+d_t^i+l_t^i=T, \quad \text{and} \quad w_t^i=w^i\left(e_t^i,a^i\right), \quad i=1,2,$$

where the change from having n_t children to n_{t+1} children is governed by the fertility probability. Denote by $h_t^{i*}, d_t^{i*}, m_t^{i*}, c_t^{i*}, b_{t+1}^*$, for $i=1,2$, the solution of the couple's problem. Then, person's i value function if this individual decides to stay married takes the following form:

$$V_t^{dm,i}\left(b_{t+1},e_{t+1}^1,e_{t+1}^2,n_{t+1},a^1,a^2\right)=u^i(c_t^{i*},l_t^{i*},Q_t^*,f_t^{i*},\theta_t)+\beta E_t\left[V_t^{em,i}\left(b_{t+1}^*,e_{t+1}^1,e_{t+1}^2,n_{t+1},a^1,a^2\right)\right].$$

Marriage, Divorce, and Renegotiation Decisions. Given the optimal choices and value functions of people who have decided to stay single and people who have selected to remain married, we can determine the optimal marriage decision. An individual who enters period t as single and the potential spouse choose to marry if the value of being married is larger than the value of staying single for both of them, i.e.

$$V_t^{dm,i}\left(b_{t+1},e_{t+1}^1,e_{t+1}^2,n_{t+1},a^1,a^2\right)\geq V_t^{ds,i}\left(b_{t+1},e_{t+1}^i,n_{t+1},a^i\right), \quad i=1,2.$$

These inequalities are also known as participation constraints (Kocherlakota (1996), Mazzocco (2007), Marcet and Marimon (2011), Bronson (2015), and Chiappori and Mazzocco (2017)).

The participation constraints determine also whether it is optimal for a married couple to divorce, remain married maintaining the current allocation of resources, or renegotiate the current allocation by changing the Pareto weights used to solve their problem. Consider two individuals who enter period t as married with Pareto weights M_{t-1}^1 and M_{t-1}^2. Denote by $z^{**}=\{h_t^{i**},d_t^{i**},m_t^{i**},c_t^{i**},b_{t+1}^{**}\}$ the solution of the couple's problem computed using the initial Pareto weights. If at the solution z^{**} the participation constraints are satisfied for both spouses, it is optimal for them to remain married at the current optimal allocation of resources. If the participation constraints of both spouses are violated, the marriage produces no surplus that can be shared. It is therefore optimal to divorce. The most interesting case is represented by a situation in which the participation constraint of one spouse is satisfied, but the participation constraint of the other is violated. In this case, there may exist a different allocation of household resources, at which both participation constraints are satisfied and, hence, at which both spouses are better off staying married. If such allocation exists, it can be achieved by increasing the Pareto weight of the constrained individual and, consequently, the share of resources allocated to this spouse. From an ex-ante perspective, the most efficient new allocation is the one that corresponds to a new set of Pareto weights M_t^1 and M_t^2 that make the constrained individual indifferent between staying married or being single (Kocherlakota (1996)). If such new allocation does not exist, the household does not generate surplus and it is optimal for the spouses to divorce.

5.4 Heuristic Argument for Identification and Moments Selection

In this section, we provide heuristic arguments describing the variation in the data that enables us to identify the parameters of the model. In Appendix A, we present formal arguments for their identification. With the exception of the curvature of the sub-utility for consumption σ_c and the discount factor β, we estimate all the model's parameters using the data described in Section 2. The parameter σ_c is set equal to 1.5 based on Blundell, Browning, and Meghir (1994) and Attanasio and Weber (1995), and the parameter β is set equal to 0.98 following Attanasio, Low, and Sánchez-Marcos (2008).

Wage and Experience Parameters: $\beta_0^{g,i}$, β_1^g, β_2^g, σ_ϵ^g, σ_a^g, λ, δ

Given the model assumptions, the fixed-effects, the parameters $\beta_0^{g,i} - \beta_2^g$, and the parameters $\psi_1 - \psi_7$ of the wage processes (3) can be consistently estimated using ordinary least squared (OLS) if years in full-time and part-time jobs and years without a job are observed. They are therefore identified.[1] Using the fixed-effects and $\psi_0 - \psi_7$, we can also consistently estimate and, hence, identify the standard deviation of the distribution of ability (the fixed effect), σ_a^g, and

[1] As we discuss in details in the next section, in the estimation we control for selection into the labor market.

of the error terms, σ_ϵ^g. The parameters governing the accumulation of human capital can then be identified by noting that $\lambda = \frac{\psi_2}{\psi_1}$ and $\delta = \frac{\psi_3}{\psi_1}$.

Production Function Parameters: $\tau,\ \upsilon,\ \eta,\ \alpha_1,\ \alpha_2$

The parameter η takes six different values depending on education (high school or college) and child status (no children, children younger than 6, children of age 6 or older). We only discuss the identification of one of the six parameters by conditioning on one particular level of education and child status. The argument for the identification of the other five parameters follows directly.

For singles, the parameter τ determines the degree of sustitutability between time and market inputs in the household production function in response to wage changes, where the degree is an increasing function of τ. This parameter can therefore be identified by the elasticity of the ratio of the two inputs with respect to changes in the individual wage. For couples, the parameter υ characterizes the substitutability between the primary and secondary earners' time in household production when their relative wages change. Thus, it can be identified by the elasticity of the ratio of the two time inputs to the relative wages of primary and secondary earners.

Given the substitution parameter τ, $1 - \eta$ determines the fraction of resources used in household production that a single individual allocates to market inputs relative to time inputs. η can therefore be identified by the ratio of the market inputs used in household production by singles divided by the sum of market inputs and time inputs valued at the individual's wage. We allow women's time inputs to have a different productivity (α_1) from men's productivity (α_2). In Appendix A, we argue that, given our production function, we can normalize one of the two parameters without loss of generality. We can identify the other productivity parameters by the different between single men and women in the ratio of market inputs to the sum of the value of market and time inputs.

Preference Parameters: $\sigma_l, \ \gamma_l, \ \gamma_Q$

In our model, the Frish leisure elasticity of single individuals is equal to $-\frac{1}{\sigma_l}$. The power parameters on leisure can therefore be identified by the changes in leisure by singles in response to expected changes in their wages or, equivalently, changes that keep the marginal utility of wealth constant. The parameters γ_l measures the the taste for leisure relative for the taste for consumption. It can therefore be identified by the average ratio of leisure to consumption for single individuals. Analogously, γ_Q captures the relative taste for public consumption relative to leisure. Thus, we can identify this parameters by the average ratio of consumption to the value of inputs used on household production.

Fertility Process

In our model, the probability of a birth is a function of discrete variables. If births and the corresponding discrete variables are observed, then there is only one conditional probability function for births that is consistent with the data. The fertility process is therefore identified.

Marriage, Divorce, and Meeting Parameters: μ_θ, σ_θ, σ_z, K_d, π_{HS}, π_C, $\rho_{g=g_s}$, $\rho_{g\neq g_s}$

The parameters of the initial match quality μ_θ and σ_θ affect the probability of marriage for a couple with given education, as higher μ_θ and lower σ_θ increase it. We can therefore identify these two parameters by means of the probability of marriage conditional on the couple's education. Given the couple's education, the probability of divorce is an increasing function of the standard deviation of the subsequent match quality shocks c and and a declining function of the cost of divorce K_d. Thus, we can identify σ_z and K_d using the probability of divorce for couples with a given education. Lastly, the probability that an individual with education g marries a potential spouse with the same education $g_s = g$ increases with the probability that two individuals with such education meet π_g. Consequently, we can identify the parameters π_{HS} and π_C using the probabilities that a person with high school (college) education married a person with the same education. The correlation between the ability of two spouses with the same education is an increasing function of $\rho_{g=g_s}$, the correlation between the ability of a person and the ability of a potential spouse with the same education. These two parameters are not identical because of selection into marriage. Using data on wages for married individuals we can identify the first correlation and then use it to identify the parameter $\rho_{g=g_s}$. The same argument applies to $\rho_{g\neq g_s}$.

6 Estimation and Moment Selection.

Wage and Experience Parameters: $\beta_0^{g,i}$, β_1^g, β_2^g, σ_ϵ^g, σ_ϵ^a, λ, δ. The parameters of the wage processes and the parameters determining the accumulation of experience are estimated separately from the other parameters using the PSID. We employ a two-stage procedure that controls for selection into working, which is applied separately to each gender-education group. The selection equation is estimated using a Probit specification that includes the following variables: non-labor income, dummies for whether someone is married, never married, widowed, separated, or divorced, a dummy for whether the household includes a child younger than 6, dummies for number of children, a dummy for black head of households, year-fixed effects, and the expected average tax rate on own income. For married women, we also include the marginal tax rate based on the husband's income. The excluded variables are the dummy for children younger than 6 and the tax variables.

Fertility Process. The probability of a birth conditional on marital status, education, age, and presence of children is estimated non-parametrically using PSID data and a bin estimator.

Household Production Parameters: τ, v, η, α_1, α_2. For singles, the elasticity of the ratio of time to market goods invested in household production with respect to the wage rate is equal to $\frac{1}{\tau-1}$. This implies that larger values of $\tau \leq 1$ generate larger substitutions away from d and toward m when after-tax wages increase. We can therefore estimate τ by targeting changes $\frac{d}{m}$ in response to the Bush tax cuts. The substitution parameter for couple v is estimated by targeting changes in $\frac{d^1}{d^2}$ in response to changes in relative wages $\frac{w^1}{w^2}$. The share parameter η is estimated by targeting the average expenditure on market goods m divided by the same average plus the average time spend on household production evaluated at the individual's wage, for singles with different education and child status. The parameter α_1 is estimated by targeting the difference between single men and women in the moment used to estimate η.

Preference Parameters: σ_l, γ_l, γ_Q. The parameter governing the response to tax rate changes, σ_l, is estimated using the variation in labor force participation generated by the Bush tax reform discussed earlier. Specifically, we match the average labor force participation change of married women with and without children before and after the Bush tax cuts, as measured in the CPS. The parameter measuring the preferences for leisure relative to private consumption is identifies using the average ratio of private consumption to leisure as observed in the PSID. The parameter on the public good γ_Q is identifies using the ratio between average private consumption and average expenditure on market good inputs in the production function.

Marriage, Divorce, and Meeting Parameters: μ_θ, σ_θ, σ_z, K_d, π_{HS}, π_C, $\rho_{g=g_s}$, $\rho_{g\neq g_s}$. In the estimation, we normalize the standard deviations σ_θ and σ_z to 1. The other parameters are estimated following the discussion in the identification section. Specifically, the parameter μ_θ is estimated by targeting marriage probabilities the parameter K_{div} is estimated by matching divorce probabilities.

The probability of drawing a spouse is normalized to be equal to 1 at any age since, as argued in the Appendix A, it cannot be separately identified from the parameters μ_θ and σ_θ without data on meetings before marriage. Conditional on meeting, we estimate the probability of meeting someone with the same education by matching the shares of married couples with spouses that have the same education. We estimate the correlation between the partners' abilities conditional on having the same education, $\rho_{g=g_s}$, by matching the correlation between the individual fixed effects estimated for the wage process for married couples with identical education. Analogously, we estimate $\rho_{g=g_s}$ by matching the correlation between fixed effects for married couples with different education. Allowing single individuals to match based on their ability measured by the fixed effect, enables us to better capture the degree of assortative matching in the marriage market.

Full Set of Moments Used in Simulated Method of Moments. All model parameters, except the ones characterizing the wage and fertility processes, are estimated using the Simulated Method of Moments. Following the discussion above, we match the following moments:

(i) changes in labor force participation of married women generated by the Bush tax cut by quantile the husband's income; (ii) the same moments for married women with children younger than 6; (iii) married women's labor force participation and hours worked by education (high school and college), child status (no children, with children younger than 6, without children younger than 6), and quartile of husband's income; married men's labor force participation and hours worked by education (high school and college) and child status (no children, with children younger than 6, without children younger than 6); (iv) single individuals labor force participation and hours worked by gender, education, and child status; (iv) labor force participation by age group (20-25, 26-54, 56-64), gender, and education; (v) hours invested in household production by gender, education, marital status, and child status (no children, with children younger than 6, without children younger than 6); for married women we also condition on work status (no work, part-time, full-time); (vi) expenditure on market inputs used in household production by marital status, child status (no children, with children younger than 6, without children younger than 6), and work status (no work, part-time, full-time);[2]; (vii) share married and share divorced by age group (22-26, 27-36, 37-50, above 50) and education; (viii) share of individuals with high school or college education married to individual with the education.

7 Results

7.1 Parameter Estimates

The parameter estimates are reported in Tables 5-7. The estimated value of σ_l implies a Frish leisure elasticity of 0.35 for both men and women. Since, on average, men have a leisure to labor hours ratio around 1, the upper bound for the implied Frish labor elasticity – obtained by setting the elasticity for the time allocated to household production to zero – is equal to 0.35, which is consistent with the low estimates obtained in the labor literature (Keane (2011)). Women's ratio leisure to hours of work is on average larger at around 1.5, which implies a labor supply Frish elasticity of 0.53. The estimated production function parameters indicates that

[2]Market input expenditure is composed of expenditure on children, housekeeping, meals, and additional daycare expenditure above the minimum required when both parents work.

the productivity of the time spent on the public good is higher for women. They also indicate that the there is substantial substitutability between time and market inputs in household production ($\tau = 0.38$), but that they are far from being perfect substitutes which would require $\tau = 1$. We obtain similar estimates for the degree of substitutability between the wife's and husband's time input to household production: significant sustitutability, but far from being perfect substitutes. Lastly, we find that time inputs represent a larger share of total resources invested in household production for individuals with college degree than without. The wage parameters have the expected sign and size. Experience increases wages at a declining rate and its effect is smaller for workers without a college degree.

7.2 Model Fit

With the estimated parameters we match well the most relevant moments, which are reported in Table 8. The share married and divorced generated by the model (0.61 and 0.12) is very close to the shares observed in the data (0.65 and 0.11). Analogously, the share of married households with young children in our simulations (0.34) is only slightly lower than the share in the data (0.38). For the share employed, we match well the ranking and level by education and gender. The share employed for men with high school degree is 0.74 in our simulations and 0.79 in the data, whereas for men with college degree it is 0.91 in the model and 0.94 in the data. For women, we have similarly good results, with the share employed being equal to 0.64 for women with a high school degree in the simulations and 0.66 in the data. Women with a college degree work slightly more both in the model (0.79) and data (0.83).

We fit the production function moments reasonable well, but not as well as the previous moments. We slightly underestimate the hours spent by men in household production (12.3 in the simulations versus 14.1 in the data) and slightly overestimate the hours devoted by women to the production of the public good (25.2 in the model versus 21.2 in the data). We also do a relatively good job matching the share of households in which the wife is the higher earner conditional on the husband's education. This share is 29.3 in our model (33.7 in the data) for families with a husband without a college degree, and 26.2 (31.2 in the data) for households in which the husband has a college degree.

In Figure 9, we report the actual and simulated income distribution of men by education.

It documents that we match well the full distribution of this variable in the data for both high school and college graduates. Figure 10 reports the same variable for women by education. The model fit is reasonably good, with higher densities at low income levels for women with a high-school degree or less than for women with a college degree, but lower densities at larger income levels. It is critical for us to match well the observed income distribution for three reasons. First, men's income has first-order effects on married women's labor supply through the taxes they have to pay on their earning, since higher husband's earnings imply that higher tax rates will be levied on their earnings. Second, the husband's earnings have income effects on the wife's choices. These first two effects determine the household's choice of whether to allocate an additional hour of the secondary earner to the labor market or to household production. Lastly, matching this distribution correctly is important for our policy analysis. With one exception, all the policies we evaluate are revenue neutral, but they change the distribution of the tax burden in the population. Since the changes in individual tax burdens generated by a tax policy depend on the underlying income distribution, our policy exercises require that the model approximates well the income distribution observed in the data.

In Figure 11, we report the share of women employed as a function of husband's earnings in the simulations and data, separately for women with and without a college degree. We fit well the decline in the share employed when the husband's earning increases, for both groups of women. In Figures 12 and 13, we describe the same variables, but we also condition on the presence of children younger than 6. Our model can account for the fact that women work less when young children are present in the household for both college and no-college women.

Figure 14 illustrates that we fit well the share of women with a college degree as a function of the husband's earnings observed in the data. Since education is a strong predictor of earnings potential, the figure documents that our model can account for marital sorting based on potential earnings of the spouse. This is important for our policy analysis, since high earnings-potential women are more likely to respond to changes in tax policies, all else equal.

In Figure 15, we document the ability of our model to replicate the labor supply decisions over the life-cycle of women and men with and without college. For women, we match well the three main patterns observed in the data. First, women without a college degree supply fewer hours than women with a degree throughout their working life. Second, both groups of women experience a decline in hours work in the middle of their working life due to fertility events, but women without a college degree experience the decrease earlier due to the fact that they have children at younger ages. Third, the dip in labor supply generated by fertility is larger for women with a college degree. For men, we match the main pattern observed in the data, which is that men with a college degree work longer hours for most of their working life.

Lastly, in Figure 9, we test whether our model can generate the labor force participation responses to the Bush tax cuts observed in the CPS. We can replicate well the responses of women both by child status and education, which suggests that our model is able to approximate well the most important patterns observed in the data.

7.3 Policy Evaluation

Using the estimated model, we evaluate three policies that have been proposed by economists, policy makers, and politicians and could have strong effects on household labor supply decisions: (i) a change to an individual taxation system; (ii) a secondary earner deduction; and (iii) child care subsidies under the joint and under the individual tax systems. In all cases, we focus on the allocation of time to market and household activities and on distributional effects.

A direct switch from a joint to an individual taxation system is the most debated tax policy. To evaluate its effects, we study the changes generated by a shift from the current U.S. joint taxation system to a system in which all individuals are taxed based on the current individual tax brackets. We maintain the current tax rates, which implies that the reform is not revenue neutral, and the existing social programs for low-income households. Specifically, eligibility for the EITC is based on pooled income before and after the reform.

In Figure 16, we describe the first effects of the reform: the change in the labor force participation decisions of married women. These effects are illustrated by the solid line, whereas the dashed line describes the tax rate on the first dollar of the wife's earnings under the joint taxation system. Since under the individual taxation system, the marginal tax rate on the first dollar is zero, the dashed line represents also the change in wife's marginal tax rate generated by the reform. The figure documents that the reform has substantial effects on the labor force participation of women who experience large redutions in their marginal tax rate. Married women whose husband earns between $\$50,000$ and $\$120,000$ increase their labor force participation by an amount that is between 2 and 5 percentage points. Married women with husbands earning more than $\$120,000$ increase their labor supply by only 1-2 percentage points even though the decline in marginal tax rates is large, due to strong income effects.

Table 10 reports the impact of the policy on other variables of interest. The policy increases the time that women supply in the labor market by slightly more than one hour and decreases the time devoted to household production by slightly more than two hours. Thus, women increase the time they spend on leisure by one hours. This result is explain by the shift in decision power toward women of about three percentage points due to the lower tax rates married women pay. Men change their allocation of time in opposite direction, with a reduction in the hours worked in the market and an increase in the time spend in the production of the public good. But the changes are smaller due to the fact that most married men are primary earners who have accumulated substantial amounts of human capital. Because of this, men do not experience changes in their wages. This is not the case for women, who enjoy wage increases of 2.4% if they are between 30 and 45 years of age, and wage increase of 3.8% if they are older than 45 due to the additional time they had to accumulate experience.

There is a reason we only observe small changes in the extensive margin even for married women. The tax change induces more women to enter the labor force, but they don't necessarily do it full-time. So when you look at the share of wives working full-time it does not increase, but part of that is a compositional effect (some previous workers increase their hours, but the new ones who were induced to enter do so with relatively low hours). This is what the model tells us is the reason for the apparent lack of intensive response, but we cannot look at this using CPS since it is not a panel. A second reason we do not see much response on the intensive margin in the model is that even though the average tax rate will be much lower after a tax cut for the secondary earner, if she works earns enough, the HH will reach that higher tax bracket and the marginal tax rate on her last dollar will still be high, pushing down her hours worked. Similar idea holds for the individual tax system simulations. The extensive response is much higher than the intensive response since under the individual system you have a very low average tax rate, but you'll still eventually reach a high tax bracket if you work enough hours, meaning you'll have a high marginal tax rate on the last dollar that pushes down hours worked.

The first policy we study has been criticized for being regressive. Economists and policy makers have based this conclusion on a static evaluation that uses incomes at the time of the reform and, hence, does not account for the optimal dynamic response of individuals. We report the results of this static analysis, which does not require the use of our model, in Figure 17. Our static findings are consistent with the common belief that a switch from a joint to an individual taxation system generates a transfer from medium and high income households to rich households. All married households with primary earner's income between $\$65,000$ and $\$340,000$ suffer a decline in their take-home income, whereas households with primary earner's income higher than $\$340,000$ enjoy substantial increases. Figure 18 documents that the static results are driven by households with only one earner, as all households with two earners experience large gains independently of their total take-home income.

Using only data, one can only generate the static results reported in Figures 17 and 18. The model estimated in this paper, however, enables us to also account for the optimal response of people to the reform. The results obtained from this dynamic evaluation, which are described in Figure 19, paint a different picture. When the optimal response is considered, almost all households benefit from the transition to the individual taxation system. It is only households with primary earner's income that is between $\$170,000$ and $\$320,000$ who suffer an income loss. But, as Figure 3a illustrates, the fraction of households in that income group is small. Moreover, even for these households, the losses are substantially smaller than the static analysis predicts, with losses that are never larger than 1 percent of the primary earner's income. Figures 17 and 18 provide an explanation for the differences between the static and dynamic analysis. Without a change in decisions, only married households with one earner suffer economic losses from a transition to an individual taxation system. After the transition, however, for most one-earner households it is optimal to reduce the degree of intra-household specialization and have both spouses working, which reduces the number of households with economic losses and their size.

The results presented so far make clear that neither taxation system Pareto dominate, as there are always some households that lose from switching to a different system. But, using the model, we can evaluate welfare performance of the two systems using different welfare functions. When we employ a welfare function that assigns the same weight to each household, we find that a shift to the individual taxation system generates welfare gains for the entire economy.

Figure 19 also suggests that this is the case for most welfare functions: unless extremely high weights are assigned to the small fraction of households with primary earner's income between $\$170,000$ and $\$320,000$, the individual taxation system produces larger aggregate welfare than the current system. The intuition for this result is related to a point we made earlier. All two-earner households experience welfare gains from switching to individual taxation. Some one-earner households suffer welfare losses if they do not modify their decisions, but this is not optimal. One-earner families respond to the reform by increasing the time the secondary earner spends in the labor market. This reduces the welfare losses for some households and transforms the losses in welfare gains for others.

In lieu of individual taxation, some economist have proposed a deduction for the secondary earner (e.g. Kearney and Turner (2013)). We can evaluate this alternative policy using our estimated model. We consider the introduction of a $\$20,000$ secondary-earner deduction to the current joint taxation system. Specifically, the secondary earner pays no taxes on the first $\$20,000$, and pays taxes at the rates established by the current tax brackets for any income above that threshold. In the example discussed in Section 3, the secondary earner would pay a marginal tax rate of 40% on every dollar above $\$20,000$. To make the policy revenue-neutral, we eliminate the standard/personal deductions for the secondary earner, and adjust the marginal tax rates in each bracket. The labor force participation responses of married women are reported in Figure 20. The deduction policy has effects on the fraction of married women working that are similar to the shift to individual taxation, but slightly smaller in size: married women subjected to large marginal tax rates in the current joint taxation system increase their labor force participation with effects that decline with the primary earner income. This result is noteworthy because the secondary-earner deduction is simple to implement and should encounter less political opposition than a full shift to individual taxation. Table 11 provides some insight of why the deduction policy has similar effects to individual taxation. The mean marginal tax rate paid by married women is substantially larger under the deduction policy. But their mean average tax rate, which is the main tax variable behind the labor force participation decisions, is similar in the two taxation systems due to the deduction of $\$20,000$. Hence, the similar effects of the two policies.

The last policy we evaluate is a revenue-neutral child subsidy and its interactions with the joint and individual taxation systems. The policy pays for up to $\$7,000$ in childcare costs to families who require it. We report the labor force participation responses of married women under the two systems in Figure 21 and we compare them to the responses to individual taxation. The childcare policy generates larger responses than the shift to individual taxation under both systems, with changes that are larger for families with secondary-earners who paid larger marginal tax rates under the current system. But it is noteworthy that the effects of the tax policy are substantially larger – by 1 to 2 percentage points – under the individual taxation system, with increases in the fraction employed that can be as large as 9 percentage points.

8 Conclusions

The objective of the paper is to evaluate the effect of different taxation systems on choices and welfare. We do this by providing descriptive evidence that distinct taxation systems produce different incentives for primary and secondary earners and that these incentives influence individual choices. We then develop and estimate using U.S. data an intertemporal model in which single and married individuals make decisions on labor supply, household production, human capital accumulation, consumption, savings, marriage and divorce. Moreover, the model accounts for the main features of the U.S. taxation and welfare systems. Lastly, using the estimated model we evaluate three popular tax policies: a shift from a joint to an individual taxation system; the introduction of a secondary earner deduction in a joint taxation system; and the addition of child care subsidies to a joint and to an individual taxation system. Our results indicate that all three policies have important effects on choices and welfare, with secondary earners that increase their labor force participation and labor supply, at the cost of lower hours spent on household production, accumulate more human capital, increase their intra-household decision power, and their welfare.

References

Alesina, Alberto, Andrea Ichino, and Loukas Karabarbounis. 2011. "Gender-Based Taxation and the Division of Family Chores." *American Economic Journal: Economic Policy* 3 (2): 1–40 (May).

Apps, Patricia, and Ray Rees. 1999a. "On the taxation of trade within and between households." *Journal of Public Economics* 73 (2): 241–263 (August).

Apps, Patricia F., and Ray Rees. 1999b. "Individual Versus Joint Taxation in Models With Household Production." *Journal of Political Economy* 107 (2): 393–403.

Attanasio, Orazio, Hamish Low, and Virginia Sánchez-Marcos. 2008. "Explaining Changes in Female Labor Supply in a Life-Cycle Model." *The American Economic Review* 98 (4): 1517–1552.

Attanasio, Orazio P., and Guglielmo Weber. 1995. "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey." *Journal of Political Economy* 103 (6): 1121–1157.

Bick, Alexander, and Nicola Fuchs-Schündeln. 2017. "Taxation and Labour Supply of Married Couples across Countries: A Macroeconomic Analysis." *The Review of Economic Studies*.

Blundell, Richard, Martin Browning, and Costas Meghir. 1994. "Consumer Demand and the Life-Cycle Allocation of Household Expenditures." *The Review of Economic Studies* 61 (1): 57–80.

Borella, Margherita, Mariacristina De Nardi, and Fang Yang. 2019. "Are Marriage-Related Taxes and Social Security Benefits Holding Back Female Labor Supply?" *NBER Working Paper*, no. 26097.

Bronson, Mary Ann. 2015. "Degrees are Forever: Marriage, Educational Investment, and Lifecycle Labor Decisions of Men and Women." *Working Paper, UCLA*.

Chiappori, Pierre-Andre, and Maurizio Mazzocco. 2017. "Static and Intertemporal Household Decisions." *Journal of Economic Literature* 55 (3): 985–1045 (September).

Gayle, George-Levi, and Andrew Shephard. 2016. "Optimal Taxation, Marriage, Home Production, and Family Labour Supply." *Working Paper*.

Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura. 2012. "Taxation and Household Labour Supply." *The Review of Economic Studies* 79 (3): 1113–1149.

Guryan, Jonathan, Erik Hurst, and Melissa Kearney. 2008. "Parental Education and Parental Time with Children." *Journal of Economic Perspectives* 22 (3): 23–46 (September).

Keane, Michael P. 2011. "Labor Supply and Taxes: A Survey." *Journal of Economic Literature* 49 (4): 961–1075.

Kearney, Melissa S., and Lesley J. Turner. 2013. "Giving Secondary Earners a Tax Break: A Proposal to Help Low- and Middle-Income Families." *Brookings Discussion Paper 2013-07.*

Kleven, Henrik Jacobsen, Claus Thustrup Kreiner, and Emmanuel Saez. 2009. "The Optimal Income Taxation of Couples." *Econometrica* 77 (2): 537–560.

Kocherlakota, Narayana R. 1996. "Implications of Efficient Risk Sharing without Commitment." *Review of Economic Studies* 63:595–609.

Marcet, Albert, and Ramon Marimon. 2011. "Recursive Contracts." *Economics Working Paper, European University Institute*, no. eco2011/15.

Mazzocco, Maurizio. 2007. "Household Intertemporal Behaviour: A Collective Characterization and a Test of Commitment." *Review of Economic Studies* 74:857–895.

Saez, Emmanuel. 2010. "Do Taxpayers Bunch at Kink Points." *American Economic Journal: Economic Policy*, no. 2:180–212.

	Taxed As Individuals			Taxed Jointly As Married Couple		
	Pooled	Primary Earner	Secondary Earner	Pooled	Primary Earner	Secondary Earner
Pre-Tax Income	$110k	$80k	$30k	$110k	$80k	$30k
Marginal Tax Rate	-	0.40	0.10	0.40	0.40	0.40
After-Tax Income	$86.5k	$59.5k	$27k	$89k	$71k†	$18k†
Marriage Bonus	$0			$2.5k		
Average Tax Rate	0.21	0.26	0.10	0.19	0.11†	0.40†

† Calculation supposes that primary earner always works, while secondary earner supplements primary earner income.

Table 1: Effects on Outcomes: Joint vs. Individual Taxation

	All Women		Women with Young Children		Women without Young Children	
	LFP	Hours	LFP	Hours	LFP	Hours
1986 Reform	-0.175*	-0.001	-0.278*	0.001	-0.121	-0.001
	[0.101]	[0.001]	[0.167]	[0.003]	[0.109]	[0.002]
1993 Reform	-0.197	0.001	-0.240	-0.008	-0.164	0.007
	[0.141]	[0.004]	[0.237]	[0.007]	[0.158]	[0.006]
2003 Reform	-0.313**	-0.001	-0.542**	-0.001	-0.227	-0.002
	[0.159]	[0.003]	[.303]	[0.004]	[0.175]	[0.003]

Notes: P-values in brackets. Coefficients presented are from the interaction between the change in marginal tax rate due to the tax reform, based on an individual's pre-reform income, and an indicator for the post-reform period.

Table 2: Labor Supply Responses to Changes in Tax Rates on First Dollar of Earnings, Based on Husband's Income

	Married Men	Single Men	Single Women
1986 Reform	0.044	-0.012	-0.220*
	[0.077]	[0.237]	[0.126]
1993 Reform	0.018	0.593	-1.187***
	[0.191]	[0.417]	[0.483]
2003 Reform	0.022	0.505	0.213
	[0.114]	[0.621]	[0.225]

Notes: P-values in brackets. Coefficients presented are from the interaction between the change in marginal tax rate due to the tax reform, based on an individual's pre-reform income, and an indicator for the post-reform period.

Table 3: Response of Weekly Hours to Change in Marginal Tax Rate

	(1) All	(2) HS	(3) Col	(4) W/Child <6	(5) No Yng. Ch.	(6) Tax Change
Post x 45,000	0.00323	0.00642	-0.00308	0.00685	0.00302	-0.0109***
	(0.00725)	(0.00949)	(0.0111)	(0.0141)	(0.00842)	(0.00255)
Post x 55,000	0.000893	0.00415	-0.00408	-0.00146	0.00111	-3.693***
	(0.00882)	(0.0122)	(0.0126)	(0.0179)	(0.0101)	(0.0573)
Post x 65,000	0.0390***	0.0300*	0.0438***	0.0599***	0.0315***	-8.339***
	(0.0107)	(0.0157)	(0.0141)	(0.0212)	(0.0122)	(0.0746)
Post x 75,000	0.00723	-0.0251	0.0375**	0.00993	0.00748	-3.408***
	(0.0136)	(0.0208)	(0.0176)	(0.0279)	(0.0153)	(0.0578)
Post x 85,000	0.0186	0.0311	0.00281	0.0140	0.0192	-1.768***
	(0.0131)	(0.0205)	(0.0167)	(0.0256)	(0.0151)	(0.0336)
Post x 95,000	-0.0176	0.0130	-0.0388	-0.0740*	-0.00363	-2.087***
	(0.0212)	(0.0353)	(0.0264)	(0.0418)	(0.0244)	(0.126)
Observations	136296	94658	41638	40389	95907	136296
Adjusted R^2	0.736	0.704	0.795	0.683	0.757	0.896

Standard errors in parentheses
Source: CPS
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Secondary Earner Employment After Reform, by Decile of Primary Earner Income Table

Parameter	Description:	Value
σ_c	Private consumption power parameter, fixed	1.50
σ_l	Leisure power parameter	2.85
Utility parameters, private consumption relative to		
	Leisure, γ_l	1.97
	Public consumption without kids present, γ_Q^i	4.43
	Public consumption if kids present (ages 6+ only), γ_Q^i	5.90
	Public consumption if kids under age 6 present, γ_Q^i	13.28
Home good production function parameters		
η	Time share parameter, no kids (high school)	0.33
η	Time share parameter, kids age 6+ (high school)	0.45
η	Time share parameter, kids under age 6 (high school)	0.24
η	Time share parameter, no kids (college)	0.47
η	Time share parameter, kids age 6+ (College)	0.57
η	Time share parameter, kids under age 6 (College)	0.42
τ	Substitution parameter, home hours vs. market Good	0.38
v	Substitution parameter, wife's vs husband's home hours	0.40
α^1	Productivity of home hours, women:	1.10
α^2	Productivity of home hours, men:	0.90

Table 5: Estimates I: Preference and Production Function Parameters

Description:	Estimate
Cost of divorce, high school	5.49
Cost of divorce, college	11.52
Mean Initial Match Quality	-0.40
Variance Initial Match Quality	1.0
Variance Match Quality	1.0
Decline in mean of initial match quality with age:	0.14
Probability of drawing a potential match, Normalized	1
Probability of drawing a partner with the same education	0.75
Correlation between the individual-fixed effects of potential partners, if same education	0.46
Correlation between the individual-fixed effects of potential partners, if different education	0.44

Table 6: Estimates II: Match Quality and Marriage Market Parameters

Description:	Women	Men
Constant:		
High School	2.085	2.229
College	2.340	2.539
Experience:		
High School	0.047	0.050
College	0.069	0.079
Experience Squared:		
High School	-0.0009	-0.0009
College	-0.0014	-0.0016
Part-time Experience Accumulation:		
High School	0.317	-0.098
College	0.630	0.433
No-time Experience Depreciation:		
High School	-0.937	-1.131
College	-1.585	-1.020
Standard Deviation of Wage Shocks:		
High School	0.370	0.373
College	0.387	0.433
Standard Deviation of Fixed Effects:		
High School	0.415	0.414
College	0.475	0.459

Table 7: Estimates III: Wage Process Parameters

Moment:	Data	Model
Share Married, Ages 22 to 60	0.61	0.65
Share Divorced, Ages 22 to 60	0.12	0.11
Share w/Child < 6, Ages 22 to 38	0.34	0.38
Share Employed:		
Men, HS	0.74	0.79
Men, College	0.91	0.94
Women, HS	0.64	0.66
Women, College	0.79	0.83
Weekly Hours Spent in Home Production:		
Men	12.3	14.1
Women	25.2	21.2
Share of Households in which Woman is Higher Earner:		
When Husband is High School Graduate	29.3	33.7
When husband is College Graduate	26.2	31.2

Table 8: Summary Statistics, Data and Model Simulation

Employment Changes:	Model	Data
By Child Status:		
Women with children under age 6:	0.0547	0.0599
Women without children under age 6:	0.0297	0.0315
By Education:		
College-educated women:	0.0461	0.0438
High school or less:	0.0269	0.0300
HS+Low-type (model), HS drop-out (data):	-0.0051	-0.0075

Table 9: Bush Tax Cut and Women's Employment (Husbands' Earning $60-70k)

	Men	Women
Weekly Hours Worked, Cond'l on Working	-0.7	1.1
Weekly Hours in Home Production	0.9	-2.9
Pareto weight	-0.03	0.03
Assortation (education)	0.01	0.01
Assortation (ability type)	0.05	0.05
Wages, 30-45	-0.1%	2.4%
Wages, 45+	-0.1%	3.8%

Table 10: Simulation Results: Effects of the Individual Taxation Policy

	Individual Taxation	Joint + Secondary Earner Deduction
Mean Women's Marginal TR	0.26	0.33
Mean Women's Average TR	0.16	0.19

Table 11: Marginal and Average Tax Rates: Individual Taxation Vs. Secondary Earner Deduction

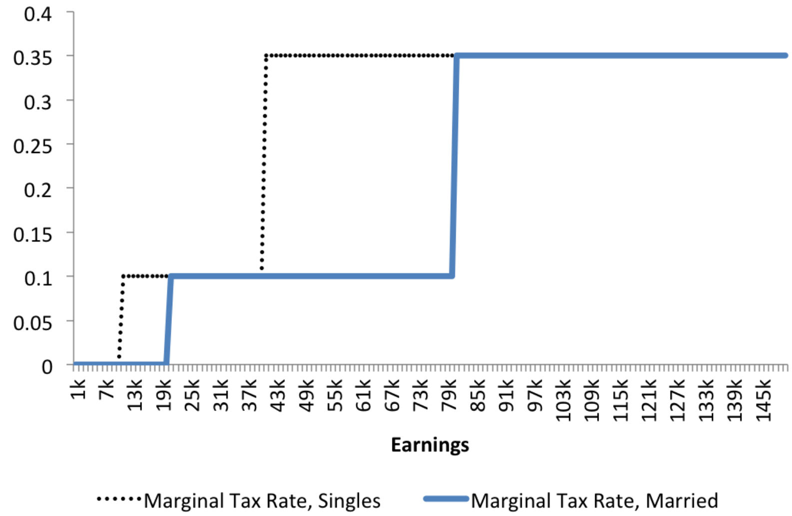


Figure 1: Tax Schedule: Marginal Tax Rate

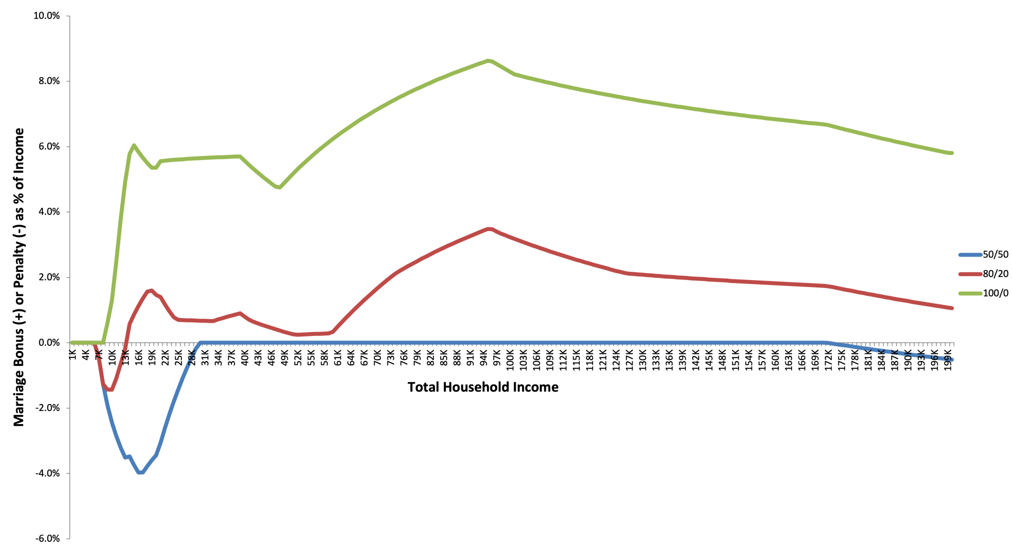
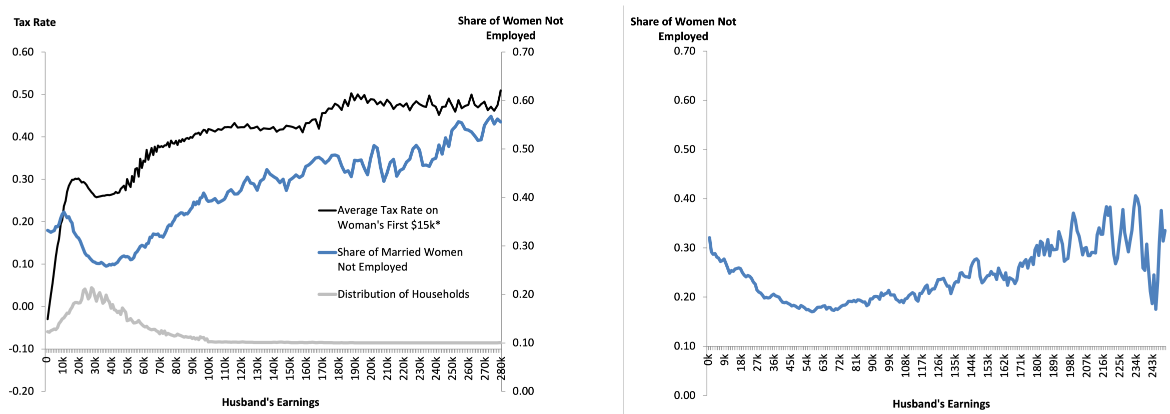


Figure 2: U.S. Tax Schedule: Marriage Bonuses and Penalties, 2015

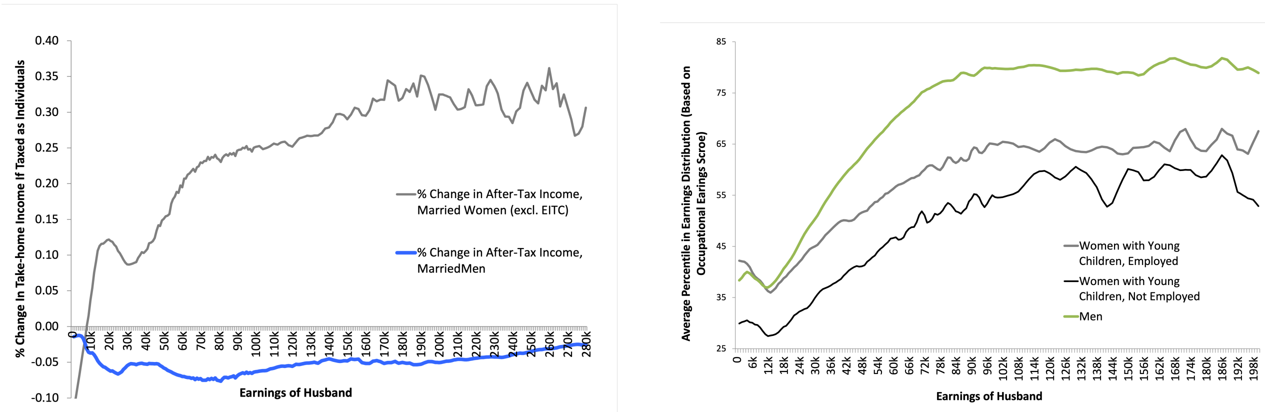


(a) Women's Non-Employment, US

(b) Women's Non-Employment, Canada

Figure 3: Women's Non-employment and Tax Rates, Comparison Between US and Canada

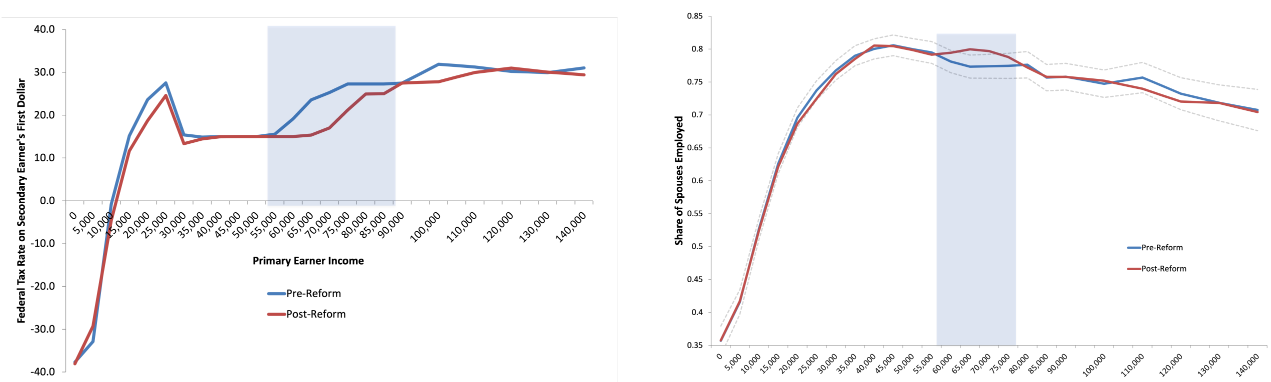
Notes: In the computation of the average tax rate, we include federal income taxes, FICA, state taxes weighted by population, the Earned Income Tax Credit and the Child Tax Credit. The EITC helps explain the steep increase in the average tax rate at very low levels of income and the subsequent decline for households with income between $\$20,000$ and $\$40,000$.



(a) Percent Change in After-tax Income

(b) Earnings Potential of Women and Men

Figure 4: After-tax Income Changes and Earnings Potential



(a) Marginal Tax Rate for Married Women

(b) Labor Force Participation Married Women

Figure 5: Effect of Bush Tax Cuts on Married Women

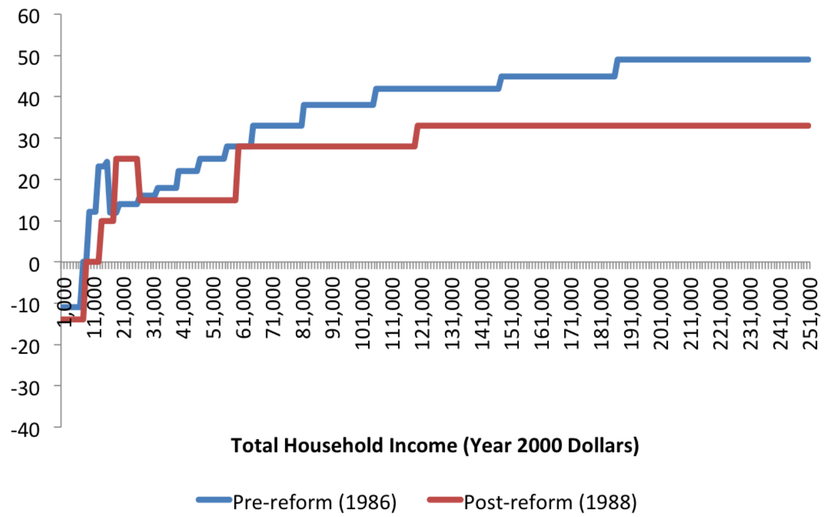


Figure 6: 1986 Reagan Tax Reform

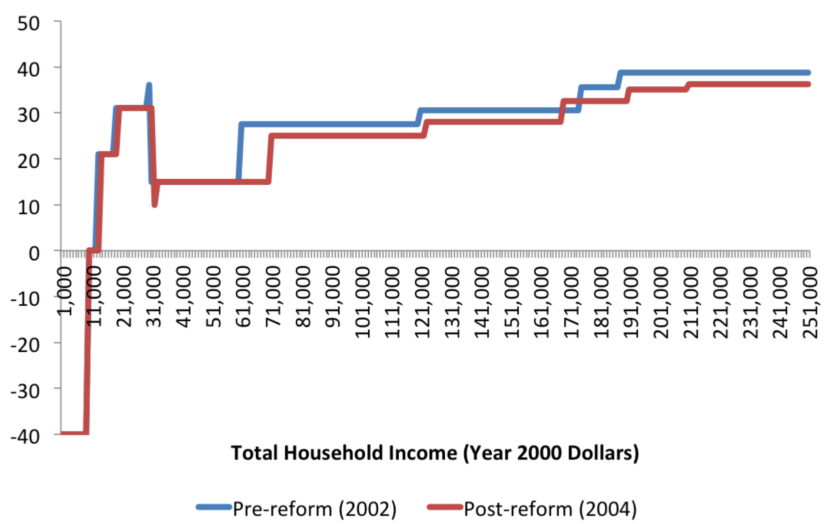


Figure 7: 2003 Bush Tax Reform

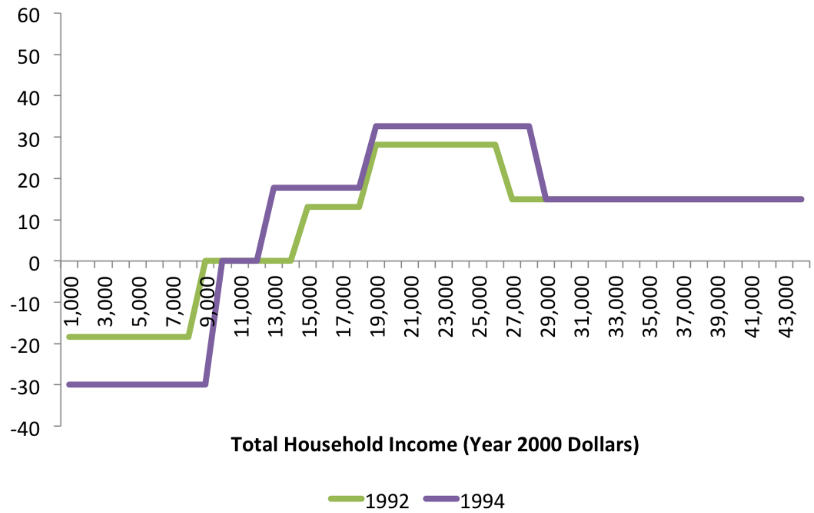


Figure 8: 1993 EITC Reform

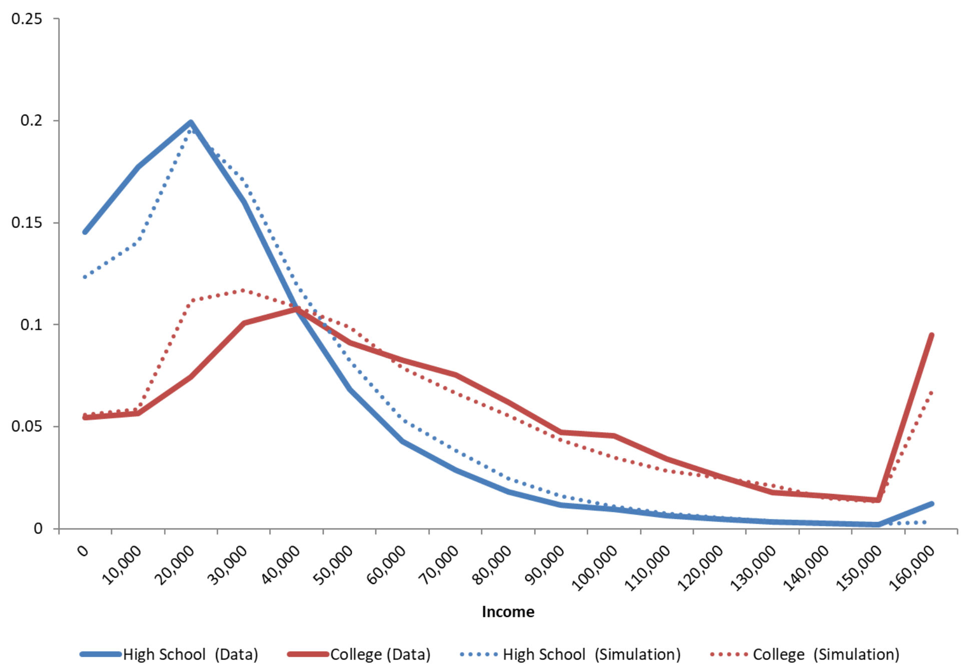


Figure 9: Income Distribution of Men By Education (Ages 25-54)

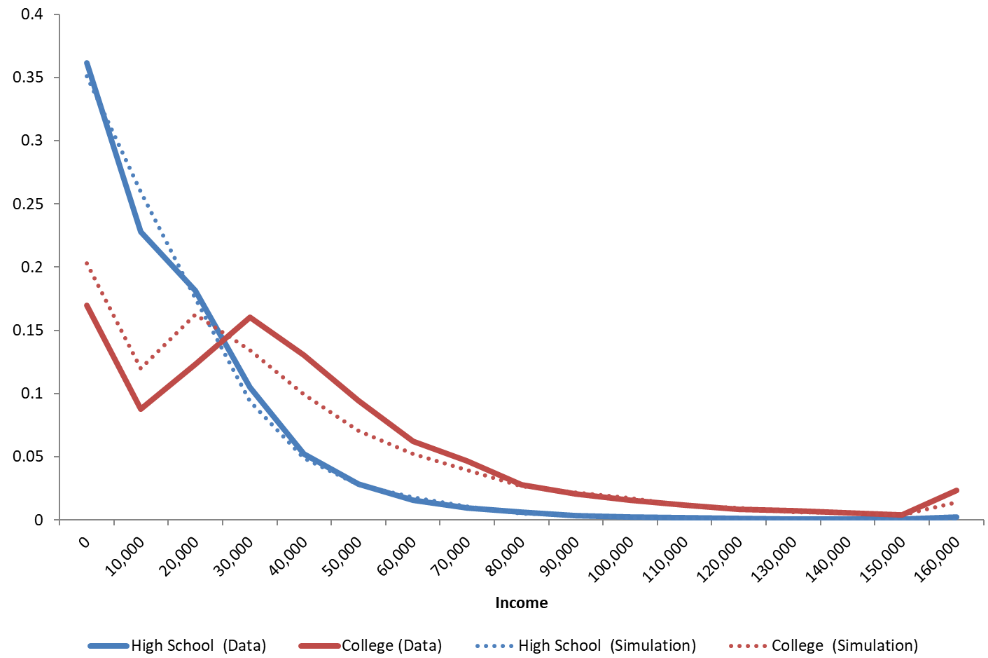


Figure 10: Income Distribution of Women (Ages 25-54)

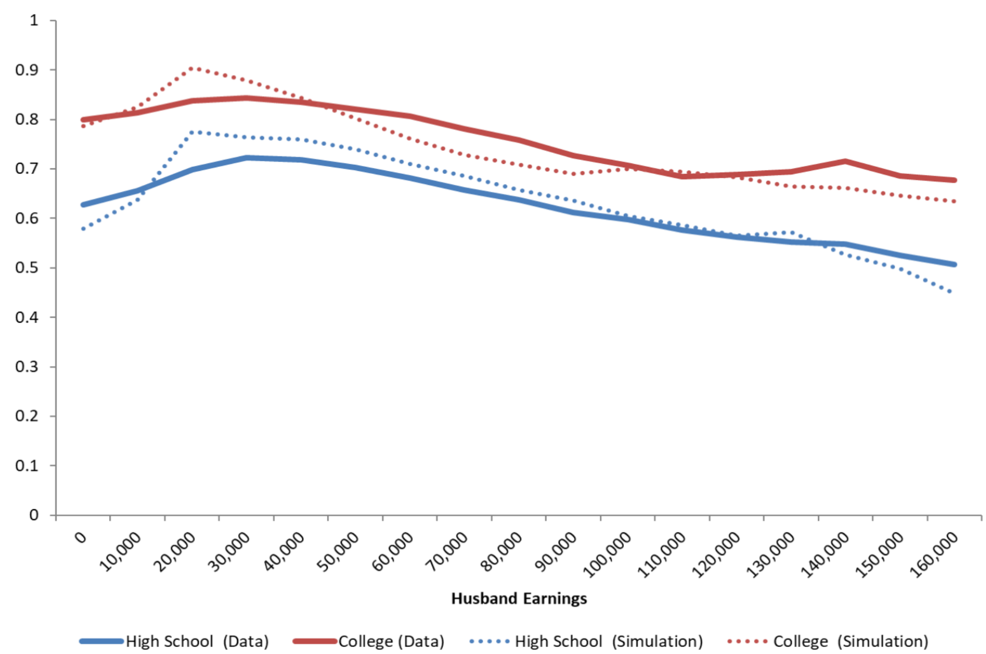


Figure 11: Share of Women Employed By Husband's Earnings and Education

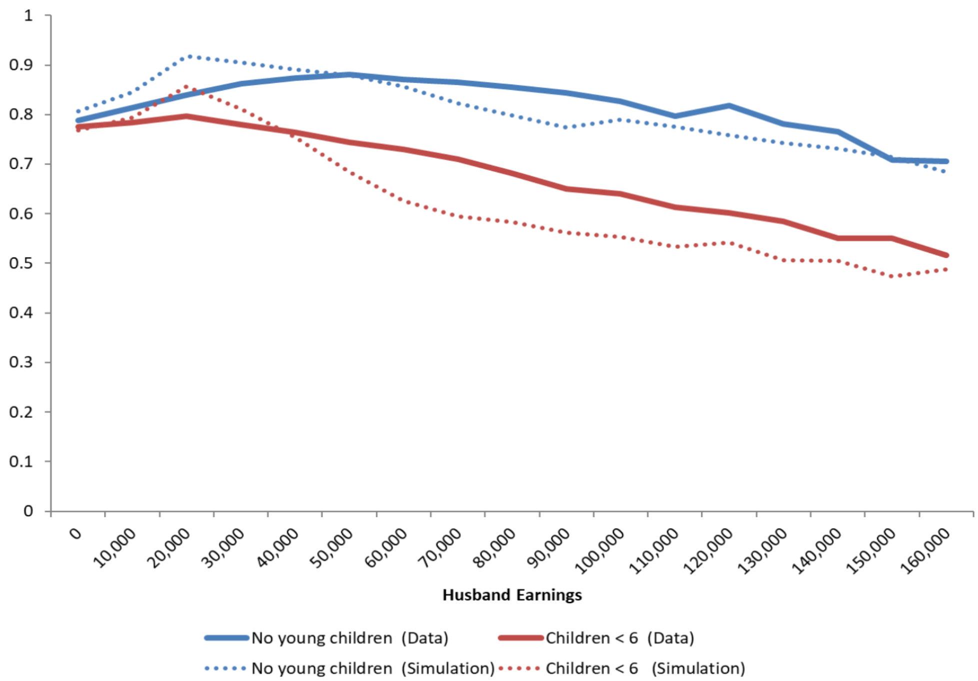


Figure 12: Share of College Women Employed By Husband's Earnings and Young Children

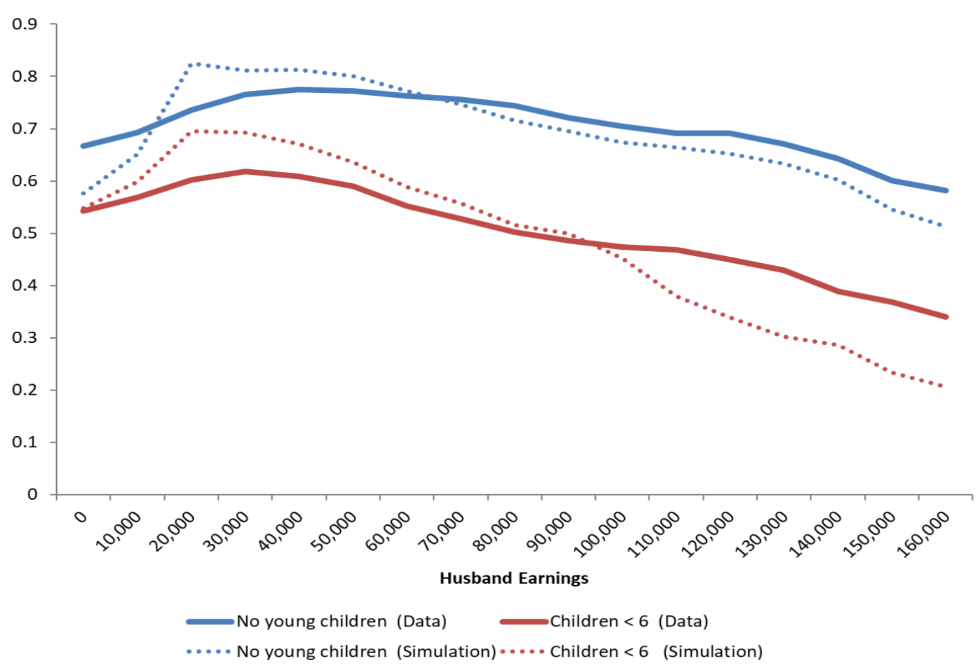


Figure 13: Share of High School Women Employed By Husband's Earnings and Young Children

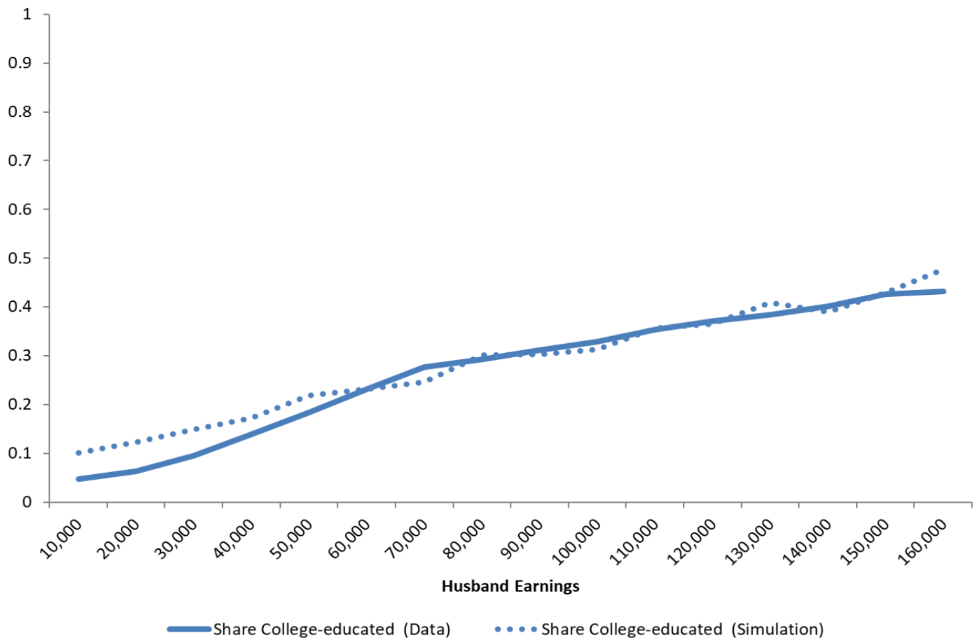


Figure 14: Share of Women With College Education, By Husband's Earnings

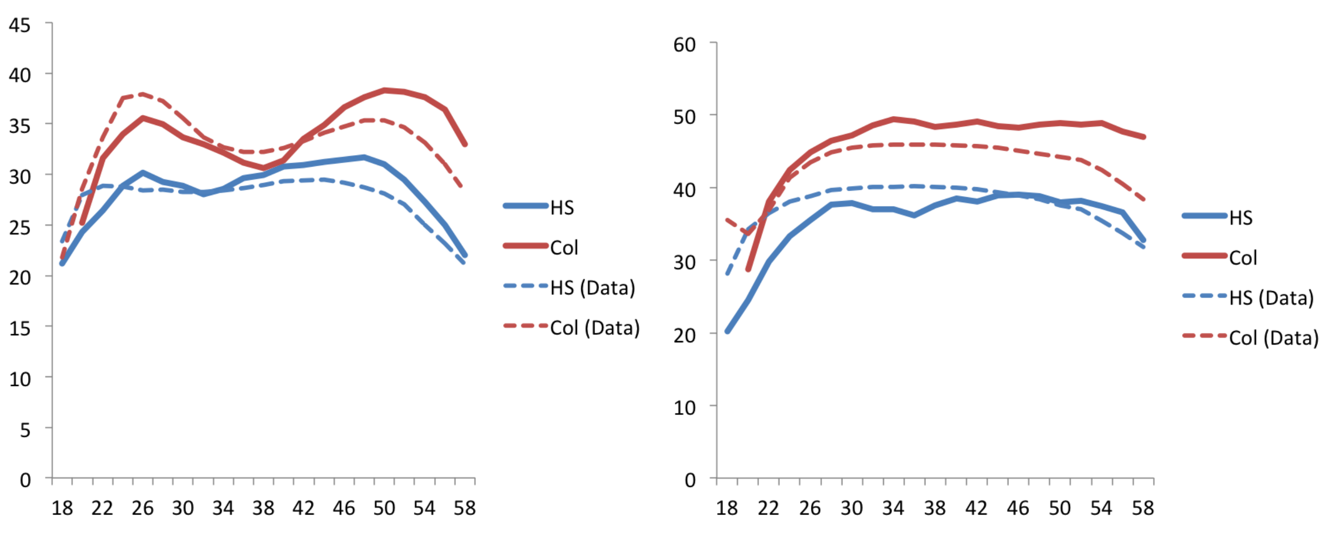


Figure 15: Weekly Hours Worked, Model and Data

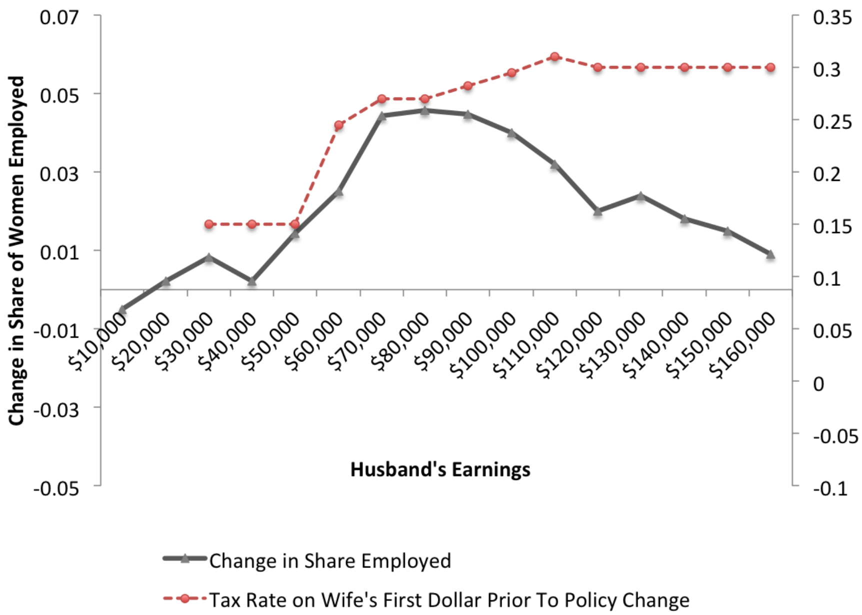


Figure 16: Change in Share of Women Employed, by Husband's Earnings

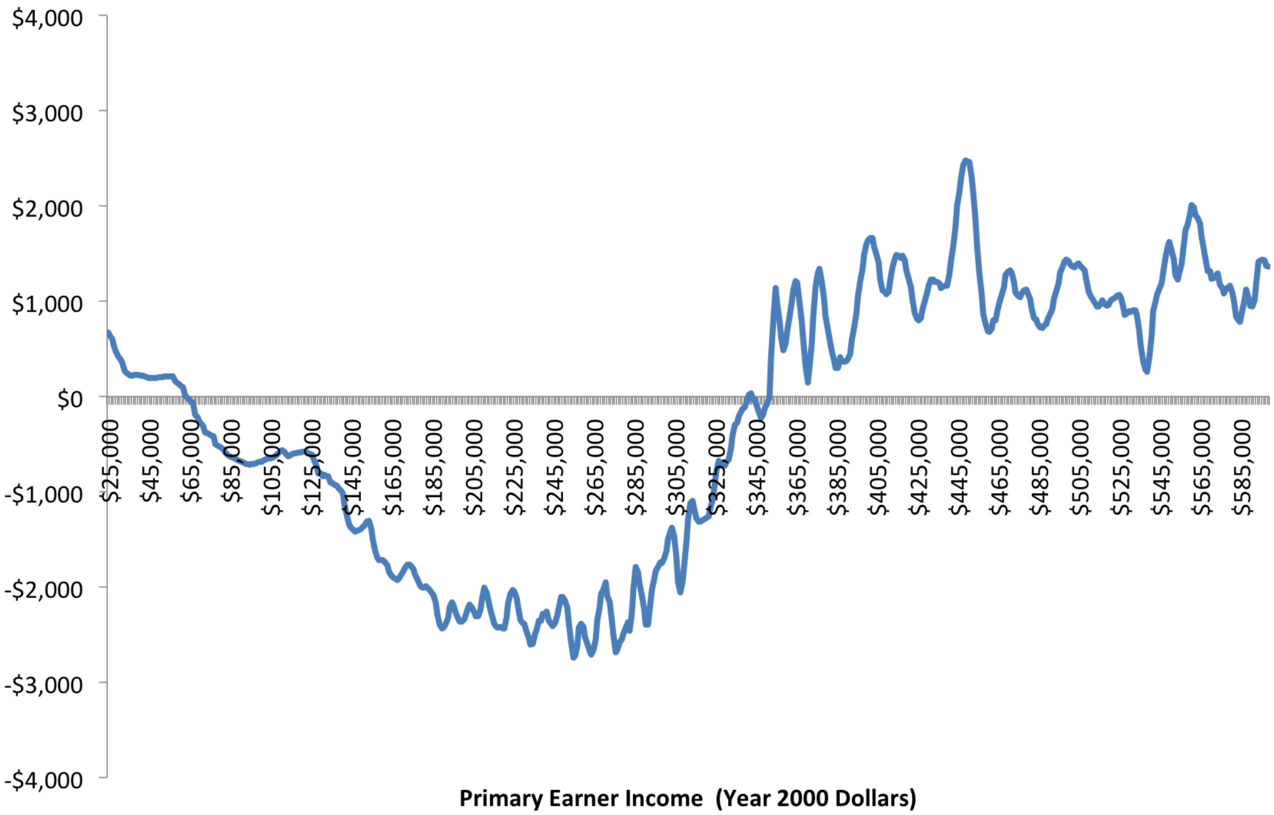


Figure 17: Change in Total Household Take-Home Income, by Income of Primary Earner: Static Evaluation

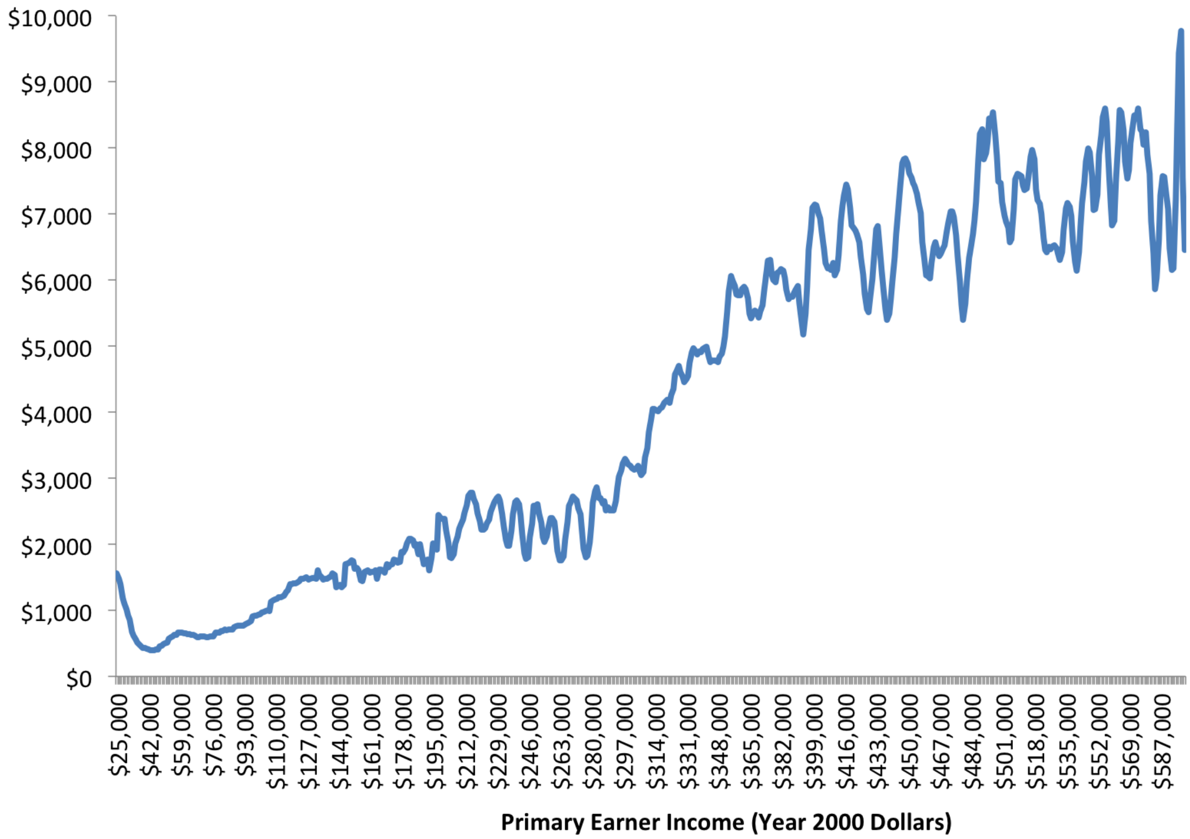


Figure 18: Change in Total Household Take-Home Income, by Income of Primary Earner: Static Evaluation, Two-Earner Households

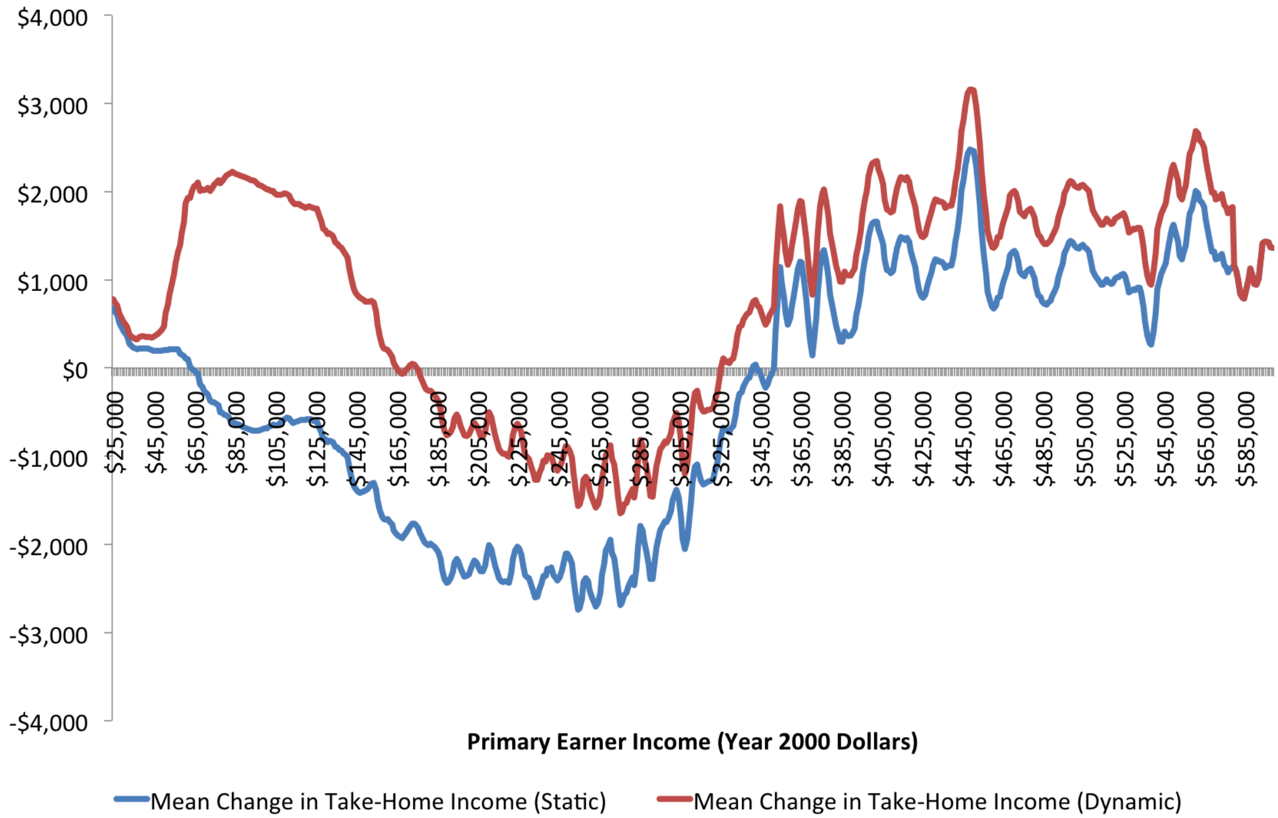


Figure 19: Change in Total Household Take-Home Income, by Income of Primary Earner: Dynamic Evaluation

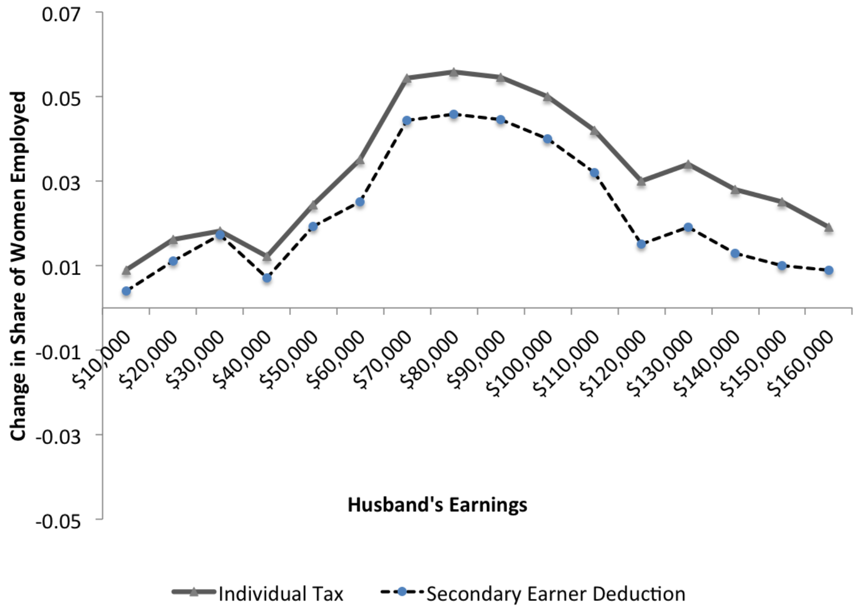


Figure 20: Labor Force Participation Responses to the Secondary Earner Tax Deduction ($20k) vs. Individual Taxation

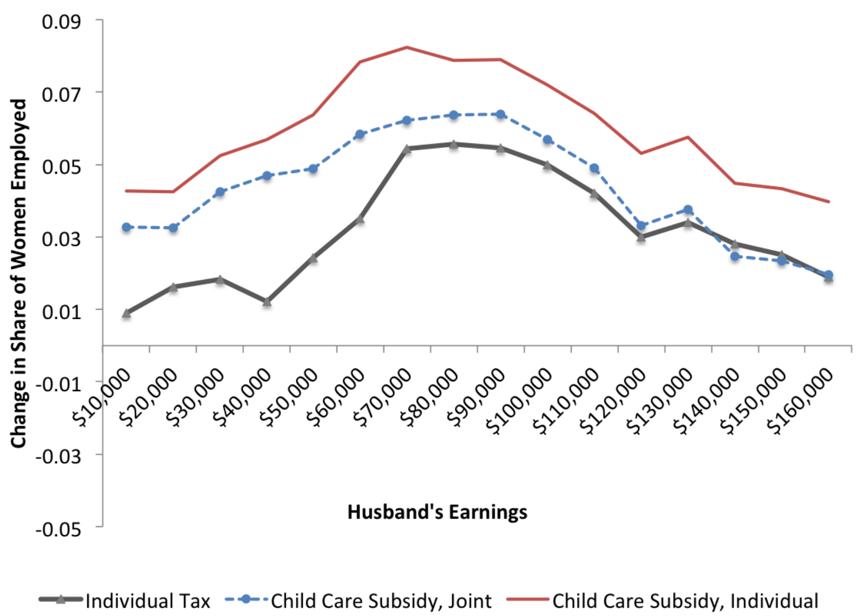


Figure 21: Labor Force Participation and the Childcare Policy (Max. $7,000)

A Appendix: Identification

In this section, we discuss the identification of the model's parameters. With the exception of the curvature of the sub-utility for consumption σ_c and the discount factor β, we estimate all the model's parameters using the data described in Section 2. The parameter σ_c is set equal to 1.5 based on Blundell, Browning, and Meghir (1994) and Attanasio and Weber (1995), and the parameter β is set equal to 0.98 following Attanasio, Low, and Sánchez-Marcos (2008).

We present formal arguments for the identification of the parameters separately for each subset. In our non-linear model, this entails showing that, under our functional form assumptions, there is only one set of parameters that corresponds to the distribution of available data. To prove identification, it is helpful to introduce a three-stage representation of the problem of an individual that is currently single and of a married couple.

A Three-stage Representation

Consider the problem of an individual that is currently single:

$$V_t^{ds}\left(b_t, e_t, n_t, a\right) = \max_{l_t, d_t, m_t, c_t, b_{t+1}} \frac{\left(c_t\right)^{1-\sigma_c}}{1-\sigma_c} + \gamma_l \frac{\left(l_t\right)^{1-\sigma_l}}{1-\sigma_l} + \gamma_Q^i \log Q_t + \beta E_t\left[V_{t+1}^{es}\left(b_{t+1}, n_{t+1}, a\right)\right] \quad (4)$$

$$s.t. \qquad c_t + m_t + \left(w_t + \tau_t^s\right)\left(l_t + d_t\right) + p_t^c n_t = \left(w_t + \tau^s\right) T + R b_t - b_{t+1}$$

$$Q_t = f\left(d_t, m_t\right),$$

where we have replaced the general tax schedule $\tau^s(w_t\left(T - l_t - d_t\right))$ with a linear schedule. This change is without loss of generality because all the tax systems we consider, are piece-wise linear for singles. In the rest of the section, we will let $w_t' = w_t + \tau_t^s$.

The problem can be first divided into two stages. Consider an arbitrary allocation of resources C to the current period t. Given this allocation, in the second stage the single individual solves the following standard static problem:

$$U\left(C, w_t', n_t\right) = \max_{l_t, d_t, m_t, c_t} \frac{\left(c_t\right)^{1-\sigma_c}}{1-\sigma_c} + \gamma_l \frac{\left(l_t\right)^{1-\sigma_l}}{1-\sigma_l} + \gamma_Q^i \log Q_t \tag{5}$$
$$s.t. \qquad c_t + m_t + w_t'\left(l_t + d_t\right) + p_t^c n_t = C$$
$$Q_t = f\left(d_t, m_t\right).$$

Then, in the first stage, the single individual chooses optimally how much to allocate to the current period by solving:

$$\max_{C, b_{t+1}} U\left(C, w_t', n_t\right) + \beta E_t\left[V_{t+1}^{es}\left(b_{t+1}, n_{t+1}, a\right)\right]$$
$$s.t. \qquad C + b_{t+1} = w_t'T + Rb_t.$$

The original problem and the two-stage representation clearly have the same solution.

The second stage of the two-stage representation can be further divided into two stages. Consider an arbitrary amount of resources $\bar{Q}$ allocated in the current period to the production of the public good. Then, in the third stage, the single individual chooses the time and market inputs invested in household production that solve the following problem:

$$U\left(\bar{Q}_t, w_t'\right) = \max_{d_t, m_t} \log Q_t \tag{6}$$
$$s.t. \quad w_t' d_t + m_t = \bar{Q}_t,$$
$$Q_t = \left(\eta \cdot \left(\alpha d_t\right)^\tau + (1-\eta) \cdot \left(m_t\right)^\tau\right)^{\frac{1}{\tau}}, \quad 0 \leq d \leq T.$$

The second stage can now be written as follows:

$$U^s\left(C, w_t', n_t\right) = \max_{l_t, c_t,} \frac{\left(c_t\right)^{1-\sigma_c}}{1-\sigma_c} + \gamma_l \frac{\left(l_t\right)^{1-\sigma_l}}{1-\sigma_l} + \gamma_Q^i U\left(\bar{Q}_t, w'\right) \tag{7}$$
$$s.t. \qquad c_t + w_t' l_t + \bar{Q}_t + p_t^c n_t = C.$$

It is straightforward to show that the three-stage representation and the original problem have the same solution.

We can derive a similar three-stage representation for a couple that is currently married.

In the identification discussion, we will only use the third stage which, for couples, takes the following form:

$$U^m\left(\bar{Q}_t, w_t^{1'}, w_t^{2'}\right) = \max_{d_t^1, d_t^2, m_t} \log Q_t \tag{8}$$
$$s.t. \quad w_t^{1'} d_t^1 + w_t^{2'} d_t^2 + m_t = \bar{Q}_t,$$
$$Q_t = \left(\eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}} + (1-\eta) \cdot m^\tau\right)^{\frac{1}{\tau}},$$

where, even for couples, the alternative formulation relies on considering only piece-wise linear taxation systems.

Wage and Experience Parameters: $\beta_0^{g,i}$, β_1^g, β_2^g, σ_ϵ^g, σ_a^g, λ, δ

Given the model assumptions, the fixed-effects, the parameters $\beta_0^{g,i} - \beta_2^g$ and $\psi_1 - \psi_7$ of the wage processes (3) can be consistently estimated using ordinary least squared (OLS) if years in full-time and part-time jobs and years without a job are observed. They are therefore identified.[3] Using the fixed-effects and $\psi_0 - \psi_7$, we can also consistently estimate and, hence, identify the standard deviation of the distribution of ability (the fixed effect), σ_a^g, and of the error terms, σ_ϵ^g. The parameters governing the accumulation of human capital can then be identified by noting that $\lambda = \frac{\psi_2}{\psi_1}$ and $\delta = \frac{\psi_3}{\psi_1}$.

Production Function Parameters: τ, v, η, α_1, α_2

The parameter η takes six different values depending on education (high school or college) and presence and age of children (no children, children younger than 6, children of age 6 or older). We only discuss the identification of one of the six parameters by conditioning on one particular level of education and child status. The argument for the identification of the other five parameters follows directly.

Consider the third stage of the problem (6) for a single woman with a particular education and child status. By taking the first order conditions for time ,d, and market inputs m, one

[3] As we discuss in details in the next section, in the estimation we control for selection into the labor market.

obtains:

$$\frac{1}{Q}\frac{\partial f}{\partial d} = w'\lambda$$
$$\frac{1}{Q}\frac{\partial f}{\partial m} = \lambda,$$

where λ is the Lagrangian multiplier of the budget constraint. As,

$$\frac{\partial f}{\partial d} = \left(\eta \cdot (\alpha_1 d_t)^\tau + (1-\eta)\cdot (m_t)^\tau\right)^{\frac{1}{\tau}-1} \eta \cdot (\alpha_1 d_t)^{\tau-1}\alpha_1$$
$$\frac{\partial f}{\partial m} = \left(\eta \cdot (\alpha_1 d_t)^\tau + (1-\eta)\cdot (m_t)^\tau\right)^{\frac{1}{\tau}-1} (1-\eta) \cdot (m_t)^{\tau-1},$$

the two first order conditions become:

$$\frac{1}{Q}\left(\eta \cdot (\alpha_1 d_t)^\tau + (1-\eta)\cdot (m_t)^\tau\right)^{\frac{1}{\tau}-1} \eta \cdot (\alpha_1 d_t)^{\tau-1}\alpha_1 = w'\lambda$$
$$\frac{1}{Q}\left(\eta \cdot (\alpha_1 d_t)^\tau + (1-\eta)\cdot (m_t)^\tau\right)^{\frac{1}{\tau}-1} (1-\eta) \cdot (m_t)^{\tau-1} = \lambda.$$

By dividing the first equation by the second, we obtain,

$$\frac{\eta\alpha_1}{1-\eta}\left(\frac{\alpha_1 d_t}{m_t}\right)^{\tau-1} = w'.$$

By taking logs and solving for $\ln\frac{d_t}{m_t}$, we have,

$$\ln\frac{d_t}{m_t} = \frac{\ln\frac{\eta}{1-\eta} + \tau\ln\alpha_1}{\tau-1} + \frac{1}{\tau-1}\ln w' + \epsilon_w,$$

where ϵ_w is a measurement error on $\ln w'_t$. Thus, if w' and $\frac{d_t}{m_t}$ are observed, $\dfrac{\partial \ln\frac{d_t}{m_t}}{\partial \ln w'}$ identifies τ and $E\left[\ln\frac{d_t}{m_t}\middle| w'\right]$ identifies $\ln\frac{\eta}{1-\eta} + \tau\ln\alpha_1$.

Following the same steps for a single men with the same education and child status, we can identify $\ln\frac{\eta}{1-\eta} + \tau\ln\alpha_2$. By taking differences between $\ln\frac{\eta}{1-\eta} + \tau\ln\alpha_1$ and $\ln\frac{\eta}{1-\eta} + \tau\ln\alpha_2$, we obtain $\tau\ln\frac{\alpha_1}{\alpha_2}$. Thus, $\frac{\alpha_1}{\alpha_2}$ is also identified. Given our production function, we cannot separately identify η, α_1, α_2, as we can multiply the production function of singles and married by the same constant and generate the some decisions. We can therefore normalize one the parameters without affecting our simulation results. We have chosen to normalize $\alpha_2 = 2 - \alpha_1$. Under this normalization, η and α_1 are identified.

To identify the last production function parameter, v, consider the third stage of a married couple's problem (8) with some education and child status. The first order conditions with respect to spousal time, d^1 and d^2, take the following form:

$$\frac{1}{Q}\frac{\partial f}{\partial d^1} = w^{1'}\lambda$$
$$\frac{1}{Q}\frac{\partial f}{\partial d^2} = w^{2'}\lambda,$$

where

$$\frac{\partial f}{\partial d^i} = \left(\eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}} + (1-\eta) \cdot m^\tau\right)^{\frac{1}{\tau}-1} \eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}-1} \alpha_i (d^i)^{v-1}.$$

Thus, two first order conditions can be written as

$$\frac{1}{Q}\left(\eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}} + (1-\eta) \cdot m^\tau\right)^{\frac{1}{\tau}-1} \eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}-1} \alpha_1 (d^1)^{v-1} = w^{1'}\lambda$$
$$\frac{1}{Q}\left(\eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}} + (1-\eta) \cdot m^\tau\right)^{\frac{1}{\tau}-1} \eta \cdot (\alpha^1 \cdot (d^1)^v + \alpha^2 \cdot (d^2)^v)^{\frac{\tau}{v}-1} \alpha_2 (d^2)^{v-1} = w^{2'}\lambda.$$

By dividing the first equation by the second, we obtain,

$$\frac{\alpha_1}{\alpha_2}\left(\frac{d_t^1}{d_t^2}\right)^{v-1} = \frac{w^{1'}}{w^{2'}}.$$

By taking logs and solving for $\frac{d_t^1}{d_t^2}$, we have,

$$\ln \frac{d_t^1}{d_t^2} = \frac{1}{v-1}\frac{\alpha_1}{\alpha_2} + \frac{1}{v-1}\ln\frac{w^{1'}}{w^{2'}} + \epsilon_{12},$$

where ϵ_{12} is the difference of measurement errors on $\ln w_t^{1'}$ and $\ln w_{t'}^2$. Thus, if $\frac{w^{1'}}{w^{2'}}$ and $\frac{d_t^1}{d_t^2}$ are observed, $\frac{\partial \ln \frac{d_t^1}{d_t^2}}{\partial \ln \frac{w^{1'}}{w^{2'}}}$ identifies v.

Preference Parameters: $\sigma_l,\ \gamma_l,\ \gamma_Q$

For the identification of the parameter σ_l, we derive the Frish leisure function from the original problem (4) of an individual that is single at t. The first order condition for leisure takes the following form:

$$\gamma_l l_t^{-\sigma_l} = w_t' \lambda_t, \tag{9}$$

where λ_t is the Lagrangian multiplier of the budget constraint or, equivalently, the marginal utility of wealth in the period in which we observe the single individual. Taking logs of both sides, we have:

$$\ln \gamma_l - \sigma_l \ln l_t = \ln w_t' + \ln \lambda_t.$$

Solving for $\ln l$, we obtain the following Frish leisure function:

$$\ln l_t = -\frac{1}{\sigma_l}\left(\ln \gamma_l + \ln \lambda_t + \ln w_t' + \epsilon_w\right).$$

Thus, the Frish leisure elasticity with respect to the after-tax wage $\frac{\partial \ln l_t}{\partial \ln w_t'} = -\frac{1}{\sigma_l}$ identifies σ_l.

Consider now the parameter γ_l. The first order condition for private consumption in the original problem (4) of an individual that is single at t take the form

$$c_t^{-\sigma_c} = \lambda_t.$$

By dividing it by the first order condition for leisure (9), we have

$$\frac{c_t^{-\sigma_c}}{\gamma_l l_t^{-\sigma_l}} = \frac{1}{w_t'}.$$

By taking logs

$$-\sigma_c \ln c_t - \ln \gamma_l + \sigma_l \ln l_t = -\ln w_t' - \epsilon_w.$$

By taking the expectation of both sides and solving for $\ln \gamma_l$, we obtain

$$\ln \gamma_l = \sigma_c E\left[\ln c_t\right] - \sigma_l E\left[\ln l_t\right] - E\left[\ln w_t'\right].$$

Since, we have already shown the σ_l is identifies, γ_l is identified if $c_t,\ l_t$ and w_t' are observed.

We can identify γ_Q using similar arguments. The first order condition for time invested in household production in the second stage problem (4) of an individual that is single at t is

$$\gamma_Q \frac{1}{Q_t} \frac{\partial f}{\partial d_t} = w_t' \lambda_t.$$

By dividing this equation by the private consumption first order condition, one obtains

$$\gamma_Q \frac{c^{\sigma_c}}{Q_t} \frac{\partial f}{\partial d_t} = w_t'.$$

We can now take logs to have

$$\ln \gamma_Q = -\sigma_c \ln c_t + lnf\left(d_t, m_t\right) - ln \frac{\partial f}{\partial d_t} - \ln w_t' - \epsilon_w.$$

Finally, by taking the expectation of both sides,

$$\ln \gamma_Q = -\sigma_c E\left[\ln c_t\right] + E\left[lnf\left(d_t, m_t\right)\right] - E\left[ln \frac{\partial f}{\partial d_t}\right] - E\left[\ln w_t'\right].$$

We have shown that the production function parameters are identified. $\ln \gamma_Q$ is therefore identified if $c_t,\ d_t,\ m_t$ and w_t' are observed.

Fertility Process

In our model, the probability of a birth is a function of discrete variables. If births and the corresponding discrete variables are observed, then there is only one conditional probability function for births that is consistent with the data. The fertility process is therefore identified.

Meeting, Marriage, and Divorce Parameters: μ_θ, σ_θ, σ_z, K_d, π_{HS}, π_C, ρ

The initial match quality parameters μ_θ and σ_θ can be identified by the probability of marriage. As we do not have data on meeting probability, we cannot separately identify the probability that a person meets someone from the probability of marrying. We therefore normalize the meeting probability to one. In the model, a single individual with a given education can meet a potential spouse with the same or different education. We start by considering a simplified case in which all individuals have the same education. We then generalize the result to include differences in education.

In our model, individuals do not change their marital status after retirement, which is a good approximation of the data. As a consequence, the expected value of a married individual at the time of retirement $t = R$, conditional on the state variables at $R-1$, takes the following form:

$$E_{R-1}\left[V^m\left(S,R\right)\right] = E_{R-1}\left[\bar{V}^m\left(S,R\right) + \theta_R\right] = E\left[\bar{V}^m\left(S,R\right)\right] + \theta_{R-1},$$

where $\bar{V}^m\left(S,R\right)$ is the value function at retirement without the realization of match quality and $E_{R-1}\left[\theta_R\right] = E_{R-1}\left[\theta_{R-1} + z_R\right] = \theta_{R-1}$. Denote by $z_M\left(S,R\right)$ the optimal decision of a married individual at time R given the state variables S. Then,

$$\begin{aligned}
&E_{R-1}\left[\bar{V}^m\left(S,R\right)\right] = E_{R-1}\left[u\left(z_M\left(S,R\right)\right) + \beta E_R\left[V^m\left(S,R+1\right)\right]\right] = E_{R-1}\left[u\left(z_M\left(S,R\right)\right)\right] \\
&+ \beta E_{R-1}\left[\bar{V}^m\left(S,R+1\right) + \theta_{R+1}\right] = E_{R-1}\left[u\left(z_M\left(S,R\right)\right)\right] + \beta E_{R-1}\left[\bar{V}^m\left(S,R+1\right)\right] + \beta\theta_{R-1} = \\
&\ldots = E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right] + \theta_{R-1}\sum_{\tau=R+1}^{T}\beta^{\tau-R}.
\end{aligned}$$

Hence,

$$E_{R-1}\left[V^m\left(S,R\right)\right] = E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right] + \theta_{R-1}\sum_{\tau=R}^{T}\beta^{\tau-R}.$$

Similar calculations for an individual single at the time of retirement $t = R$, conditional on the state variables at $R-1$, produces

$$E_{R-1}\left[V^s\left(S,R\right)\right] = E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_s\left(S,\tau\right)\right)\right].$$

Consider a couple that meets at $R-1$. Let $\bar{\mu}$ be the Pareto weight that makes individual 2 in the couple indifferent between marrying and staying single. The, this couple chooses to marry if individual 1 satisfy the following inequality:

$$V^m(S,R-1,\bar{\mu}) = u(z_M(S,R-1,\bar{\mu})) + \theta_0 + \beta E_{R-1}[V^m(S,R)] \geq u(z_s(S,R-1)) + \beta E_{R-1}[V^s(S,R)] = V^s(S,R-1).$$

Let a and a_s be the ability of the individual and potential spouse. The couple observes the realizations a, a_s and θ_0 before making the marriage decision. But, as econometricians, we do not observed them. The probability that this individual marries the partner is therefore equal to the probability that the three unobservables θ_0, a, and a_s are such that the previous inequality is satisfied, i.e.

$$\begin{aligned}
&P(\theta_0, a, a_s : V^m(S,R-1,\bar{\mu}) \geq V^s(S,R-1)) \\
&= \int_a \int_{a_s} P(\theta_0 : V^m(S,R-1,\bar{\mu}) \geq V^s(S,R-1) | a, a_s) f(a, a_s; \rho)\, da\, da_s \\
&= \int_a \int_{a_s} P\left(u(z_M(S,R-1,\bar{\mu})) + \theta_0 + \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_M(S,\tau))\right] + \theta_0 \beta \sum_{\tau=R}^{T} \beta^{\tau-R} \geq \right. \\
&\left. \geq\ u(z_s(S,R-1)) + \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_s(S,\tau))\right] \middle| a, a_s \right) f(a, a_s; \rho)\, da\, da_s \\
&= \int_a \int_{a_s} P\left(\theta_0 \sum_{\tau=R-1}^{T} \beta^{\tau-R+1} \geq -u(z_M(S,R-1,\bar{\mu})) - \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_M(S,\tau))\right] + \right. \\
&\left. +\ u(z_s(S,R-1)) + \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_s(S,\tau))\right] \middle| a, a_s \right) f(a, a_s; \rho)\, da\, da_s \\
&= \int_a \int_{a_s} P\left(\frac{\theta_0 - \mu_\theta}{\sigma_\theta} \geq \frac{-u(z_M(S,R-1,\bar{\mu})) - \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_M(S,\tau))\right]}{\sigma_\theta \sum_{\tau=R-1}^{T} \beta^{\tau-R+1}} + \right. \\
&\left. + \frac{u(z_s(S,R-1)) + \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_s(S,\tau))\right]}{\sigma_\theta \sum_{\tau=R-1}^{T} \beta^{\tau-R+1}} - \frac{\mu_\theta}{\sigma_\theta} \middle| a, a_s \right) f(a, a_s; \rho)\, da\, da_s \\
&= \int_a \int_{a_s} \left[1 - \Phi\left(\frac{-u(z_M(S,R-1,\bar{\mu})) - \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_M(S,\tau))\right]}{\sigma_\theta \sum_{\tau=R-1}^{T} \beta^{\tau-R+1}} + \right.\right. \\
&\left.\left. + \frac{u(z_s(S,R-1)) + \beta E_{R-1}\left[\sum_{\tau=R}^{T} \beta^{\tau-R} u(z_s(S,\tau))\right]}{\sigma_\theta \sum_{\tau=R-1}^{T} \beta^{\tau-R+1}} - \frac{\mu_\theta}{\sigma_\theta} \middle| a, a_s \right) f(a, a_s; \rho) \right] da\, da_s
\end{aligned}$$

We have already shown identification of the parameters defining

$$\frac{-u\left(z_M\left(S,R-1,\bar{\mu}\right)\right)-\beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right]+u\left(z_s\left(S,R-1\right)\right)+\beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_s\left(S,\tau\right)\right)\right]}{\sum_{\tau=R-1}^{T}\beta^{\tau-R+1}}.$$

This quantity is therefore known and only the parameters μ_θ, σ_θ and ρ need to be identified. The derived probability distribution satisfies all the conditions required for a maximum likelihood estimator to produce consistent estimates of $\mu_\theta, \sigma_\theta$ and ρ. These parameters are therefore also identified.

In the model, an individual with education g can meet a spouse with the same education ($g_s = g$) with probability π or with a different education with probability $1-\pi$. The probability that someone with education g marries someone with the same education, different education, or does not marry are therefore:

$$\pi P\left(\theta_0, a, a_s : V^m\left(S,R-1,\bar{\mu}\right) \geq V^s\left(S,R-1\right)|g_s = g\right),$$

$$\left(1-\pi\right)P\left(\theta_0, a, a_s : V^m\left(S,R-1,\bar{\mu}\right) \geq V^s\left(S,R-1\right)|g_s \neq g\right),$$

and

$$\begin{aligned}&1-\pi P\left(\theta_0, a, a_s : V^m\left(S,R-1,\bar{\mu}\right) \geq V^s\left(S,R-1\right)|g_s = g\right)\\&-\left(1-\pi\right)P\left(\theta_0, a, a_s : V^m\left(S,R-1,\bar{\mu}\right) \geq V^s\left(S,R-1\right)|g_s \neq g\right).\end{aligned}$$

By using these probabilities in place of the one used before to construct the maximum likelihood estimator and the previous argument, one can show that $\mu_\theta, \sigma_\theta$, ρ, and ρ are identified.

The variance of the match quality shock σ_z and the cost of divorce K_d can be identified by the probability of divorce. Consider a couple that enters the period before retirement $R-1$ as married and let $\bar{\mu}$ be the Pareto weight that makes individual 2 in the couple indifferent between staying married and becoming single. Then, this couple chooses to divorce if individual

1 satisfy the following inequality:

$$V^m(S,R-1,\bar{\mu}) = u(z_M(S,R-1,\bar{\mu})) + \theta_{R-1} + \beta E_{R-1}[V^m(S,R)] <$$
$$u(z_s(S,R-1)) + \beta E_{R-1}[V^s(S,R)] - K_d = V^s(S,R-1) - K_d.$$

Let a and a_s be the ability of the individual and potential spouse and θ_{R-2} the match quality with which they enter the period. Then, conditional on the state variables $a,\ a_s$ and θ_{R-2} the probability that the couple divorces is equal to the probability that match quality θ_{R-1} is such that the previous inequality is satisfied, i.e.

$$P\left(\theta_{R-1} : V^m(S,R-1,\bar{\mu}) \geq V^s(S,R-1) - K_d \right| a,\ a_s, \theta_{R-2}\right),$$

where $\theta_{R-1}|\theta_{R-2} = \theta_{R-2} + z_R|\theta_{R-2} \sim N(\theta_{R-2}, \sigma_z)$. Also, let y_{mar} be the years the couple has been married and $\sigma^2_{\theta,z} = \sigma^2_\theta + (y_{mar}-1)\sigma^2_z$. Then, $\theta_{R-2} = \theta_0 + \sum_\tau^{y_{mar}} z_\tau \sim N(\theta_0, \sigma_{\theta,z})$. As econometricians, we do not observe $a,\ a_s$ and θ_{R-2}. We therefore need to integrate the previous probability over $a,\ a_s$ and θ_{R-2}, to obtain

$$\int_{\theta_{R-2}}\int_a\int_{a_s} P\left(\theta_{R-1} : V^m\left(S,R-1,\bar{\mu}\right) \geq V^s\left(S,R-1\right) - K_d \middle| a, a_s, \theta_{R-2}\right) f\left(a,a_s;\rho\right) g\left(\theta_{R-2};\mu_\theta,\sigma_{\theta,z}\right) da da_s d\theta_{R-2}$$

$$= \int_{\theta_{R-2}}\int_a\int_{a_s} P\left(u\left(z_M\left(S,R-1,\bar{\mu}\right)\right) + \theta_{R+1} + \beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right] < \right.$$

$$\left. < u\left(z_s\left(S,R-1\right)\right) + \beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_s\left(S,\tau\right)\right)\right] - K_d \middle| a, a_s, \theta_{R-2}\right) f\left(a,a_s;\rho\right) g\left(\theta_{R-2};\mu_\theta,\sigma_{\theta,z}\right) da da_s d\theta_{R-2}$$

$$= \int_{\theta_{R-2}}\int_a\int_{a_s} P\left(\theta_{R-1} \geq -u\left(z_M\left(S,R-1,\bar{\mu}\right)\right) - \beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right] + \right.$$

$$\left. + u\left(z_s\left(S,R-1\right)\right) + \beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_s\left(S,\tau\right)\right)\right] - K_d \middle| a, a_s, \theta_{R-2}\right) f\left(a,a_s;\rho\right) g\left(\theta_{R-2};\mu_\theta,\sigma_{\theta,z}\right) da da_s d\theta_{R-2}$$

$$= \int_{\theta_{R-2}}\int_a\int_{a_s} P\left(\frac{\theta_{R-1}-\theta_{R-2}}{\sigma_{\theta,z}} \geq \frac{-u\left(z_M\left(S,R-1,\bar{\mu}\right)\right) - \beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right] + u\left(z_s\left(S,R-1\right)\right)}{\sigma_{\theta,z}} + \right.$$

$$\left. + \frac{\beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_s\left(S,\tau\right)\right)\right] - K_d}{\sigma_{\theta,z}} - \frac{\theta_{R-2}}{\sigma_{\theta,z}} \middle| a, a_s, \theta_{R-2}\right) f\left(a,a_s;\rho\right) g\left(\theta_{R-2};\mu_\theta,\sigma_{\theta,z}\right) da da_s d\theta_{R-2}$$

$$= \int_{\theta_{R-2}}\int_a\int_{a_s} \left[1 - \Phi\left(\frac{-u\left(z_M\left(S,R-1,\bar{\mu}\right)\right) - \beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_M\left(S,\tau\right)\right)\right] + u\left(z_s\left(S,R-1\right)\right)}{\sigma_{\theta,z}} + \right.\right.$$

$$\left. + \frac{\beta E_{R-1}\left[\sum_{\tau=R}^{T}\beta^{\tau-R}u\left(z_s\left(S,\tau\right)\right)\right] - K_d}{\sigma_{\theta,z}} - \frac{\theta_{R-2}}{\sigma_{\theta,z}} \middle| a, a_s, \theta_{R-2}\right) f\left(a,a_s;\rho\right) g\left(\theta_{R-2};\mu_\theta,\sigma_{\theta,z}\right) da da_s d\theta_{R-2}$$

Analogously to the marriage probability, the derived probability distribution satisfies the four conditions required for a maximum likelihood estimator to produce consistent estimates of $\frac{K_d}{\sigma_{\theta,z}}$ and $\sigma_{\theta,z}$. These parameters are therefore also identified. Consequently, K_d is identified. Moreover, as $\sigma^2_{\theta,z} = \sigma^2_\theta + \left(y_{mar}-1\right)\sigma^2_z$ and σ_θ is identified by the marriage decision, σ_z is also identified. To account for differences in education, we just have to condition on the education of the couple in the previous probabilities of marriage.