Anti-poverty Income Transfers in the U.S.: A Framework for the Evaluation of Policy Reforms

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Anti-poverty Income Transfers in the U.S.: A Framework for the Evaluation of Policy Reforms

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Abstract

We develop a dynamic model of labor supply, consumption, savings and marriage decisions to study the behavioral responses of low-income workers to anti-poverty income transfers in the U.S. The model is calibrated to match moments from a sample of non-college-educated workers with children drawn from the 2014 Annual Social and Economic Supplement. The categorical, asset and income eligibility criteria of the transfer programs, along with the income and payroll taxes, yield complex budget constraints and introduce a web of interactions whose effects we identify and measure. We examine the workers' behavioral responses across the model's equilibrium distribution over living arrangements, labor productivities, wealth and number of children. Then we use the model to assess the effects of three recent proposals to reform the U.S. tax-transfer system, including the "21st Century Worker Tax Cut Act" and the "Tax Reform Act of 2014". A core objective of these proposals is the mitigation of the disincentives introduced by the Earned Income Tax Credit to married mothers' labor market participation. (JEL E21, H24, H31, J12)

Keywords: Anti-poverty income transfers; household decisions; cohabitation and marriage.

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1   Introduction

Income redistribution to low-income households in the U.S. has increasingly shifted toward means-tested programs with work and earnings requirements. For instance, the Earned Income Tax Credit (EITC), which subsidizes earnings for eligible tax filers, was expanded since its creation in 1975 to become one of the largest anti-poverty programs, distributing almost \$70 billion in 2014. The large size of three of its expansions —1986, 1990 and 1993— triggered a vast empirical literature estimating their effects on labor supply and marriage (Nada Eissa and Jeffrey B. Liebman 1996; Bruce D. Meyer and Dan T. Rosenbaum 2001; Eissa and Hilary W. Hoynes 2003, 2004, 2006a, 2006b, 2011; Raj Chetty, John N. Friedman and Emmanuel Saez 2013).

In a different strand of the literature, discrete choice dynamic programming models of labor supply and welfare program participation have been developed. Dynamic structural models allow for the estimation of the effects of each transfer program, as well as for assessing how the interactions among the different programs shape the costs and welfare implications of policy reforms. Some of these models contain a rich set of individual choices, such as labor supply, marriage and fertility, but do not include a consumption/savings decision, thus neglecting the role of savings as a means of self-insurance against earnings risk (Christopher A. Swann 2005; Michael P. Keane and Kenneth I. Wolpin 2010; Marc K. Chan 2013). In an important paper, Richard Blundell, Monica Costa Dias, Costas Meghir and Jonathan Shaw (2016) acknowledge this role of savings and allow households to accumulate assets in a model of female education choice, labor supply and human capital accumulation.[1] These authors use their model to evaluate the effects of recent reforms to the Income Support program and the Working Families Tax Credit in the U.K.

Despite progress in this area, models of means-tested transfers assume that households have a single decision maker (typically a female), and if a spouse is present he is assumed to supply a fixed number of hours to work (typically 40 hours per week) and to remain unresponsive both to individual and household circumstances and to policy. However, since transfer programs — which are phased out and have earnings limits— are based on household earnings, this household decision process fails to capture all the responses to policy, especially among those households in the phase-out regions of the transfer programs. In this paper, we argue that joint decision making in two-adult households, along with within-household risk sharing, are key to understanding the effects of policy reforms. We show that these ingredients bring new behavioral responses to transfers, particularly with regard to marriage/cohabitation decisions, and to the labor supply

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[1]Kartik Athreya, Devin Reilly and Nicole Simpson (2014) also introduce a consumption/savings decision in their analysis of the effects of the EITC on the labor supply of single mothers.

decisions across spouses/partners.[2] To support these arguments, we draw attention to the fact that in the U.S. the participation tax rate of a working married parent in a low-income household ranges between −10 and 70 percent depending on her/his spouse earnings. That is, low-income couples face high incentives to set individual labor supplies jointly. Indeed, in our sample of non-college-educated households, the average employment rate of married fathers with two children and wife's earnings below $30,000$ is 94 percent, it falls to 89 percent among those whose wives earn between $30,000$ and $45,000$, and rises again to 97 percent at wife's earnings above $45,000$.

We develop a dynamic model of labor supply, consumption, savings, marriage decisions and transfer program participation. Our model embeds the income tax schedule and the four main anti-poverty income transfer programs in the U.S. — the EITC, the Child Tax Credit (CTC), Temporary Assistance for Needy Families (TANF) and the Supplemental Nutrition Assistance Program (SNAP). In our framework, individuals are subject to uninsurable idiosyncratic risk and they face borrowing constraints. We allow for one- and two-adult households, and an endogenous choice of the living arrangement between (i) single alone, (ii) unmarried and cohabiting, and (iii) married. Our modeling of the decision-making process in two-adult households follows the approach pioneered by Pierre A. Chiappori (1988), where the utility of each adult carries a weight reflecting her/his power in the household. Besides labor productivity shocks, adult females are also subject to fertility shocks. The presence and number of qualifying children, alongside the living arrangement, are key determinants of taxes and transfers. Since our model yields an equilibrium distribution of households across living arrangements, labor productivities, wealth and number of children, we can examine the individual and average effects of anti-poverty policy reforms. We can also ascertain the cost of these reforms, both to the government and to households.

Labor supply in our model includes a participation decision (extensive margin) and an hours worked decision (intensive margin). The cost of labor market participation is modeled as commuting and child care expenses, and the latter are assumed to vary with the number of children and adults in the household. In particular, two-adult households are assumed to have a relative advantage at allocating individual working times to save on child care while working. Likewise, two-adult households, contrary to one-adult households, share risks within the household. That is, couples are assumed to pool their resources, share idiosyncratic risks and make joint decisions on savings, individual consumptions and labor supplies. This is a key feature of our model, which accounts for the potential crowding-out effects of anti-poverty income transfers on the labor

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[2]For an analysis of the labor supply and savings effects of unemployment benefits in a model with within-household risk sharing and joint decision making, see Ortigueira and Siassi (2013).

supplies of primary and secondary earners.

Unpartnered single females in our model receive proposals to cohabit and to marry, which they may accept or turn down. Cohabiting couples get married as soon as they are better off than under cohabitation. The tax-transfer system introduces both incentives and disincentives to marry, depending on individuals' characteristics. For instance, the EITC may increase marriage among lone mothers with no earnings if the prospective husband has earnings between $20,000 and $40,000.[3] However, a lone mother already receiving the EITC may become ineligible if she marries. TANF may disincentivize lone mothers to marry and also to cohabit with the father of their children, but it incentivizes cohabitation with a male who is not their biological father. Our detailed modeling of the U.S. income tax scheme and the transfer program rules for the different living arrangements allows us to examine their effects on marriage and cohabitation.

Our model is calibrated to match moments from a sample of 3,945 one- and two-adult households with children formed by non-college-educated workers. Our sample is drawn from the 2014 Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS). The calibrated model fits quite well non-targeted moments from our sample and other moments estimated in the empirical literature, such as the participation elasticity of single mothers with respect to net income, and the sensitivity of hours worked to EITC expansions. We first use the model to understand how the U.S. tax-transfer system affects individual and household decisions across the equilibrium distribution. The categorical, asset and income eligibility criteria of transfer programs, along with income and payroll taxes, yield complex budget constraints and introduce a web of interactions whose effects we identify and measure. Then, we assess the effects of three recent proposals to reform the tax-transfer system, which seek to mitigate the disincentives created by the current EITC schedule to married mothers' labor market participation.[4]

We first evaluate the "21st Century Worker Tax Cut Act", a legislative proposal introduced to the 113th Congress on March 26, 2014. This Act would establish a new deduction to the EITC of two-earner married couples of 20 percent of the earnings of the secondary worker. This reform plan is a response to the strong disincentives faced by married women to work. Since the EITC for married couples is based on households earnings, it introduces high participation tax rates for most secondary earners. It should be noted that this proposed two-earner deduction introduces a positive substitution effect on the labor supply of most secondary earners (those in the phase-

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[3]In our model, we refer to single mothers by the British term "lone mothers" to emphasize that there is no partner or a family member in the house helping them to bring up their children (beyond child support).

[4]Since there is no unemployment in our model, the terms *labor market participation* and *employment* shall be used interchangeably throughout the paper.

out region of the credit), and hence it contributes to increasing their labor supply. Indeed, we find that the employment rate of married females increases by 3.36 percent, and the fraction of two-earner married households by 4.67 percent. Hours worked fall slightly, both for married females and males. The deduction, however, lowers household wealth as the precautionary motive is reduced. Overall, the poverty rate among married households goes down by 3.35 percent, and there are welfare gains both for females and males. Interestingly, our model also helps us to identify an unintended consequence of this reform impinging on lone mothers. Namely, the higher value of marriage brought in by the new deduction increases their marriage acceptance rate. In anticipation of marriage, lone mothers reduce precautionary savings, yielding an increase in the poverty rate by 0.13 percent and a loss of welfare. There is no cost to the government of implementing this reform. Actually, its net revenue per non-college-educated household with children would increase from $860 under the current policy to $879 under the reform. However, this reform would create winners and losers and hence no universal efficiency gains.

The second proposal to reform the U.S. tax-transfer system considered here is the "Tax Reform Act of 2014", introduced to the 113th Congress on December 10, 2014. This Act would reduce the EITC to almost all households. It would also extend the married couples' bottom income bracket to $71,200, increase the subsidy rate per child in the Child Tax Credit, reduce the personal exemption and increase the standard deduction. We find that this reform plan has sizable, positive effects on the labor supply of married couples, but it reduces the the employment rate of lone mothers. Hours worked, however, increase among both population groups. Overall, we find that this reform reduces poverty and increases average welfare among these two groups. Moreover, this is a reform plan that would save the government $405 a year per household in our population of interest (non-college-educated households with children).

The third reform proposal we evaluate would replace the current EITC schedule by an EITC based on personal earnings, which would depend neither on the living arrangement nor on the number of children. We show that this plan would remove the disincentives to married females to supply labor, raising their employment rate and the fraction of two-earner married couples. However, this reform, as implemented in this paper, would cost the government $279 per household and year.

The remainder of the paper is organized as follows. Section 2 describes the income and payroll tax schedules, and the four income transfer programs included in our analysis. In Section 3 we present our model, define the steady-state equilibrium and parameterize preferences, consumption commitments and work and child care costs. Section 4 describes our sample of households,

calibrates the model and assesses its fit with the data. Section 5 examines the effects of the tax-transfer system across the equilibrium distribution. The evaluation of the three policy reforms is conducted in Section 6. Finally, Section 7 concludes.

2 Taxes and Means-tested Transfers

In this section we briefly describe the U.S. federal income tax scheme, two tax credits and two transfer programs to assist low-income households. These tax and transfer schemes are then embedded into a model of savings, labor supply and living arrangements in the next section.

2.1 Income and Payroll Taxes

There are three main filing statuses with the Internal Revenue Service (IRS): single (s), head of household ($\hbar$) and married filing jointly (x). The filing status affects both taxes paid (tax rates and deductions), as well as eligibility and benefits for tax credits.

A tax filer's income is made up of earnings, e, and capital income, ra, where r is the return on investment and a is the filer's asset level. Income taxes before credits owed by a tax filer under filling status $j = s, \hbar, x$, with income $y = e + ra$ and n qualifying children, are given by

$$T^j(y,n) = \sum_{i=1}^{7} \tau_y^{j,i} \max\{\min\{y - d_T^j - \xi_T^{jn}, b^{j,i}\} - b^{j,i-1}, 0\},$$

where $b^{j,i} \geq 0$ are parameters characterizing the seven income brackets in the U.S. tax code, and $\tau_y^{j,i}$ are the corresponding tax rates. The upper bound for the last bracket, $b^{j,7}$, is set to a very large value such that taxable income for any household is below this limit. The remaining values, $b^{j,i}$, are the break points between the different income brackets. The income tax deduction is denoted by d_T^j and personal exemptions by ξ_T^{jn}.

Payroll taxes are denoted by $T_p(e) = \tau_p \min\{e, \bar{e}\}$, where $\tau_p = \tau_{p,\text{SS}} + \tau_{p,\text{ME}}$ is the employee's tax rate (the sum of social security and medicare tax rates), and $\bar{e}$ is the payroll tax cap.

2.2 The Earned Income Tax Credit (EITC)

The Earned Income Tax Credit is a refundable credit which cost the government 63 billion dollars in 2013. Eligibility is determined by the following conditions: (i) Investment income, ra, cannot exceed a level, say $\bar{r}\bar{a}_I$; (ii) Income (earned plus non-earned income) cannot exceed a level, say

y_I^{jn}, which depends on the number of children and the filing status. That is, the EITC-eligibility set, $\{a, e, n\}$, of a tax filer with n qualifying children under filing status $j = s, \hbar, x$ is

$$\{ra \leq \bar{r}\bar{a}_I\} \cap \{e + ra \leq y_I^{jn}\}. \tag{1}$$

Provided eligibility, the amount of the credit accruing to a tax filer with earned income e, n qualifying children and filing under status j is given by

$$I^j(e, n) = \begin{cases} \kappa_1^{jn} e & \text{if} \quad 0 \leq e \leq e_{I_1}^{jn} \\ \kappa_1^{jn} e_{I_1}^{jn} & \text{if} \quad e_{I_1}^{jn} \leq e \leq e_{I_2}^{jn} \\ \max\{\kappa_1^{jn} e_{I_1}^{jn} - \kappa_2^{jn}(e - e_{I_2}^{jn}), 0\} & \text{if} \quad e \geq e_{I_2}^{jn}, \end{cases}$$

where κ_1^{jn} is the earnings subsidy rate in the phase-in region and κ_2^{jn} is the credit phase-out rate. The thresholds, $e_{I_1}^{jn}$ and $e_{I_2}^{jn}$, mark the end of the phase-in region and the beginning of the phase-out region, respectively. In the region between these two thresholds, the credit is constant at its maximum value $\kappa_1 e_{I_1}^{jn}$. Note that both the credit rates and the earnings thresholds depend on the number of qualifying children and the filing status. However, the maximum level of investment income for program eligibility, $\bar{r}\bar{a}_I$, does not depend on either of the two. (Figure A1 in online Appendix A shows the EITC schedule for the 2013 tax returns.)

2.3 The Child Tax Credit (CTC)

The (non-refundable) child tax credit for a tax filer under status j, income y and n qualifying children is

$$CTC^j(y, n) = \begin{cases} \theta n & \text{if} \quad y \leq y_{CTC}^j \\ \max\{\theta n - \eta(y - y_{CTC}^j), 0\} & \text{if} \quad y > y_{CTC}^j, \end{cases}$$

where θ is the subsidy per child and y_{CTC}^j is the income level at which the child tax credit starts being phased out. Parameter η characterizes the child tax credit phase-out rate.

If the child tax credit, $CTC^j(y, n)$, is lower than the tax liability, $T^j(y, n)$, then this liability is reduced by the amount of the child tax credit. If the child tax credit is higher than the liability, then the liability is reduced to zero and the filer can apply for the (refundable) Additional Child Tax Credit (ACTC). The additional child tax credit depends on the number of children, in

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particular on whether it is two or less, or larger than two. The amount of this tax credit is

$$ACTC^j(y,e,n) = \begin{cases} \min\left\{ CTC^j(y,n) - T^j(y,n),\ \max\{\phi(e-\delta),0\} \right\} & \text{if } n \leq 2 \\ \\ \min\left\{ CTC^j(y,n) - T^j(y,n),\max\{\phi(e-\delta),\ T_p(e) - I^j(e,n),0\} \right\} & \text{if } n > 2, \end{cases}$$

where ϕ and δ are parameters.

2.4 Temporary Assistance for Needy Families (TANF)

Families with children may be eligible for assistance from state-run TANF. The federal TANF block grant contributes 16.5 billion dollars to states each year to assist families in need. States must also contribute with their own funds in order to receive funds from the federal block grant. This program replaced the former Aid to Families with Dependent Children in 1996.

Despite variation across states, many features of the program are common across most states. Eligibility and benefits are determined by categorical and quantitative variables of the assistance unit on a monthly basis. When the childrens' two parents live together, marital and tax filing statuses become irrelevant for the purpose of TANF. The assistance unit in this case is formed by the two parents and their children. Hence, for the sake of our analysis, we consider two different types of assistance units: one-parent households with children (u), and two-parent households (either cohabiting or married) with children (ν). Financial eligibility requirements include: (i) Family resources (stocks, bonds, bank deposits, property) cannot exceed a certain limit, say a_B, which is independent of family size. (ii) Gross family income cannot exceed $y_{B_1}^{jm}$, say, where $j = u, \nu$. Gross income includes earned and non-earned income, such as interests and child support income. (iii) Net family income cannot exceed $y_{B_2}^{jm}$. Net income for the purpose of determining TANF eligibility is computed as

$$\iota_B^j(a,e,n) = \left(e - d_{B_1}\mathbb{1}_{\{h>0\}} - d_{B_2}\Gamma(n) - d_{B_3}\right)\sigma_B + ra + \vartheta n, \tag{2}$$

where $\sigma_B < 1$ is a parameter that introduces an earned income disregard; d_{B_1} is a work deduction, $\mathbb{1}_{\{h>0\}}$ is an indicator function which takes value 1 if hours worked are strictly positive; d_{B_2} is a child care deduction, which is set as a fraction of child care costs incurred while working, $\Gamma(n)$, and d_{B_3} is a fixed deduction. Parameter ϑ is child support per child. Notice that the work deduction applies to every working person in the assistance unit. That is, in households with two working adults the work deduction must be applied twice.

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These three financial requirements define the TANF-eligibility set, $\{a, e, n\}$, of an assistance unit of type $\jmath$ and n qualifying children as

$$\{a \leq \mathbf{a}_B\} \cap \{e + ra + \vartheta n \leq \mathbf{y}_{B_1}^{\jmath n}\} \cap \{\iota_B^{\jmath}(a, e, n) \leq \mathbf{y}_{B_2}^{\jmath n}\}. \tag{3}$$

If eligible, the income transfer, $B^{\jmath}(a, e, n)$, is determined by a standard of need and net family income, with a maximum payment set by a payment standard. That is, an eligible assistance unit of type $\jmath = u, \nu$ is entitled to TANF benefits

$$B^{\jmath}(a, e, n) = \min\left\{\bar{B}^{\jmath n}, \ \max\{[S^{\jmath n} - \iota_B^{\jmath}(a, e, n)] \times \varsigma, 0\}\right\}, \tag{4}$$

where $\bar{B}^{\jmath n}$ is the maximum transfer for a family of type $\jmath$ with n children; $S^{\jmath n}$ is the standard of need for that family, which is typically set as a percentage of the federal poverty level; $\iota_B^{\jmath}(a, e, n)$ is net income as defined above; and ς is a parameter that controls when, and the rate at which, transfers are phased out. (Figure A2 in online Appendix A shows the 2013 TANF schedule.)

TANF has work requirements and time limits, typically of 60 months, to receive TANF benefits. However, the extent of enforceability of these limits varies widely across states. Besides a number of exemptions from time limits, states are allowed to extend assistance beyond these limits to up to 20% of their caseload.

2.5 Supplemental Nutrition Assistance Program (SNAP)

SNAP is a federal program that provides monthly food assistance to nearly 23 million U.S. households.[5] For SNAP, an assistance unit is an individual or a group of individuals who live together and purchase and prepare meals together. Eligibility is determined by (i) a resource limit, $\mathbf{a}_F$, which is independent of household size; (ii) a gross income limit, $\mathbf{y}_{F_1}^{\jmath n}$, which depends on household size. Gross income includes earned and non-earned income, such as investment income, child support and income received from TANF; and (iii) a net income limit, $\mathbf{y}_{F_2}^{\jmath n}$. Net income is computed as gross income minus an earned income disregard, a child care deduction when needed for work, d_{F_1}, a standard deduction and an excess shelter deduction. More specifically, net income for the purpose of determining SNAP eligibility and benefits is calculated as follows. First, the earned income disregard and the child care and standard deductions are subtracted from gross income to obtain countable income

$$c\iota_F^{\jmath}(a, e, n) = e\sigma_F + ra + \vartheta n + B^{\jmath}(a, e, n) - d_{F_1}\Gamma(n) - d_{F_2}. \tag{5}$$

[5]Even though SNAP is an in-kind transfer program, the food coupons are considered near-cash transfers and thus studied by the literature along with income transfer programs.

Next, the shelter deduction is calculated by subtracting half of countable income from shelter costs, $\hat{c}$ say. Finally, net income is obtained by subtracting the shelter deduction from countable income, i.e.

$$\iota_F^{\jmath}(a, e, n) = c\iota_F^{\jmath}(a, e, n) - \max\{\hat{c} - \frac{1}{2}c\iota_F^{\jmath}(a, e, n), 0\}. \tag{6}$$

In sum, the SNAP-eligibility set $\{a, e, n\}$ of an assistance unit is

$$\{a \leq a_F\} \cap \{e + ra + \vartheta n + B^{\jmath}(a, e, n) \leq y_{F_1}^{\jmath n}\} \cap \{\iota_F^{\jmath}(a, e, n) \leq y_{F_2}^{\jmath n}\}. \tag{7}$$

As an exception, households where *all* its members receive TANF income do not need to pass the income tests, and are immediately entitled to SNAP transfers if they meet the resource test.

SNAP benefits are calculated by subtracting the family's expected contribution towards food, i.e. χ times net income, from a maximum allotment for the family. That is, an eligible assistance unit of type $\jmath = u, \nu$ is entitled to SNAP benefits

$$F^{\jmath}(a, e, n) = \max\left\{\bar{F}^{\jmath n} - \chi \iota_F^{\jmath}(a, e, n), \underline{F}^{\jmath n}\right\}, \tag{8}$$

where $\bar{F}^{\jmath n}$ is the maximum allotment an assistance unit of type $\jmath$ with n children can receive from SNAP, and $\underline{F}^{\jmath n}$ is the minimum benefit an eligible unit can get. (Figure A3 in online Appendix A shows the 2013 SNAP schedule.)

3   A Model of Savings, Labor Supply and Living Arrangements

3.1   Demographics

Our model economy is populated by ex-ante identical females, ex-ante identical males and by children. The population of interest for our analysis of the effects of anti-poverty transfers is made up of non-college-educated households with children. This population includes lone mothers, unmarried cohabiting couples and married couples. Within the group of unmarried cohabiting couples we distinguish between both-parents-present couples and mother-only-present couples. Our focus on households with children formed by non-college-educated workers is motivated by their higher at-risk-of-poverty rate, relative to households where at least one adult is college educated.

Individuals of gender $g \in \{f, m\}$ enter the economy as singles with no children. Females

(f) are subject to fertility shocks and can have up to three children.[6] We assume that children age stochastically, i.e. every period a fraction of households see their children become adults, in which case the household leaves our target group. Within a household, all children age at the same time. That is, from one period to the next the number of children either stays constant, grows or becomes zero, but it never decreases gradually.

Specifically, the number of children in a household follows a Markov chain with five states: childless ($n = 0$), with one child ($n = 1$), with two children ($n = 2$), with three children ($n = 3$) and, finally, with grown-up children who have already left the nest ($n = \emptyset$). We denote the set of these five states by $N = \{0, 1, 2, 3, \emptyset\}$, where state $\emptyset$ is an absorbing state, as children eventually become adults and leave the household. The transition matrix between these five states is

$$M = \begin{pmatrix} m_{00} & m_{01} & m_{02} & m_{03} & m_{0\emptyset} \\ 0 & m_{11} & m_{12} & m_{13} & m_{1\emptyset} \\ 0 & 0 & m_{22} & m_{23} & m_{2\emptyset} \\ 0 & 0 & 0 & m_{33} & m_{3\emptyset} \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \qquad (9)$$

where $m_{nn'}$ is the probability of moving from state n to state n'. We make the following two simplifying assumptions. First, we rule out the possibility that a female gives birth to triplets, i.e. $m_{03} = 0$. Second, the probability that a household will move to state $\emptyset$ next period is independent of the number of children, i.e. $m_{1\emptyset} = m_{2\emptyset} = m_{3\emptyset}$. As stated above, our population of interest is made up of households in states 1, 2 and 3. The measure of this population and the average number of years a household remains on it are pinned down by the fertility-aging parameters in matrix M.

3.2 Productivity and Earnings

Adult individuals allocate their time endowment to leisure and work, and the productivity of their working time is subject to idiosyncratic shocks. We denote labor productivity by z, and assume that it evolves according to the process

$$\ln z' = \rho \ln z + \epsilon, \qquad \text{with } \epsilon \sim N(0, \sigma_\epsilon^2). \qquad (10)$$

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[6]Our modeling of fertility as a process independent of taxes and transfers is supported by empirical evidence showing that fertility does not respond to changes in the EITC (Reagan Baughman and Stacey Dickert-Conlin 2009).

For households with two adults we denote the vector of individual labor productivities by $z = [z_f \, z_m]$ and the vector of log productivities by $\ln z = [\ln z_f \, \ln z_m]^{\mathrm{T}}$. The vector of productivity shocks is denoted by $\epsilon = [\epsilon_f \, \epsilon_m]^{\mathrm{T}}$ and the shocks' variance-covariance matrix by σ_ϵ^2. Productivity shocks for workers within the same household are allowed to be partially correlated. We write the evolution of labor productivities within two-adult households as $\ln z' = \rho \ln z + \epsilon$, since the persistence parameter ρ is assumed to be the same for females and males.

Earnings of a worker of gender $g \in \{f, m\}$ are given by $e_g = h_g z_g \omega_g$, which is the product of the number of hours worked, h_g, the worker's labor productivity, z_g, and her/his wage rate, ω_g, which is assumed to be exogenous. For households with two adults we denote by e the vector of earnings, i.e. $e = [e_f \, e_m]$. Households can save in a risk-free asset subject to a non-borrowing constraint. Household asset holdings are denoted by a.

3.3 Living Arrangements

A female with children can be in one of the following four living arrangements: single living alone with her children (ℓ_s); unmarried and cohabiting with the father of her children (ℓ_{cp}); unmarried and cohabiting with a male who is not the father of her children (ℓ_c); and married and living with her husband and their children (ℓ_m). We denote the living arrangement by $\ell \in L = \{\ell_s, \ell_{cp}, \ell_c, \ell_m\}$. Single males are not modeled explicitly. They are simply assumed to receive "love shocks" and make either cohabitation or marriage proposals to single females living alone or with her children, if any. These females, provided that they have a proposal, decide whether to accept it or not. If they accept, the female and the male form a household, pool resources and solve a joint decision problem. In particular, cohabiting couples make decisions on individual consumptions, hours worked, joint savings and on whether or not to get married. Married couples decide on individual consumptions, hours worked and joint savings. Both cohabiting and married couples have full commitment and do not separate.[7]

Living arrangements have implications beyond taxation and eligibility/generosity of tax credits and assistance programs. In particular, in our model economy one- and two-adult households differ in terms of: (i) the extent of intra-household risk sharing; (ii) household consumption commitments; and (iii) child care demand while working.

As it should be apparent, intra-household risk sharing is not available to one-adult households.

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[7]In light of the empirical finding by Chris M. Herbst (2011) establishing a lack of relationship between the EITC and divorce rates, our assumption of commitment does not seem to be key for our analysis of EITC reforms.

In two-adult households, however, individuals are assumed to share idiosyncratic risks efficiently, in the sense that individual allocations lie on the Pareto frontier.

By consumption commitments we refer to the quasi-non-discretionary, minimum expenses needed to run a household, such as shelter and utilities. We assume that these expenses vary with the number of adults and children in the household, but are otherwise fixed. As is well known, the presence of consumption commitments increases individuals' risk aversion, which in our framework enhances the role played by intra-household risk sharing.

Finally, regarding child care costs, we assume that two-adult households can allocate their working times in a way that reduces child care costs incurred while working. By contrast, lone mothers must necessarily incur child care costs during their working time. That is, two-adult households not only have twice as much adult time resources as one-adult households, but they can also allocate individual working times so that they save on child care.

3.4 Bellman Equations

Before laying out the problems solved by the households in our model, we introduce some notation. For the sake of brevity, we merge the non-refundable part of the child tax credit with income and payroll taxes and denote it by $\mathcal{T}^j(a, e, n)$, i.e.

$$\mathcal{T}^j(a, e, n) = T^j(y, n) + T_p(e) - \min\{CTC^j(y, n), T^j(y, n)\}. \tag{11}$$

Likewise, we merge the refundable part of the child tax credit with the Earned Income Tax Credit, which is also refundable, and denote it by $\mathcal{I}^j(a, e, n)$, i.e.

$$\mathcal{I}^j(a, e, n) = I^j(y, a, n) + ACTC^j(y, e, n). \tag{12}$$

We denote a household's net balance with the Internal Revenue Service (tax liabilities after credits) by $IRS(a, e, n)$. Two remarks are in order. First, while taxes and tax credits in the U.S. are based on annual income and earnings, TANF and SNAP are monthly-based programs. We resolve this mixed timing by setting the length of a period in the model equal to one year and by annualizing transfers from TANF and SNAP. Second, it should be noted that households will always choose to participate in the CTC, the ACTC and SNAP, if eligible. However, since EITC income affects the credit from the ACTC, and TANF income affects the transfer from SNAP, some households may choose not to participate in the EITC and/or in TANF. To account for these instances, we introduce two binary choice variables, p_e and p_{tf}, which each takes value 1 for participation, and value 0 for non-participation in EITC and TANF, respectively.

Lone mothers of n children

A lone mother of $n > 0$ children makes decisions on consumption, hours supplied to work, savings, EITC and TANF participation and, provided she has a cohabitation or a marriage proposal, on whether she accepts the proposal or remains alone. The probabilities of receiving proposals from single males are denoted as follows: $\pi_{\ell_{cp}}$ is the probability that she receives a cohabitation proposal from the father of her children; π_{ℓ_c} is the probability that she receives a cohabitation proposal from a single man who is not the father of the children; and π_{ℓ_m} is the probability that she receives a marriage proposal. The probability that she has no proposal is hence $\pi_{\ell_s} = 1 - \pi_{\ell_{cp}} - \pi_{\ell_c} - \pi_{\ell_m}$.

We denote the value function of a female in living arrangement $\ell \in L$ by v_f^ℓ. Then, the value of a lone mother of $n > 0$ children with labor productivity z and asset holdings a is given by

$$v_f^{\ell_s}(z, a, n) = \max_{c, l, a', p_e, p_{tf}} \left\{ U_f(c, l) + \beta \, \mathbb{E}\left[\pi_{\ell_s} v_f^{\ell_s}(z', a', n') + \sum_{\ell \in L \setminus \ell_s} \pi_\ell \max\{v_f^\ell(\mathbf{z}', \tilde{a}', n'), v_f^{\ell_s}(z', a', n')\} \right] \right\}$$

s.t. (13)

$$c + \hat{c}(n) + \Gamma(h, n) + a' = e_f + (1 + r)a + \vartheta n - IRS(a, e_f, n) + p_{tf} B^u(a, e_f, n) + F^u(a, e_f, n)$$

$$\ln z' = \rho \ln z + \epsilon, \quad \text{with} \quad \epsilon \sim N(0, \sigma_\epsilon^2)$$

$$c \geq F^u(a, e_f, n), \quad 0 \leq l \leq 1 \quad \text{and} \quad a' \in A,$$

where

$$IRS(a, e_f, n) = \mathcal{T}^\hbar(a, e_f, n) - \mathcal{I}^\hbar(a, e_f, n),$$ (14)

and where $h = 1 - l$ are hours worked, $e_f = h \, z \, \omega_f$ are household earnings, a' are next-period asset holdings of the lone mother if she receives no cohabitation/marriage proposal or if she rejects either proposal, and $\tilde{a}' = a' + a'_m$ are household asset holdings if the lone mother accepts a proposal made by a single male with assets a'_m. The function $\hat{c}(n)$ represents the consumption commitments of a lone mother with n children. The function $\Gamma(h, n)$ represents work-related expenses (commuting costs, etc.) plus child care costs paid while working. The participation decision in the EITC, p_e, enters in equation (14) multiplying $I^\hbar(y, a, n)$. Asset holdings lie in the set $A = [0, \bar{a}]$, where $\bar{a}$ is a non-binding upper bound. The expectation is taken on her own labor productivity next period, z', on the labor productivity and the level of assets of the potential suitors, z'_m and a'_m, respectively, and on the number of children, n'. The value functions when the children have left the household, $v_f^\ell(z, a, \emptyset)$ for $\ell \in L$, in the maximization problem above, correspond to the values of remaining childless forever.

The problem of a single female without children ($n = 0$) is similar to the one above, with the exception that the probability that she receives a proposal to cohabit is the sum of $\pi_{\ell_{cp}}$ and π_{ℓ_c}.[8]

Cohabiting couples with n children

We model cohabitation as an unmarried female and an unmarried male living in the same dwelling, pooling wealth and income, sharing the fixed costs of running the household and making joint decisions on savings, individual consumption and labor supplies. Risk sharing within the household is assumed to be efficient, in the sense that the couple maximizes a weighted sum of the two adults' utility functions. These weights are referred to as Pareto weights, and will be denoted by η_g for $g \in \{f, m\}$. Cohabiting couples file separate tax returns and get married as soon as marriage yields more value to the couple than cohabitation. As will become clear below when we describe the problem of a married couple, we assume no difference between cohabitation and marriage other than the tax and transfer schemes they face, and the fact that cohabitants can get married. The assumption that cohabiting and married couples are ex-ante identical will help us to assess the effects of the differential tax-transfer treatment of these two types of couples.

Since taxes, credits and the TANF also vary across cohabiting couples, depending on whether or not the cohabiting male is the father of the children, we present these two cases in turn.

Both-parents-present cohabiting couples

Both-parents-present cohabiting couples face the additional, non-trivial decision of who of the two adults will file as head of household ($\hbar$) and who as single (s). The simultaneous labor supply and filing status decisions are made so that the optimal level of household earnings creates the minimum tax liabilities after credits.[9] In the instance where only one adult works, then, trivially, she/he claims the children as dependent and files as head of household. Importantly, the parent that does not claim the children as qualifying children cannot take the EITC using the rules for those with no qualifying child. This is one of the key differences with respect to cohabiting households where the male is not the father of the children.

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[8]Even though households without children are not in our population of interest, we include single childless females in the model so that single males can propose to them and start a cohabiting or married household before they have their first child. Without single childless females, all cohabiting and married couples in the model would have at least one child born to a lone mother, and we do not want to restrict our sample of U.S. households to this group when we compare outcomes from our model with the data.

[9]We do not impose the statutory requirement that the head of household must contribute at least 50 percent to household expenses. Contribution to household expenses is self-declared and hence difficult to verify. Indeed, using CPS data (which we present below) we observe a substantial number of both-parents-present cohabiting couples where the head of household is not the worker with the highest earnings.

The problem of a both-parents-present cohabiting couple with labor productivities $\boldsymbol{z} = [z_f z_m]$, assets a and n children involves decisions on savings, individual consumption, labor supplies, tax filing statuses, EITC and TANF participation, and on whether to get married or remain as cohabitants. Formally, a cohabiting couple in living arrangement ℓ_{cp}, with Pareto weights on individual utilities η_g, solves

$$V^{\ell_{cp}}(\boldsymbol{z}, a, n) = \max_{c_f, c_m, l_f, l_m, a', p_e, p_{tf}} \left\{ \sum_{g=f,m} \eta_g U_g(c_g, l_g) + \beta \, \mathbb{E} \left[\max\{ V^{\ell_{cp}}(\boldsymbol{z}', a', n'), V^{\ell_m}(\boldsymbol{z}', a', n') \} \right] \right\}$$

s.t. (15)

$$c_f + c_m + \hat{c}(n) + \Gamma(h_f, h_m, n) + a' = e + (1+r)a - IRS(a, \boldsymbol{e}, n) + p_{tf} B^\nu(a, e, n) + F^\nu(a, e, n)$$

$$\ln \boldsymbol{z}' = \rho \ln \boldsymbol{z} + \boldsymbol{\epsilon}, \quad \text{with} \quad \boldsymbol{\epsilon} \sim N(0, \sigma_{\boldsymbol{\epsilon}}^2)$$

$$c_f, \, c_m \geq 0, \quad c_f + c_m \geq F^\nu(a, e, n), \quad 0 \leq l_f, \, l_m \leq 1 \quad \text{and} \quad a' \in A,$$

where

$$IRS(a, \boldsymbol{e}, n) = \begin{cases} \mathcal{T}^\hbar(a/2, e_f, n) + \mathcal{T}^s(a/2, e_m, 0) - \mathcal{I}^\hbar(a/2, e_f, n) & \text{if} \quad \text{female files as } \hbar \\ \mathcal{T}^s(a/2, e_f, 0) + \mathcal{T}^\hbar(a/2, e_m, n) - \mathcal{I}^\hbar(a/2, e_m, n) & \text{if} \quad \text{male files as } \hbar, \end{cases}$$

and where $h_g = 1 - l_g$ are hours worked, $e = e_f + e_m = h_f \, z_f \, \omega_f + h_m \, z_m \, \omega_m$ are household earnings. The function $V^{\ell_{cp}}$ denotes the value of the both-parents-present cohabiting couple, and the function V^{ℓ_m} denotes the value of a married couple. The expectation is formed over the two labor productivities and over the number of children. As mentioned above, the adult filing taxes as single cannot apply for the EITC. Also note that TANF eligibility and benefits depend on total household wealth, a.

Mother-only-present cohabiting couples

We now write the problem of a mother cohabiting with a man who is not the father of her children. The main differences with respect to both-parents-present cohabiting couples are: First, the male cannot claim the children as dependents, as they fail to satisfy the relationship test. Consequently, he cannot file as head of household, but he can apply for the EITC as single without dependents. Note that this is in contrast to the case of both-parents-present cohabiting couples, where the father of the children is not allowed to apply for the EITC as single without dependents. Second, most states do not include the male is in the TANF assistance group, and his resources and income are not counted towards eligibility and benefits. This is in contrast to cohabiting couples where the male is the father of the children. For SNAP, the male is in the assistance group regardless of his biological relationship with the children, as long as the cohabiting couple shares and prepares food together.

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The value of a mother-only-present cohabiting couple is

$$V^{\ell_c}(\boldsymbol{z}, a, n) = \max_{c_f, c_m, l_f, l_m, a', p_e, p_{tf}} \left\{ \sum_{g=f,m} \eta_g U_g(c_g, l_g) + \beta \, \mathbb{E} \left[\max\{V^{\ell_c}(\boldsymbol{z}', a', n'), V^{\ell_m}(\boldsymbol{z}', a', n')\} \right] \right\}$$

s.t.   (16)

$$c_f + c_m + \hat{c}(n) + \Gamma(h_f, h_m, n) + a' = e + (1+r)a + \vartheta n - IRS(a, \boldsymbol{e}, n) + p_{tf} B^u(a/2, e_f, n) + F^\nu(a, e, n)$$

$$\ln \boldsymbol{z}' = \rho \ln \boldsymbol{z} + \boldsymbol{\epsilon}, \quad \text{with} \quad \boldsymbol{\epsilon} \sim N(0, \sigma_{\boldsymbol{\epsilon}}^2)$$

$$c_f, \, c_m \geq 0, \quad c_f + c_m \geq F^\nu(a, e, n), \quad 0 \leq l_f, \, l_m \leq 1 \quad \text{and} \quad a' \in A,$$

where

$$IRS(a, \boldsymbol{e}, n) = \mathcal{T}^{\hbar}(a/2, e_f, n) + \mathcal{T}^s(a/2, e_m, 0) - \mathcal{I}^{\hbar}(a/2, e_f, n) - \mathcal{I}^s(a/2, e_m, 0),$$

and where $h_g = 1 - l_g$ are hours worked, and $e = e_f + e_m = h_f \, z_f \, \omega_f + h_m \, z_m \, \omega_m$ are household earnings. Note that TANF eligibility and benefits depend on the female's wealth and earnings (assistance unit $\jmath = u$), while SNAP is based on household-level variables ($\jmath = \nu$).

Married couples with n children

The problem solved by married couples is similar to the one solved by cohabitants, save for the tax-transfer system they face, and for the fact that once married they cannot change marital status. Married couples file with a *married filing jointly* status ($j = x$). Hence, a married couple with labor productivities $\boldsymbol{z}$, assets a and n children solves

$$V^{\ell_m}(\boldsymbol{z}, a, n) = \max_{c_f, c_m, l_f, l_m, a', p_e, p_{tf}} \left\{ \sum_{g=f,m} \eta_g U_g(c_g, l_g) + \beta \, \mathbb{E} \, V^{\ell_m}(\boldsymbol{z}', a', n') \right\}$$ (17)

s.t.

$$c_f + c_m + \hat{c}(n) + \Gamma(h_f, h_m, n) + a' = e + (1+r)a - IRS(a, e, n) + p_{tf} B^\nu(a, e, n) + F^\nu(a, e, n)$$

$$\ln \boldsymbol{z}' = \rho \ln \boldsymbol{z} + \boldsymbol{\epsilon}, \quad \text{with} \quad \boldsymbol{\epsilon} \sim N(0, \sigma_{\boldsymbol{\epsilon}}^2)$$

$$c_f, \, c_m \geq 0, \quad c_f + c_m \geq F^\nu(a, e, n), \quad 0 \leq l_f, \, l_m \leq 1 \quad \text{and} \quad a' \in A,$$

where

$$IRS(a, e, n) = \mathcal{T}^x(a, e, n) - \mathcal{I}^x(a, e, n),$$ (18)

and where $h_g = 1 - l_g$ are hours worked and $e = e_f + e_m = h_f \, z_f \, \omega_f + h_m \, z_m \, \omega_m$ are household earnings. Note that the married couples' taxes, tax credits and assistance transfers are based on household income, earnings and wealth.

3.5 The Steady-State Partial Equilibrium

Let us start with some notation. We denote by $\mathcal{B}^s$ the Borel σ-algebra on the space of labor productivity and asset holdings of lone mothers, $Z^f \times A$, where Z^f is the space of labor productivity and A is the space of asset holdings. The projections of $B \in \mathcal{B}^s$ on Z^f and A are denoted, respectively, by B_{z_f} and B_a. Let $\mathcal{B}^c$ denote the Borel σ-algebra on the space of labor productivities and asset holdings of couples, $Z^f \times Z^m \times A$.

The probability that a lone mother with labor productivity z_f, assets a_f, and n children will have productivity and assets lying in set $B \in \{\mathcal{B}^s \cup \mathcal{B}^c\}$, will have n' children and will move to living arrangement $\ell' \in L$ next period is denoted by $P^s(z_f, a_f, n; B, n', \ell')$.

The probability that a couple with productivities z^f and z^m, assets a, n children and in living arrangement ℓ will transit to productivities and assets lying in set $B \in \mathcal{B}^c$, will have n' children and will move to living arrangement ℓ' next period is denoted by $P^c(z_f, z_m, a, n, \ell; B, n', \ell')$. (These transition functions are derived in online Appendix B.)

The mass of lone mothers at each $B \in \mathcal{B}^s$ with n children is denoted by $\psi^s(B, n)$. The mass of couples at each $B \in \mathcal{B}^c$, with n children and in living arrangement $\ell \in \{\ell_{cp}, \ell_c, \ell_m\}$ is denoted by $\psi^c(B, n, \ell)$.

We now define the steady-state partial equilibrium as:

DEFINITION: *A steady-state partial equilibrium in our economy is: (i) A set of prices and a tax-transfer system; (ii) a set of value functions $\{v_f^{\ell_s}, V^{\ell_{cp}}, V^{\ell_c}, V^{\ell_m}\}$; (iii) policy functions for consumption, hours worked, savings, lone mothers' acceptance/rejection of cohabiting and marriage proposals, cohabiting couples' marriage decisions, filing statuses in both-parents-present cohabiting couples, and for EITC and TANF participation; and (iv) time-invariant measures of one-adult households, $\psi^s(B, n)$, and two-adult households, $\psi^c(B, n, \ell)$, such that*

1. *Given the set of prices and the tax-transfer system, the value functions $\{v_f^{\ell_s}, V^{\ell_{cp}}, V^{\ell_c}, V^{\ell_m}\}$ solve equations (13) – (17) above with the corresponding policy functions.*

2. *The invariant probability measures: The invariant measure of lone mothers is given by*

$$\psi^s(B, n') = \sum_{n \in N} \int_{Z^f \times A} P^s(z_f, a, n; B, n', \ell_s) \psi^s(dz_f, da, n), \tag{19}$$

for all $B \in \mathcal{B}^s$ and $n' \in N \setminus \{0, \emptyset\}$. For $n' = 0$

$$\psi^s(B, 0) = \int_{Z^f \times A} P^s(z_f, a, 0; B, 0, \ell_s) \psi^s(dz_f, da, 0) + \mathbb{1}_{\{0 \in B_a\}} \psi_0^s \int_{B_{z_f}} \tilde{f}_{z_f}(dz_f), \ \textit{for all } B \in \mathcal{B}^s,$$
(20)

where ψ_0^s is the measure of entering single females (who enter with zero assets), and $\tilde{f}_{z_f}(\cdot)$ is the unconditional density function from where the newborn draw their initial productivity shock. To ensure a stationary measure of households at non-absorbing states, the measure of entering single females must be equal to the number of households that transit to the absorbing state $\emptyset$ each period. That is,

$$\psi_0^{\ell_s} = \frac{1}{\tilde{m}_{1,*} \cdot \mathbf{1}},$$
(21)

where $\tilde{m}_{1,*}$ is the first row of matrix $(\mathbf{I}_4 - \tilde{M})^{-1}$; $\mathbf{I}_4$ is the (4×4) identity matrix, $\tilde{M}$ is the (4×4) upper-left block of M, and $\mathbf{1}$ is the (4×1)-vector of ones.

The invariant probability measures of couples are given by

$$\psi^c(B, n', \ell') = \sum_{n \in N} \sum_{\ell \in L \setminus \ell_s} \int_{Z^f \times Z^m \times A} P^c(z_f, z_m, a, n, \ell; B, n', \ell') \psi^c(dz_f, dz_m, da, n, \ell) +$$
$$\sum_{n \in N} \int_{Z^f \times A} P^s(z_f, a, n; B, n', \ell') \psi^s(dz_f, da, n)$$
(22)

for all $B \in \mathcal{B}^c$, $n' \in N \setminus \{\emptyset\}$ and $\ell' \in L \setminus \ell_s$.

It should be noted that the value functions for cohabiting and married females, $v_f^{\ell_{cp}}, v_f^{\ell_c}$ and $v_f^{\ell_m}$, are readily obtained from their respective policy functions. For example, the value function of a married female is obtained as $v_f^{\ell_m}(\mathbf{z}, a, n) = U_f(c_f^*, l_f^*) + \beta \mathbb{E} v_f^{\ell_m}(\mathbf{z}', a'^*, n')$, where $\{c_f^*, l_f^*\}$ are the married females policy functions for consumption and leisure, and a'^* is the policy function for married households' savings. The computation of the value functions for cohabiting females must also embed the filling status, marriage and program participation policy functions.

3.6 Parameterization

Preferences.—We assume that females and males have identical preferences over consumption and leisure, which are represented by the following per-period utility function

$$U(c, l) = \frac{c^{1-\sigma} - 1}{1 - \sigma} + \varphi \frac{l^{1-\zeta} - 1}{1 - \zeta},$$
(23)

where σ is the coefficient of relative risk aversion, $\varphi > 0$ is a utility weight on leisure, and $\zeta > 0$ controls the Frisch elasticity of labor supply.

Consumption Commitments.—We specify the fixed, non-discretionary expenses for households of type $\ell \in L$ with n children as

$$\hat{c}(n) \ = \ \hat{c}_0^\ell + \hat{c}_1^\ell \cdot n, \tag{24}$$

where $\hat{c}_0^\ell$ and $\hat{c}_1^\ell$ are parameters.

Work-related and Child Care Costs.—Households incur direct budgetary costs when adult members choose to supply positive hours to market work. We distinguish two such costs: (i) Work-related costs such as transportation, meals outside of the home, buying clothing, etc, and (ii) Child care paid while working. We parameterize these costs as a function of labor market participation, hours worked and the number of children

$$
\begin{aligned}
\Gamma(h^f, n) &= \gamma_1 \mathbb{1}_{\{h^f > 0\}} + \gamma_2 \mathbb{1}_{\{h^f > 0\}} n^\alpha && \text{for} \quad \ell = \ell_s, \\
\Gamma(h^f, h^m, n) &= \gamma_1 \left[\mathbb{1}_{\{h^f > 0\}} + \mathbb{1}_{\{h^m > 0\}} \right] + \gamma_2 \mathbb{1}_{\{h^f + h^m > 1\}} n^\alpha && \text{for} \quad \ell = \ell_{cp}, \ell_c, \ell_m,
\end{aligned} \tag{25}
$$

where γ_1 denotes work-related costs and γ_2 denotes child care costs per child. $0 < \alpha \leq 1$ is a parameter that introduces economies of scale in child care (all else equal child care costs decrease with the number of children: For example, multiple children at the same school, sibling discounts at day care center, etc.). The distinction between these two types of costs allows us to embed the possibility for couples of making use of their joint time allocation problem to reduce child care costs. Specifically, γ_1 includes all expenditures that cannot be eluded when an adult in the household chooses to work. By contrast, γ_2 characterizes expenditures that can be avoided if there are two working adults in the households who split their working hours so that there is always at least one adult at home (note the indicator function $\mathbb{1}_{\{h^f + h^m > 1\}}$).

4 Data, Calibration and Model Fit

In this section we first describe the sample of households that we use to calculate moments for key variables. Then, we calibrate the parameters of the model. Some of the parameters have a direct empirical counterpart and, hence, values to these parameters are set outside of the model. Values to the remaining twelve parameters are set so that the steady-state partial equilibrium of our model matches twelve moments calculated from our sample of households.

4.1 Data

Personal and household data on employment, annual hours worked, earnings and taxes and transfers are taken from the 2014 Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS), which also contains information on marital status, living arrangements, filing status, education and number of children. The ASEC is administered to households in March and surveys information for the previous calendar year.

The sample of households we use to calibrate our model is obtained from the ASEC by removing all households with characteristics that do not match the characteristics of the households in our model economy. More specifically, from the 2014 ASEC we drop: households with more than one family (i.e. where a subfamily is present); households with a member who is not a child, partner, partner's child or spouse of the reference person (i.e. we remove households where a grandparent, uncle, or another non-related individual is present); households formed by cohabiting couples where at least one of the cohabitants has been previously married or is separated; households where the female is not the mother of all the children in the household; households where the male is the father of some of the children but not all; households headed by a male with children and without a wife or cohabitant; households where there is a child with neither parent present; households with at least one adult in the armed forces; households with no children or more than three children; households with at least one member holding a college degree; households with no income; households receiving disability, retirement, survivor or veterans income; and households where there is a member with negative earnings. After completing this pruning of the raw data, we end up with a sample of $14,540$ individuals in $3,945$ households.

Table 1 below shows the breakdown of our sample into the four living arrangements: Lone mothers, both-parents-present cohabiting couples, mother-only-present cohabiting couples and married couples with children. The first two rows of the table show the percentages of individuals and households in each living arrangement, respectively.[10] 19.6 percent of households in our sample are made up by lone mothers, 7.1 percent are both-parents-present cohabiting couples, 2.3 percent are mother-only-present cohabiting couples and 70.9 percent are married couples. For each living arrangement, the distribution of households over the number of children is shown in rows (3) to (5). Nearly half of lone mothers have only one child. Among married couples, about 63 percent have two or three children.

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[10]For the calculation of the statistics presented in Table 1 and in the next sections we use the CPS ASEC supplement household weights.

The distribution of households over the number of earners is shown in rows 6 to 8. Almost 20 percent of lone mothers do not work. About 40 percent of both-parents-present cohabiting couples and married couples have only one adult with earnings, and almost 60 percent have two earners. Among mother-only-present cohabiting couples, 10 percent do not work, 25 percent have only one earner and the remaining 65 percent have two earners.

TABLE 1— OUR SAMPLE OF HOUSEHOLDS

	Lone mothers	Cohabiting couples		Married couples
		Both parents present (bpp)	Mother only present (mop)	
Individuals (%)	14.81	7.08	2.22	75.89
Households (%)	19.65	7.12	2.35	70.87
Distribution (# children)				
1	45.60	55.01	66.20	36.51
2	36.55	29.10	19.88	42.74
3	17.83	15.88	13.90	20.74
Distribution (# earners)				
0	19.72	3.43	10.34	2.47
1	80.28	37.47	25.07	40.98
2	–	59.10	64.59	56.55

Source: Sample of households from the 2014 Annual Social and Economic Supplement (ASEC).

Average labor supply and average earnings for groups of individuals in this sample of households will be used as targets to calibrate some parameter values in our model. It must be stressed, however, that all the moments used as targets are from lone mothers and married couples. We purposely leave aside moments from cohabiting couples so that we can then use the model to assess the effects of the differential tax-transfer treatment of cohabiting and married couples. As noted above, cohabiting and married couples in our model are ex-ante identical along all dimensions, except for the taxes and transfers they face. Hence, the model so calibrated can inform us on the existence and extent of a marriage penalty/bonus in the tax-transfer system.

4.2 Parameters calibrated outside of the model

Taxes, tax credits and assistance programs.—Tax rates, income brackets, deductions and personal exemptions are taken from the IRS website for the 2013 tax returns. Parameter values determining eligibility and benefits for the federal Earned Income Tax Credit and the Child Tax Credit in 2013 are also taken from the IRS website. Tables A1 to A5 in online Appendix A present all

these parameter values. Since there is some variation across U. S. states in the parameter values determining eligibility and benefits of the Temporary Assistance for Needy Families (TANF), we take the values for 2013 from the Delaware's TANF schedule, which does not show large deviations from national mean values.[11] Parameter values of the 2013 Supplemental Nutrition Assistance Program (SNAP) are taken from the U.S. Department of Agriculture, Food and Nutrition Service website.[12] Tables A6 and A7 in online Appendix A present TANF and SNAP parameter values, respectively.

Demographics.—After the assumptions made on the fertility and children-aging process, the transition matrix M contains seven parameters: m_{00}, m_{01}, m_{02}, $m_{1\emptyset}$, m_{12}, m_{13} and m_{23}. We set these probabilities so that matrix M and its associated stationary distribution match the following seven moment conditions: (1) The average age at first birth among non-college-educated females is 23 years. Since in our model single females enter the economy childless at age 18, we must set values to m_{00} and $m_{0\emptyset}$ so that the expected number of years until a child is born, conditional on having a child, is equal to 5;[13] (2) the share of households with 1 child in our ASEC sample of households is 40.31 percent; (3) the share of households with 2 children is 40.01 percent; (4) the probability of having twins, conditional on having a conception, is 3.26 percent (National Vital Statistics Reports, 2010). We assume that this conditional probability is the same for childless females and for those who are already mothers of one child, and hence obtain two moment conditions to match; (5) for households with children, the expected duration until the children leave the house, and hence the household leaves our population of interest, is 20 years; (6) the fraction of women without a college degree who remain childless throughout their childbearing years is 17 percent.[14] Given the demographic structure of the model, these seven moment conditions uniquely identify the seven free parameters (online Appendix C provides a detailed explanation of how we pin down the seven demographic parameters from these seven moments).

The elasticity of intertemporal substitution, labor productivities and the risk-free rate of return.— Standard values for the elasticity of intertemporal substitution, $1/\sigma$, range between 1 and 1/3, so we choose an intermediate value and set $\sigma = 1.5$. The process governing the evolution of

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[11]www.dhss.delaware.gov/dhss/ds/tanf.html.

[12]www.fus.usda.gov/snap.

[13]Note that the expected number of periods for a female before she becomes a mother, conditional on becoming a mother, is $1/(1 - m_{00} - m_{0\emptyset})$.

[14]Source: PEW 2010. This number is calculated as the fraction of women aged 40-44 without children. The share of childless women without a high school degree is 15%, while it is 17% for high school graduates and 18% for women with some college. We choose an intermediate value of 17%. All numbers are based on CPS data from 2006-08.

idiosyncratic labor productivity is assumed to be the same for females and males (Jonathan Heathcote, Kjetil Storesletten and Giovanni L. Violante 2010). The two parameters characterizing this process are set as in Martin Flodén and Jesper Lindé (2001), who estimate $\rho = 0.914$ and $\sigma_\epsilon = 0.206$. We set the cross-spouse/partner correlation of productivity shocks to 0.15 (Dean Hyslop 2001). The annual risk-free rate of return on savings is set to 3 percent.

Consumption commitments.— A number of assistance programs not explicitly considered in our analysis, such as reduced rent, public housing projects, the housing choice vouchers program and energy assistance benefits contribute to reducing households' consumption commitments. These programs disproportionately benefit lone mothers. For example, in our ASEC sample of households, we find that the fraction of lone mothers benefiting from reduced rent, public housing or energy assistance is more than six times the fraction among households formed by couples with children. In addition, the total tenant payment in public housing units is calculated as a fraction of household income, which implies a higher subsidy to one-earner households. We take all this as indication that consumption commitments are lower for lone mothers. Using average household earnings among lone mothers in our sample and the formula used to calculate the total tenant payment in public housing units, we set annual consumption commitments for lone mothers with two children at $2,000$. We break down this total by setting $\hat{c}_0^{\ell_s} = 1,000$ and $\hat{c}_1^{\ell_s} = 500$. While we calibrate total consumption commitments for couples internally, we set $\hat{c}_1^{\ell_{cp}} = \hat{c}_1^{\ell_c} = \hat{c}_1^{\ell_m} = 1,500$. This number is obtained by multiplying the minimum extra income needed to remain above the 2013 official poverty line per additional child ($4,300$ according to the U.S. Census Bureau) by the share of income spent on rent and utilities.

Child care and child support.—We set the value of α, which governs child care savings per child as the number of children in the household increases, using data on child care expenses from the Survey of Income and Program Participation (SIPP). Among households with children under 15 years old, we find that families with 2 (3+) children spend on average 46% (64%) more on child care than families with 1 child. We set $\alpha = 0.5$ to be roughly consistent with these estimates. Finally, we set child support per child, ϑ, using information from the lone mothers in our sample receiving child support. We find that lone mothers of one child receive on average $3,019$, and lone mothers of two children receive $5,480$. Based on these numbers, we set $\vartheta = 3,000$.

Distribution of asset holdings across single males.—The wealth distribution across single males, who make cohabitation or marriage proposals to single females, is treated as an exogenous object and will be kept fixed throughout our numerical experiments. We estimate this distribution from the 2013 wave of the Survey of Consumer Finances (SCF). Our sample consists of single males

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below 45 years of age who do not hold a college degree and who have never been married. From this sample we exclude individuals with negative net wealth or above $500,000$ (the wealthiest 3 percent). The empirical wealth distribution within the remaining sample is summarized in Table 2. As can be seen, there is substantial dispersion with regard to the assets that a potential cohabitant/spouse may contribute to the common pool of assets: more than 20 percent of single males hold less than $1,000$, while males from the upper decile own more than $170,000$. The median male making a cohabiting or marriage proposal owns roughly $9,700$.

TABLE 2—SINGLE MALES' ASSET DISTRIBUTION (IN THOUSAND DOLLARS)

Decile	1	2	3	4	5	6	7	8	9	10
Net worth	0.2	0.8	2.9	6.5	9.7	13.5	22.7	41.0	77.8	174.6

Source: 2013 Survey of Consumer Finances (SCF).

4.3   Parameters calibrated endogenously

The remaining twelve parameters are calibrated internally: β, φ, ζ, η_f, ω_f, ω_m, $\hat{c}_0^{\ell m}$, γ_1, γ_2, $\pi_{\ell_{cp}}$, π_{ℓ_c} and π_{ℓ_m}. We set values to these parameters so that the equilibrium of our model economy matches twelve moments from the data. While we cannot uniquely identify each parameter by a particular target, we report below in parenthesis the parameter that influences the most each moment. In particular, the moments used as targets to calibrate the twelve parameters are:

1-3. The shares of each household type in our 2014 ASEC sample are as follows: lone mothers, 19.6 percent; two-parent cohabiting couples, 7.1 percent; mother-only-present cohabiting couples, 2.3 percent; married couples, 70.9 percent ($\pi_{\ell_{cp}}, \pi_{\ell_c}, \pi_{\ell_m}$).

4. The employment rate of lone mothers is 80.3 percent (γ_2).

5. Average hours worked by lone mothers represent 22.3 percent of their time endowment (φ).

6. The employment rate among married individuals (females and males) is 77.1 percent (γ_1).

7. Average hours worked by all married individuals (females and males) represent 27.3 percent of their time endowment ($\hat{c}_0^{\ell m}$).

8. Average hours worked by working married females are 20.2 percent lower than those worked by working married males (μ).

9. Micro estimates of the intensive-margin Frisch elasticity of labor supply for single females without children are roughly the same as for males, which range between 0.2 and 0.7 (Blundell

and Thomas MaCurdy, 1999). We target an intensive-margin Frisch elasticity, evaluated at average hours worked, of 0.64 for single females without children and taxable income between \$8,925 and \$36,250. We choose workers in this group to help us identify parameter ζ because they are not entitled to tax credits and transfers and we can hence obtain their intensive-margin Frisch elasticity as $\frac{1}{\zeta}\frac{1-h}{h}$, where h is the worker's number of hours. (Note that lone mothers and couples have non-differentiable budget constraints, hindering the calculation of their Frisch elasticities.) (ζ).

10. Median net worth among married households, conditional on non-negative net worth, is \$22,804 (2013 SCF) (β).

11. Average earnings across lone mothers and married females are \$15,737 (ω_f).

12. The gender wage gap, defined as the mean log wage difference between full-time male and female workers, is 18 percent (ω_m).

The parameter values that match these moments are presented in Table 3.

TABLE 3— PARAMETERS CALIBRATED ENDOGENOUSLY

Description	Parameter	Value	Moment	Data	Model
Discount factor	β	0.956	median wealth marr.	22,804	22,815
Regulates Frisch elasticity	ζ	3	single f. Frisch elast.	0.64	0.64
Utility weight	φ	0.200	hours single females	0.223	0.224
Pareto weight	η_f	0.555	ratio hours	0.798	0.798
Female wage rate	ω_f	52.3	avg. earnings females	15,737	15,734
Male wage rate	ω_m	80.0	gender wage gap	0.180	0.180
Consumption commitment	$\hat{c}_0^{\ell_m}$	\$9,800	hours married indiv.	0.273	0.272
Work&child care costs (monthly)	γ_1	\$135	LFP married indiv.	0.771	0.772
Work&child care costs (monthly)	γ_2	\$507	LFP single females	0.803	0.803
Prob. no proposal	π_{ℓ_s}	0.791	population share ℓ_s	0.197	0.197
Prob. bpp-cohabitation proposal	$\pi_{\ell_{cp}}$	0.032	population share ℓ_{cp}	0.071	0.071
Prob. mop-cohabitation proposal	π_{ℓ_c}	0.006	population share ℓ_c	0.023	0.023
Prob. marriage proposal	π_{ℓ_m}	0.171	population share ℓ_m	0.709	0.709

4.4 Model fit

In this section we assess the fit of the model using a set of moments which have not been used as targets. Our focus is on labor supplies, household earnings, EITC recipients and costs, and on the

labor supply and marriage responses to the EITC. We compare moments generated by our model with those that we obtain from either our ASEC sample of lone mothers and married couples or the empirical literature. Since our calibration does not use information from cohabitants, we postpone the discussion of this type of couple to the next section, where we address the effects of the differential tax-transfer treatment of married and cohabiting couples.

Labor supply.—While our targets above pin down the employment rate and average hours worked by lone mothers, they do not uniquely pin down those of married females and married males separately. Hence, we start by comparing the average labor supply of married workers in the model with those in our sample. As shown in panel A of Table 4, our model does well in accounting for both participation and average hours worked of married individuals. Namely, the employment rate of married females in the model is 59.06 percent, against 61.07 percent in the data. Average annual hours worked by working married females are $1,665$ in the model and $1,684$ in the data. For married males, the model yields an employment rate of 95.29 percent, against 93.02 percent in the data. Average hours worked by working married males equal $2,086$ in the model and $2,111$ in the data.

The employment rate among married females varies with the level of their husbands' earnings. In our 2014 ASEC sample, this relationship is U-shaped, reaching the minimum at husbands' earnings in the range between 20 and 35 thousand dollars. In the model, we find a similar U-shaped relationship, with the minimum employment rate in the same earnings range as in the data. At higher levels of husbands' earnings, female employment rates in the model and the data are very close to each other. However, at lower levels of earnings, the model yields female employment rates somewhat higher than in the data. Similar patterns are found for married males, both in the data and in the model, although their employment rate is relatively less sensitive to wives' earnings. We will return to this relationship below in our discussion of the effects of the EITC on married females' labor supply.

Household earnings.—Panel B of Table 4 shows moments of household earnings in the model and in the data for each type of household. Average household earnings in the model are very close to those in the data for lone mothers, and about 13 percent below the data for married couples. Volatility is lower in the model than in the data. This is a consequence of a thinner right tail in the model's distribution of households earnings. That is, our model generates less households with six-figure earnings than in the data. For instance, the model does not generate married couples with earnings above $150,000$. Since our interest is on anti-poverty policy, this inability of the model to generate high-earning households has no sizable implications for our results.

TABLE 4—DATA *vs.* MODEL: LABOR SUPPLY AND HOUSEHOLD EARNINGS

	Lone mothers		Married couples	
	data	model	data	model
PANEL A. LABOR SUPPLY				
Employment rates				
Females	80.28	80.26	61.07	59.06
Males	–	–	93.02	95.29
Distribution (# earners)				
1	80.28	80.26	40.98	45.65
2	–	–	56.55	54.35
Average hours worked†				
Females	$1,523$	$1,532$	$1,684$	$1,665$
Males	–	–	$2,111$	$2,086$
PANEL B. HOUSEHOLD EARNINGS‡				
Average	$20,490$	$20,909$	$58,807$	$50,807$
Std. Dev.	$21,062$	$11,875$	$58,010$	$27,357$
Median	$17,000$	$17,162$	$50,000$	$45,737$
p25	$8,000$	$13,431$	$29,200$	$25,924$
p75	$28,000$	$25,012$	$75,000$	$67,786$

Source: Data: Calculations from our 2014 ASEC sample of households; model: Simulations from steady-state equilibrium. †Conditional on positive hours; ‡conditional on positive earnings.

Median household earnings in the model are very close to those in the data, both for lone mothers and married couples. The 25th earnings percentile for lone mothers in the model is somewhat higher than in the data. This is because some lone mothers in our sample have annual earnings as low as \$100, and our model does not generate households with such low annual earnings, as it would not be optimal for them after having paid the fixed costs of participation. The 75th earnings percentiles in the model are, on the contrary, lower than in the data. As explained above, our model does not match well the measure of households at the top of the empirical earnings distribution.

EITC recipients and costs.—We now look at the fraction of households within each household type receiving the EITC, and at the distributions of EITC recipients and costs by number of children. The percentage of households in the model receiving the EITC is quite close to that in the data, both for lone mothers and for married couples (see panel A of Table 5). For instance, in the model 74.4 percent of lone mothers receive the EITC, against 71.7 percent in our sample.

TABLE 5—DATA *vs.* MODEL: EITC

	Lone mothers		Married couples	
	data	model	data	model
A. EITC recipients (%)	71.78	74.42	43.67	50.45
B. Distr. of EITC recipients				
One child	11.92	18.70	17.62	14.83
Two children	9.85	5.52	27.74	27.77
Three children	5.54	0.76	14.56	18.34
C. Distr. of EITC costs				
One child	8.81	13.99	13.02	6.26
Two children	10.54	7.34	30.58	29.39
Three children	5.99	1.09	20.69	25.37

Notes: EITC recipients and EITC distributions in the data and in the model.

Among married couples, the model yields 50.4 percent of households receiving EITC, against 43.6 percent in our sample.

Panel B of Table 5 presents the distribution of EITC recipients by household type and number of children. The model matches fairly well this distribution in the data, especially for married couples. The relatively low representation of lone mothers with three children among EITC recipients in the model —0.76 against 5.5 in the data— is a result of our assumption of a constant arrival rate of proposals. That is, in our model lone mothers with three children are more likely to move to cohabitation or marriage than in the data, rendering a lower fraction of these lone mothers in the total population. This could be fixed by assuming (maybe realistically) that their probability of receiving proposals declines with the number of children. However, since lone mothers with three children are not, in any case, a numerous group in the data, our aggregate results would not be significantly affected.

The distribution of EITC costs by household type and number of children is shown in Panel C of Table 5. EITC costs are the sum of the non-refundable reductions in tax liabilities and the amounts refunded to eligible tax filers. Again, with the exception of lone mothers with three children, the model matches quite well this distribution in the data.

EITC effects on employment.—There is a vast empirical literature that has examined the labor supply responses to the EITC expansions of the 1980's and 1990's (TRA86, OBRA90 and OBRA93). A well-established consensus in this literature is that these EITC expansions increased employment among single mothers, with an estimated elasticity with respect to net income in

the range of $0.69 - 1.16$ (see Eissa and Hoynes 2006b for a review of this literature). Here, as another test of the model fit, we compute this elasticity in the model and compare it to the range of estimated values.

Specifically, we consider an expansion of the EITC that increases the phase-in rates and the maximum credits by 20%, and increases the phase-out rates by 10% for all household types. This expansion amounts to an average increase in the maximum credit by \$950. We then solve the model under this expanded EITC and compute the lone mothers' participation elasticity with respect to net earnings. More precisely, we compute this elasticity as

$$\varepsilon_{\ell_s}^P = \frac{\partial \ln \mathcal{P}_{\ell_s}}{\partial \ln E[1 - \tau_{\ell_s}^P]}, \tag{26}$$

where $\mathcal{P}_{\ell_s}$ is the employment rate of lone mothers and $E[1 - \tau_{\ell_s}^P]$ is the mean net-of-participation tax rate. The participation tax rate of a working lone mother is defined as

$$\tau_{\ell_s}^P = \frac{TT(a, e_f, n) - TT(a, 0, n)}{e_f}. \tag{27}$$

The function TT in the numerator of (27) is the tax-transfer function of lone mothers, which includes taxes, tax credits and assistance transfers, i.e. $TT = IRS - B^u - F^u$. The numerator is the difference in tax-transfers between employment and non-employment. Note that in the computation of the two percentage changes in (26) we must use the time-invariant measures of the steady-state equilibrium (ψ^s in our equilibrium definition). If the measures used to calculate the employment rate and the mean net-of-participation tax rate after the EITC expansion are those of the steady-state equilibrium pre-policy reform, we obtain the short-run participation elasticity. In this case, the change in the wealth distribution and the change in living arrangements triggered by the EITC expansion are not taken into account. If, on the other hand, we use the measures of the steady-state equilibrium post-policy reform, we obtain the long-run participation elasticity, which also accounts for the lone mothers' responses in wealth and living arrangements.

We find short- and long-run participation elasticities for lone mothers equal to 0.68 and 0.73, respectively. Although a comparison of these two elasticities with those estimated in the empirical literature is not straightforward, they are within the range of estimated values. On the one hand, most papers in the empirical literature examining the labor supply response of single mothers use the tax-filling unit as the relevant unit of analysis. Hence, they also include those unmarried mothers who live with a partner, or with their parents or other family members. In our model, however, a lone mother lives alone with her children and, hence, is unable to share both risks and household consumption commitments. On the other hand, while the empirical elasticities

are estimated from the equilibrium prior to the 1980's and 1990's EITC expansions, our elasticity is computed from the equilibrium after these reforms, and it may well be that this elasticity has not remained constant.

The participation elasticity for lone mothers computed from (26) masks substantial heterogeneity in participation elasticities within the population of lone mothers. For instance, the long-run participation elasticities among lone mothers of one, two and three children are, respectively, 0.47, 1.22 and 2.26. When disaggregated by asset holdings, we find a larger elasticity, 0.94, among lone mothers with assets in the lower half of the wealth distribution, and a smaller elasticity, 0.45, among those with assets in the upper half of the wealth distribution.

We have also computed the lone mothers' participation elasticity with respect to induced EITC income. To do this, we replace the percentage change in the mean net-of-participation tax rate in the denominator of (26) by the percentage change in mean EITC income, i.e. $\partial \ln E[I^s(e_f, n)]$. We obtain an elasticity of 0.2, which is below the 0.36 elasticity estimated by Hoynes and Ankur J. Patel (2015). Once again, we must emphasize that lone mothers in our model live alone with their children.

Regarding married couples, the empirical literature estimates that the EITC expansions reduced the employment rate of married mothers by 1.1 percentage points, but did not affect married fathers' (Eissa and Hoynes 2004). In our model, we find that the EITC expansion described above reduces married mothers' employment by 2.6 percentage points, from 59.1 to 56.5. This reduction comes primarily from married mothers in households where the male is the primary earner and household earnings are at, or slightly above, the phase-out region of the credit before the expansion. For these households, both income and substitution effects reduce participation among secondary earners. We also find that the employment rate of married fathers is unaffected by the EITC expansion. Overall, we obtain a reduction in total labor supply of married couples with children, a result that is consistent with the findings in Eissa and Hoynes (2004).

EITC effects on hours worked.—The estimation of responses in hours worked to EITC expansions is inherently more elusive than the estimation of responses in participation, and has consequently received less attention in the empirical literature. One of the main challenges faced in the estimation of intensive-margin responses among those working is the change in the working sample after an EITC reform, which yields a combination of behavioral and composition effects.[15]

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[15] A recent attempt to circumvent this difficulty is Chetty et al. (2013), who exploit local variation in knowledge about the EITC schedule and the change in eligibility at the birth of the first child to estimate new parents' intensive-margin responses to the EITC. These authors use a sample of individuals who filed a tax return as

Some authors (e.g., Eissa and Liebman 1996 and Jesse Rothstein 2005) find that the EITC has no impact on hours worked by low-educated single mothers, conditional on working. This finding contrasts with the decline in hours predicted by economic theory, since the EITC produces negative income and substitution effects to most single mothers (those whose earnings fall in the flat and phase-out regions of the credit).

To shed light on this discrepancy between the estimated EITC hours effects and those predicted by theory, we use our model to compute the long-run change in hours worked induced by our EITC expansion under two scenarios concerning the working sample. In the first scenario, we maintain the working sample unchanged, which is the one formed by lone mothers working *both* before and after the expansion. In the second scenario, which tries to replicate the working samples observed by the econometrician, we compute the change in hours worked from the samples of working lone mothers before and after the expansion. Note that in the latter sample some of the working lone mothers did not work before the expansion, which creates the above-mentioned challenge for the estimation of the hours effects. We obtain a decline in hours worked by working lone mothers of 3.7 percent under the first scenario, and of 3.2 percent under the second. This shows that while sample selection introduces a downward bias in the size of the hours response, it is not enough to explain the lack of effects found in the empirical literature. Again, the focus of this literature on unmarried mothers, including both those living alone with their children and those cohabiting, could explain the zero estimated effect. As we show below, cohabiting working mothers with low earnings choose to file as singles without dependents (hence losing entitlement to the EITC) when their partners can collect more income from tax credits by claiming the children as dependents and filling as head of household.

Among working married mothers, the empirical literature found that the EITC expansions reduced their hours worked between 1 and 4 percent (Eissa and Hoynes 2006a). In our model, the EITC expansion described above reduces hours worked by working married mothers by 2.2 percent under the first scenario (i.e. holding the working sample fixed), and by 1.3 percent under the second (i.e. using the samples of working married mothers before and after the expansion). It should be noted, however, that the combined expansions of the 1980's and 1990's amounted to larger increases in the maximum credit than the expansion considered in our exercise.

EITC effects on marriage.—The consensus in the empirical literature (Rosenbaum 2000, Eissa and Hoynes 2003, Herbst 2011) is that while the EITC expansions had overall negative effects on marriage, they raised marriage rates among those at the very bottom of the income distribution.

primary or secondary filers and claimed at least one child, but do not distinguish between males and females.

We now use our model to compute the change in the number of new marriages brought about by the EITC expansion introduced above. To pin down the immediate effect, which is the one typically estimated by the empirical literature, we calculate the number of new marriages after the expansion holding the wealth distribution and the measure of unmarried females fixed at the pre-expansion steady state. We first compute the overall effect, i.e. without conditioning on income, and obtain that new marriages decline by 0.79 percent. Then we look at the effect within each of the following three income groups: bottom (up to $30,000), middle (from $30,000 to $60,000) and high (more than $60,000). We find that new marriages increase by about 10 percent in the bottom group, decline by 4.8 percent in the middle group, and decline by 2.6 percent in the high group.

5   The Effects of the U.S. Tax-transfer System Across the Equilibrium Distribution

5.1   Lone Mothers

Labor supply.—Before examining the (dis)incentives introduced by the tax-transfer system to supply labor across the equilibrium distribution, we first show the participation tax rates of lone mothers with no assets as a function of the number of children and the level of earnings (left panel of Figure 1). The participation tax rates in this plot are as defined in equation (27) above, $\tau_{\ell_s}^P(0, e_f, n)$, which are calculated using only the tax-transfer system and, hence, are not equilibrium tax rates. It is apparent from this figure that the tax-transfer system, especially the EITC, provides large incentives to lone mothers to participate in the labor market. Compared to single females without children, lone mothers face negative participation tax rates up to earnings of about $21,000$ in the case of mothers of three children. The second kink of the EITC schedule and the loss of eligibility to TANF and SNAP for mothers of one, two and three children are visible in these tax rates from the jumps occurring at earnings levels of 17, 19 and 21 thousand dollars, respectively.

We turn now to the participation tax rates in equilibrium. Specifically, we plot the participation tax rates of working lone mothers with no assets as a function of the number of children and labor productivity, $\tau_{\ell_s}^P(0, e_f(z, 0, n), n)$, where $e_f(z, 0, n)$ are earnings in equilibrium (right panel of Figure 1). This plot allows us to assess the incentives to participate, as well as the disincentives to hours worked present in the U.S. tax-transfer system. Our focus on lone mothers with no assets

in this plot simplifies the exposition without affecting the implications qualitatively. As was to be expected, working lone mothers with low productivity get the highest incentives to work. In particular, low-productive working lone mothers of three get a participation subsidy of almost 25 percent of their earnings. Participation tax rates increase with productivity, converging to about 25 percent. The disincentives to hours worked can readily be seen from the flat parts in the schedules in this plot. The existence of productivity intervals yielding the same participation tax rate means that an increase in productivity does not always increase earnings. That is, working lone mothers with labor productivity in this interval reduce hours worked to avoid losing income from taxes and transfers. As is clear from the figure, the incidence of these disincentives is highest among lone mothers of three children, as they get more generous transfers and have, therefore, relatively more to lose. (For instance, lone mothers of three with labor productivities between 1.7 and 2.4 have the same level of earnings.)
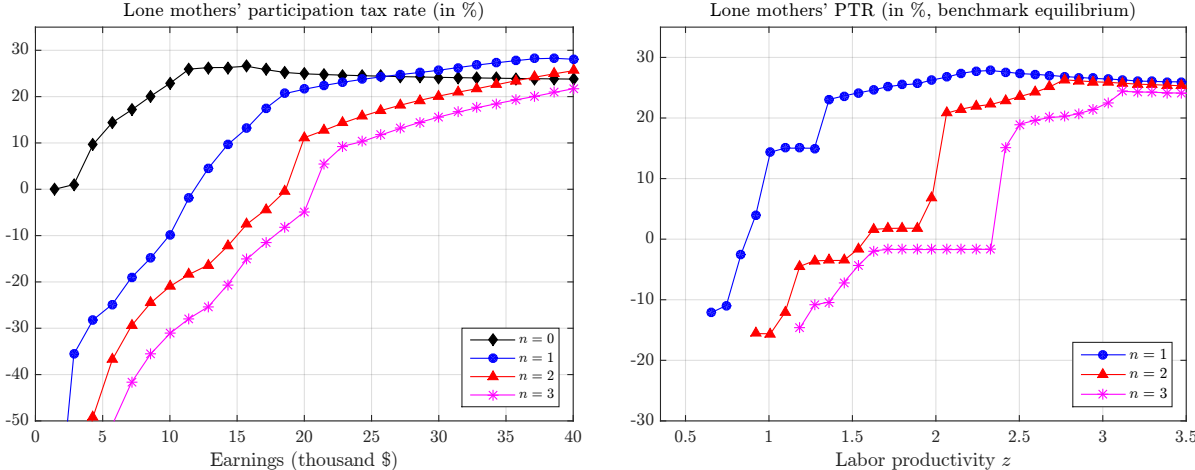

FIGURE 1. LONE MOTHERS' PARTICIPATION TAX RATES

Notes: Lone mothers' participation tax rates calculated from the tax-transfer system as a function of earnings (left panel), and lone mothers' participation tax rates in equilibrium as a function of labor productivity (right panel).

We now address the question of how much it costs the government to have lone mothers participating in the labor market. To answer this question we compute the government's net extra cost of employment across lone mothers (the difference between net cost of employment and net cost of non-employment). We abstract from payroll taxes as they create entitlements to future government expenses that are not included in our model. Table 6 presents these net extra costs of labor market participation to the government, expressed in terms of dollars both

per working lone mother and per hour worked.

TABLE 6—GOVERNMENT'S NET EXTRA COST OF LONE MOTHERS' EMPLOYMENT

	Working lone mothers			
	All	$n = 1$	$n = 2$	$n = 3$
Net cost of employment ($)	-388	-1,099	1,664	2,531
(per working lone mother)				
Net cost of employment ($)	-0.25	-0.69	1.20	1.91
(per lone mothers' hours worked)				

Notes: Numbers in this table represent the net extra cost to the government of lone mothers' employment (excluding payroll taxes).

As expected, the employment of lone mothers of two and three children is the most costly to the government. In fact, the government pays $1,664$ extra dollars per employed lone mother of two, and $2,531$ extra dollars per employed lone mother of three. The cost of employment of lone mothers of one child is -$1,099$, meaning that the government collects a revenue from their participation.

Savings.—The $2,000$ asset limit for TANF and SNAP eligibility distorts the savings decision of lone mothers. The extent of the distortion depends importantly on their labor productivity. For instance, lone mothers of one child with average labor productivity ($z = 1$) will choose savings so that they meet the asset test even when their wealth level is as high as $14,000$ (i.e., they are willing to dissave up to $12,000$ in order to gain TANF and SNAP eligibility). Beyond this level of wealth, these lone mothers find it optimal to hold wealth above $2,000$ and give up TANF and SNAP. On the other hand, high-productive lone mothers choose savings above the TANF and SNAP asset limit from much lower wealth levels. As an illustration, Figure 2 plots next-period assets as a function of current assets for lone mothers of one child with low, average and high labor productivity. It is apparent from this figure that introducing an asset limit as a threshold cliff is bound to have sizable effects on savings. Phasing out TANF and SNAP benefits on the basis of assets, as is done on income, would help reduce distortions on savings. (The newly created Universal Credit that will replace all extant tax credits and income support programs in the U.K. does indeed introduce a phase out on assets between £6,000 and £16,000.)
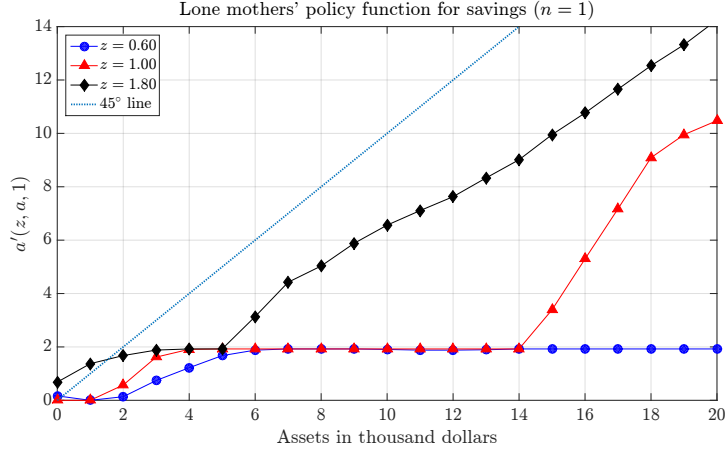
FIGURE 2. POLICY FUNCTIONS FOR SAVINGS

Notes: Savings policy functions for lone mothers of one child evaluated at three labor productivity levels. Values below the forty-five degree line correspond to negative net savings.

5.2 Cohabitation *vs.* Marriage

To shed light on the existence of a marriage penalty in the tax-transfer system, relative to cohabitation, and on the behavioral response to such a penalty, we now compare labor supplies across these two types of couples. As noted above, in our model any difference in their labor supply decisions is a behavioral response to their tax-transfer schemes. We find that the employment rate of cohabiting males is only 3 percentage points higher than that of married males. However, the employment rate of cohabiting females is 30 percentage points higher than among married females. As for average hours worked (conditional on working), cohabiting males work 70 hours less per year than married males. Working females cohabiting with the father of their children work about 40 hours more per year than married females. Working females cohabiting with a male who is not the father of their children work almost 80 hours less than married females. This indicates that, everything else equal, the differential tax-transfer treatment of cohabiting and married couples has sizable labor supply effects, especially for females at the extensive margin. Employment among married mothers is significantly hindered by their tax-transfer scheme. The implied cost in terms of annual household earnings goes from almost $3,000$ (if compared to mother-only-present cohabiting couples) to $6,000$ (if compared to both-parents-present cohabiting couples).

Participation tax rates of cohabiting and married mothers.—To understand the disincentives introduced by the tax-transfer scheme on female labor supply, Figure 3 (left panel) plots the participation tax rates of cohabiting and married mothers as a function of the number of children

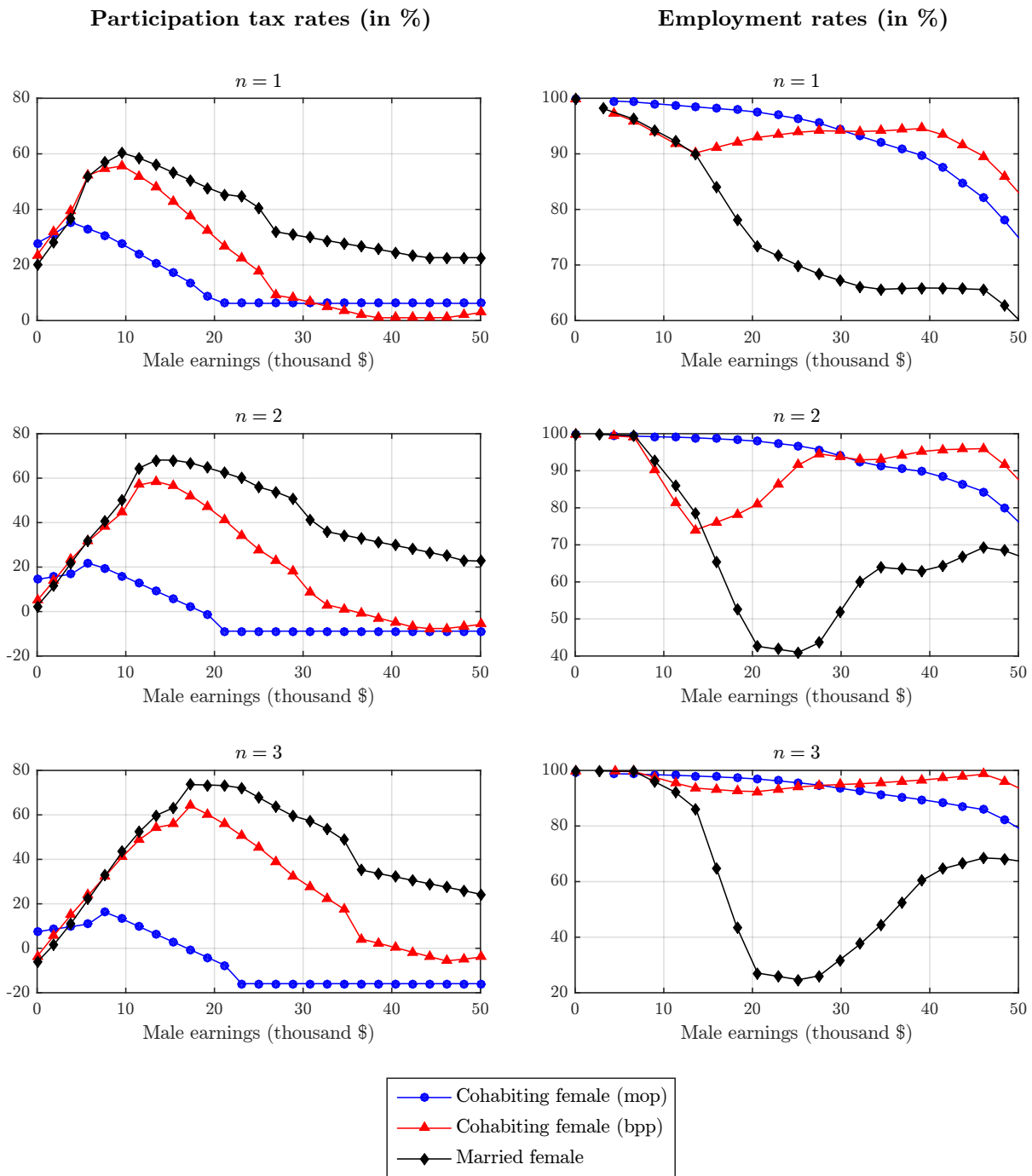**Participation tax rates (in %)**   **Employment rates (in %)**

FIGURE 3. FEMALE PARTICIPATION TAX RATES AND EMPLOYMENT RATES

Notes: Female participation tax rates (left panels) and female employment rates (right panels) in cohabiting and married households, as a function of their partners/husbands earnings and the number of children.

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and the earnings of their partners/husbands. More specifically, we use the tax-transfer system to calculate the participation tax rate of working females earning $20,000$ as

$$\frac{TT(0, 20,000 + e_m, n) - TT(0, e_m, n)}{20,000},$$

where TT is the respective tax-transfer function of cohabiting or married couples. Note that these female participation tax rates correspond to couples with no assets; however, similar qualitative results would have been obtained under different levels of wealth or female earnings upon participation. Also note that these are not equilibrium tax rates. (In the calculation of these participation tax rates we only use the corresponding tax-transfer function and the optimal choice for the filling status within the couple.)

Figure 3 shows that married mothers face higher participation tax rates than cohabiting mothers. The maximum difference between their tax rates is reached at male earnings between $30,000$ and $45,000$, which is the earnings interval that has most of the male workers in our sample. Interestingly, both-parents-present cohabiting mothers can obtain negative participation tax rates by filing as head of household when their partners earnings are at or above the third kink of the EITC schedule. That is, when male earnings are too high to gain EITC income, the female can take over as head of household and the couple can continue to receive EITC income. This is in contrast to married couples, for whom the EITC is based on household earnings.

Employment rates of cohabiting and married mothers.—We now use our model to obtain the behavioral labor supply response to this differential in participation tax rates. Figure 3 (right panel) plots the employment rates of cohabiting and married mothers, conditioning on the number of children and the earnings level of their partners/husbands. Married females have the lowest employment rates, except at very low levels of male earnings. The maximum gap in employment rates between cohabiting and married mothers occurs at male earnings around $30,000$. This shows the large disincentives introduced by the EITC on married mothers (vis-a-vis cohabiting mothers), especially when their husbands' earnings are in the phase-out region of the credit.

Effective tax rates of cohabiting and married couples.—As a final inquiry into the marriage penalty, we compare the difference between effective tax rates before and after tax credits across cohabiting and married couples. We find that, up to household earnings of about $35,000$, married couples gain more from tax credits than cohabiting couples. However, for household earnings above this level, it is cohabiting couples who make a wider use of the tax credits (see left panel of Figure 4). Further, while cohabiting couples with combined earnings above $80,000$ still remain entitled to tax credits, married couples lose entitlement at combined earnings over $50,000$. This is explained

by the ability of cohabiting working females to file as head of household, and earn EITC income, regardless their partners' earnings. As explained above, both-parents-present cohabiting couples may find it optimal that the secondary earner takes over as head of household as soon as the primary worker's earnings fall into the phase-out region of the EITC.
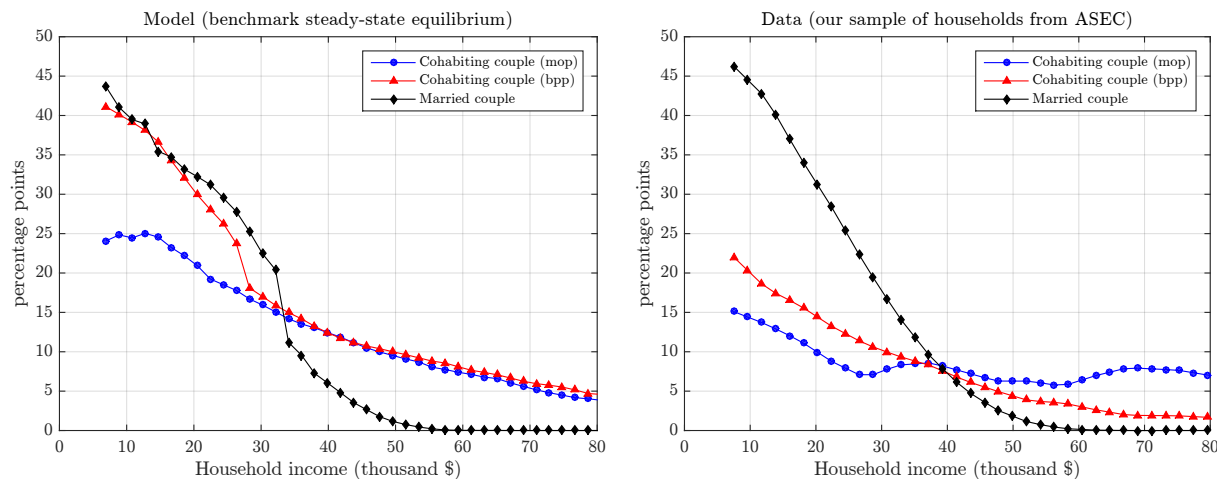

FIGURE 4. DIFFERENCE BETWEEN EFFECTIVE TAX RATES BEFORE AND AFTER TAX CREDITS

Notes: This figure shows the difference between effective tax rates before and after tax credits in the model (left panel) and in our data (right panel).

We show that these implications of the model are also present in the data. The right panel of Figure 4 shows the difference between effective tax rates before and after credits for households in our ASEC sample. The same patterns found in the model are observed in the data: Married couples gain more than cohabiting couples from tax credits at low levels of combined earnings, but the latter remain entitled to tax credits further beyond the level of earnings at which married couples lose their entitlement.

Lone mothers' cohabiting and marriage acceptance rates.—We now show average acceptance rates as a function of the lone mother's labor productivity. By comparing acceptance rates of cohabiting and marriage proposals we seek to identify the effects of the tax-transfer system on marriage. In our model, cohabitation and marriage provide the same opportunities to share risks within the households and entail the same consumption commitments. Any difference in the acceptance rates of proposals to marry and cohabit stems from the tax-transfer system, and hence informs on the (dis)incentives faced by lone mothers to marry, relative to cohabit. In Figure 5 we plot average acceptance rates. More productive lone mothers are pickier and accept less proposals, either to

marry of to cohabit. Proposals to cohabit from a male who is not the father of the children have the highest acceptance rate at all levels of the lone mother's productivity. For proposals coming from the father of her children, a low-productive lone mother ($z \leq 0.75$) is more likely to accept marriage than cohabitation. However, average and high-productive lone mothers are more likely to accept cohabitation than marriage proposals from the father of her children. These results are consistent with our findings above showing that low-earning couples benefit more from tax credits if they are married than if they cohabit.
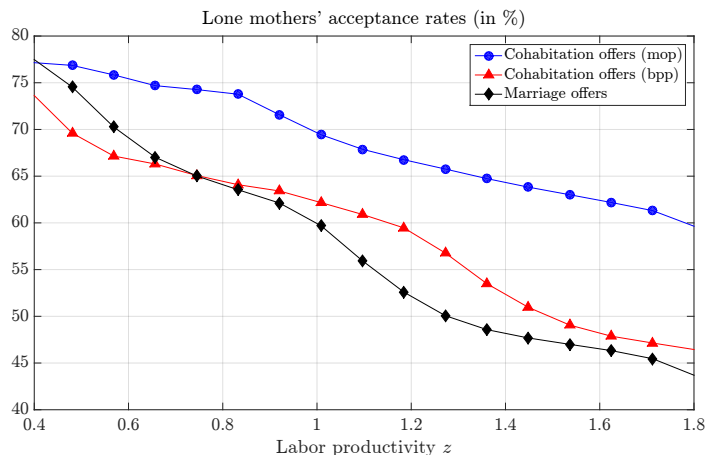

FIGURE 5. LONE MOTHERS' ACCEPTANCE RATES

Notes: This figure shows lone mothers' average acceptance rates of cohabiting and marriage proposals. That is, for each labor productivity we plot average acceptance rates across the equilibrium distribution over assets and number of children.

6   An Evaluation of Three EITC Reform Plans

The good fit of our model to non-targeted empirical moments, and especially to the estimated responses in labor supply and marriage to EITC expansions, provides support for its use as a tool for counterfactual policy evaluation. This section sets out to evaluate three recent proposals to reform the EITC. The first proposal introduces a new deduction for two-earner married couples. The second proposal amounts to an across-the-board reduction of the EITC. The third one calls for an EITC schedule based on personal rather than family earnings.

Reform #1: A new deduction for two-earner married couples. This is a plan included in the "21st Century Worker Tax Cut Act", a legislative proposal introduced on March 26, 2014 to the 113th Congress by Patricia Murray (D), then Chairwoman of the U.S. Senate Budget

Committee.[16] This reform would create a new deduction for married couples with children of 20 percent of the earnings of the secondary worker. The deduction would be applied before computing EITC eligibility.[17] That is, the income requirement for EITC eligibility for a married couple with n children would be $e_f + e_m + ra - 0.2 \min\{e_f, e_m\} \leq \mathrm{y}_I^{jn}$. And household earnings for the purpose of calculating the credit for eligible married couples would be $e = e_f + e_m - 0.2 \min\{e_f, e_m\}$. To evaluate the long-run effects of this reform, we compute the steady-state equilibrium under this new EITC schedule, holding taxes and other transfers unchanged.[18] We do not impose revenue neutrality so that we can ascertain the cost of the reform.

Our results are shown in column [2] of Table 6 as percentage changes with respect to the benchmark steady-state equilibrium (column [1]). Although the effects of this reform are largest among married couples, it also affects lone mothers' decisions and hence living arrangements. The employment rate of married females increases by more than 3 percent, and the fraction of two-earner married households goes up by almost 5 percent (panel C). Average hours worked, by contrast, remain mostly unchanged: Married females reduce hours by 0.93 percent, and married males by 0.48 percent. To understand these labor supply effects, it should be noted that this new deduction introduces a positive income effect on labor supply for married couples with earnings in the phase-in region and at the beginning of the flat region, and negative income effects in the phase-out region. It also introduces negative substitution effects for married females in the phase-in region, but positive substitution effects at the beginning of the flat region and in the phase-out region. This expansion in labor supply reduces the poverty rate (measured using the guidelines of the Census Bureau) among married couples with children by 6.38 percent. As expected, the fraction of EITC recipients and EITC costs per household increase, but, interestingly, this reform reduces the sum of TANF and SNAP costs. Overall, this reform increases married couples' net contribution to the federal budget (per married couple) by 1.14 percent. Average welfare of married females and males increase with this reform by 0.02 and 0.29 percent, respectively (in consumption equivalent units).

Panel B shows the effects on lone mothers. Although their EITC schedule remains unchanged under this reform, the new deduction to two-earner couples increases the value of marriage and

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[16]The bill was read twice and referred to the Finance Committee, but it did not advance further.

[17]A plan similar to this one had already been put forward by Mike Brewer, Emmanuel Saez and Andrew Shephard (2009) to reform the UK tax-transfer system. To improve the incentives of secondary earners to enter work, these authors propose expanding earnings disregards for secondary earners.

[18]Actually, the new deduction introduced in this Tax Cut Act extends to the calculation of income taxes for married couples where the secondary worker's earnings are below $60,000$. Here, we chose to introduce the deduction only into the EITC in order to better understand its effect on low-income households.

hence lone mothers' marriage acceptance rates. This has two main implications. First, the increased prospects of marriage lead lone mothers to save less, as they need less precautionary savings. The second effect changes the composition of this population. This is because the new deduction lessens the marriage penalty especially for high-productivity lone mothers if they marry. Hence, this is the group of lone mothers where the transition rate to marriage increases the most, reducing their share in this population. Overall, lone mothers' average wealth declines by 0.53 percent, and the poverty rate increases by 0.19 percent. Average welfare among lone mothers declines by 0.03 percent, and welfare for an entering single female without children declines by 0.01 percent. Panel A shows that the higher marriage acceptance rate reduces the populations of lone mothers and cohabiting couples, and increases the population of married couples. Consequently, this reform yields a reduction in the rate of births outside of marriage by 0.75 percent, and in the share of children living in poverty by 4.25 percent.

To compute the cost of this reform we divide the sum of the net contributions to the federal budget (taxes minus transfers) across all households in our population of interest by the total number of households in this population. We obtain that under this reform the net contribution per household would be $879, against $860 in our benchmark steady state. This implies an increase in government revenues of $19 per non-college-educated household with children. It should be noted that this increase is in part explained by the reduction in the fraction of lone mother households, who are net recipients of federal funds, and by the increase in the fraction of married couples, who are net contributors.

Reform #2: A comprehensive reform of taxes and tax credits. This reform plan is part of the "Tax Reform Act of 2014", introduced in House on December 10, 2014 by Dave Camp (R), then Chairman of the Ways and Means Committee. This Act is a comprehensive tax-transfer reform plan which, in addition to changes to the EITC also proposes the elimination of the head-of-household filing status, a reduction in tax rates and in the number of income brackets, the elimination of personal exemptions, and an increase in the standard deduction and in the child tax credit. We evaluate the effects of this comprehensive reform plan by replacing the current schemes by those proposed in the Act. As far as the EITC is concerned, the Act reduces the subsidy rates and the maximum credit for almost all filers, except for families with one child with earnings between $25,000 and $35,000.

The proposed changes to the income tax schedule include a reduction in the number of tax rates to three (10, 25 and 35 percent), and a reduction in the number of rate schedules to two (one for married filing jointly and the other for the rest). The lowest income bracket for married

filers, which would continue to be taxed at 10 percent, is extended from $17,850 to $71,200. Concerning the child tax credit, the plan increases the subsidy per child to $1,500, and the phase-out thresholds to $623,000 for joint fillers and $411,800 for all other filers. (Standard deductions, income brackets and the EITC parameters under this plan are shown in online Appendix D.)

The effects of this reform plan are presented in column [3] of Table 7, again as percentage changes with respect to the benchmark steady state. Its effects are notably larger than those of reform plan #1 for all household types. Panel B shows that the lower EITC subsidy rates bring about a reduction in the employment rate of lone mothers by 15.65 percent, and an increase in their hours worked by 9.35 percent. Poverty among lone mothers decreases, while their marriage acceptance rate increases. Importantly, the large drop in the EITC leads to a reduction in the net federal transfers received by lone mothers by 23 percent. However, their average welfare increases by 0.6 percent, and welfare of an entering single female without children increases by 1.15 percent. Panel C presents the effects for married couples. The reduction in tax rates and, especially, the expansion of the lowest income bracket, yield an increase in employment among married individuals, notwithstanding the lower EITC subsidy rates. For instance, the married females' employment rate goes up by more than 10 percent, which contributes to increasing the fraction of two-earner households by 14 percent. Hours worked also increase, especially among married males. This expansion in labor supply yields a significant drop in the poverty rate of married households. However, transfers from the EITC, TANF and SNAP fall sharply, which increases the net contribution of married households to the federal budget by 13 percent. Average welfare of married females and males increase by 2.25 and 1.89 percent, respectively.

This reform plan would yield an increase in net government revenues accruing from our population of interest of $405 per household. In this case, the extra net government revenues result from both the sharp reduction in the amount redistributed to lone mothers, and from the increase in the net contribution of married households. In light of these results, this reform plan would reduce redistribution, while reducing poverty and increasing average welfare among all household types in our population of interest. It would also increase ex-ante welfare to entering single females without children.

Reform #3: An EITC based on personal earnings. This reform plan, put forth by Elaine Maag (2015) of the Urban Institute's Tax Policy Center, calls for replacing the current EITC schedule with a worker credit based on personal rather than household earnings. This is a bolder reform proposal which would overhaul the EITC schedule. The new worker credit would be blind with respect to filing status and number of children. The intended objectives of this reform plan

are the mitigation of both marriage penalties and the work disincentives for secondary earners present in the current schedule. It would also eliminate the cost and high error rates associated with determining who has qualifying children. Our implementation of this reform plan offers *all* workers in households with children the current EITC schedule for lone mothers with one child.

Column [4] of Table 7 presents the effects of this reform plan. Among lone mothers (panel B) this reform yields a reduction in the employment rate, which is explained by the reduction in the EITC for lone mothers with two or more children. Since this reform increases the value of marriage, lone mothers accept more marriage proposals and save less in anticipation of the reduced need for precautionary savings once married. The lower employment and savings rates bring about a sharp increase in poverty among lone mothers. Net transfers from federal programs decline by 11 percent. Average welfare among lone mothers declines by 0.52 percent, but welfare for an entering single female without children increases by 0.2 percent.

By contrast, under this reform employment would increase among married couples (panel C), especially for married females. The percentage of two-earner households increases by 52 percent. As a result, poverty among married couples drops significantly. There is a large increase in households' EITC income, but a reduction in transfers from TANF and SNAP. Overall, their per-household net contribution to the federal budget goes down by 30 percent.

The cost of this reform plan to the government amounts to $284 per household in our population of interest. This cost stems mainly from the sharp decline in the net contribution of married households to the federal budget and, in particular, from the large increase in EITC costs for these households.

6.1 Participation Tax Rates and Employment Rates Across the Three Reforms

In order to better understand the effects of each of these three reform plans on the decision to work among married females, Figure 6 shows their average participation tax rates and employment rates. From the left panel of this figure, it is apparent that the 20 percent deduction introduced by reform plan #1 yields a modest reduction in the participation tax rates of married females only when their husbands' earning are between $10,000$ and $30,000$. This reduction fosters employment among these married females up to 5 percentage points, relative to the benchmark steady state. Reform plan #2 is more effective than reform #1 at reducing married females' participation tax rates, especially among those whose husbands earn between $5,000$ and $25,000$, boosting

their employment relative to reform #1. Interestingly, participation tax rates when husbands' earnings are between $25,000 and $30,000 are the same under reform plans #1 and #2. Finally, reform plan #3, by transforming the EITC into a personal, rather than a household tax credit, brings about the largest reduction in married females' participation tax rates. Consequently, it yields the largest increase in their employment rates.
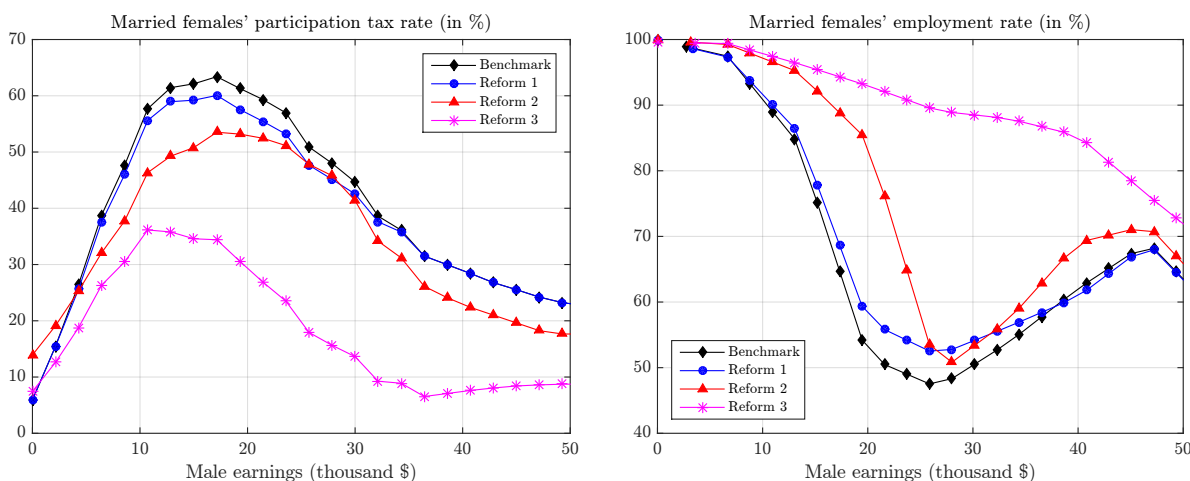
FIGURE 6. MARRIED FEMALES' PARTICIPATION TAX RATES AND EMPLOYMENT RATES

Notes: Married females' participation tax rates (left panels) and married females' employment rates (right panels) under the three reform plans.

7 Conclusion

Understanding the effects of taxes and transfers on households' decisions, especially among those with low income, is key for positive and normative analyses. In this paper, we contribute to an active literature using structural dynamic models to measure the (dis)incentives to work, save and marry inherent in tax-transfers systems. Measuring the responses along these margins will help design more efficient schemes to assist low-income households. We present a model of labor supply, consumption, savings and marriage decisions that allows us to examine these responses and evaluate the consequences of three recent proposals to reform the U.S. tax-transfer system. Our model generates an equilibrium distribution of households and, hence, we can measure the (dis)incentives across households, and assess the effects of policy reforms on a given population.

Since income transfers to assist low-income households with children are means-tested and

phased out, we assume joint decision making in two-adult households. That is, instead of assuming that the decisions of one of the workers in the household are exogenous and unresponsive to household conditions, we endogenize the decisions of each adult member. We do so by adopting the decision making process in Chiappori (1988), whereby the household attains Pareto efficient intra-households allocations by maximizing a weighted sum of the members' utilities. Hence, we can compute the value for single females of forming a two-adult household, and thus endogenize marriage and cohabitation decisions as well.

The main contribution of this paper is the development of a model that can be used as a laboratory for ex-ante evaluation of the distributional and aggregate consequences of policy reforms. While our model builds on the workhorse framework of precautionary savings and income inequality, it departs from it by introducing one- and two-adult households, an endogenous decision of the living arrangement and joint decision making within the household. We model the U.S. income tax scheme and the income transfer programs in great detail, embedding the eligibility and benefits criteria for households according to their number of qualifying children, filing status and living arrangement. This allows us to examine the behavioral responses to the tax-transfer system at a more disaggregated level, to shed light on the marriage penalty/bonus, and to identify new effects of policy reforms. For instance, our evaluation of the "21st Century Tax Cut Act", reveals that introducing a new deduction to the EITC of two-earner married couples has the non-intended consequence of increasing the poverty rate among lone mothers.

There are two extensions of our model that we leave for future research: (1) The introduction of an endogenous labor demand. In our model, the wage rate is assumed to be exogenous and, hence, unaffected by any change in labor supply that may be brought about by transfer programs. This assumption does not allow us to address issues related to the incidence of taxes and transfers (see Rothstein 2010). While endogenizing labor demand in our framework is rather straightforward, we chose to focus on the supply side for the sake of clarify and space limitation. (2) The introduction of time limits to TANF. As mentioned, TANF has time limits (5 years) which we did not introduce in our model. We do not believe this is an important omission in our analysis. First, since their introduction in 1996 many states have been allowed to waive time limits on and off. Second, in states were time limits are in place, they are allowed to extend TANF benefits beyond the time limit for up to 20 percent of their caseload. Third, families affected by the time limits are converted to TANF child-only units, where only the number of children is used to calculate the benefits. Also, affected families are typically transferred to state and locally funded programs providing about the same benefits.

TABLE 7—LONG-RUN EFFECTS OF EITC REFORMS

	Benchmark	Steady state post-reform: % change		
		Reform #1	Reform #2	Reform #3
PANEL A. DEMOGRAPHICS	[1]	[2]	[3]	[4]
Lone mothers (%)	19.69	−0.11	−3.67	−5.88
Married couples (%)	70.85	+0.41	+4.75	+11.01
Cohabiting couples (%)	9.46	−2.83	−27.89	−70.17
New marriage rate[†]	7.58	+1.34	+17.33	+54.23
% all births outside of marriage	60.42	−0.75	−2.89	−10.12
% children living in poverty	25.01	−4.25	−48.01	−41.81
PANEL B. LONE MOTHERS				
Marriage acceptance rate	55.03	+0.07	+4.32	+7.03
Employment rate (%)	80.26	−0.06	−15.65	−6.68
Avg. hours worked[‡]	1,532	+0.00	+9.35	+1.50
Avg. household earnings[‡]	20,909	−0.04	+15.32	+3.29
Avg. household disposable income	25.291	−0.06	−5.64	−4.55
Avg. household wealth	5,272	−0.53	+10.76	−2.83
Poverty rate (%)	34.95	+0.19	−7.59	+16.56
EITC recipients (%)	74.42	−0.05	−23.46	−11.14
EITC costs[*]	2,451	−0.05	−50.56	−25.83
SNAP + TANF costs[*]	2,629	+0.15	+3.12	+7.56
Net transfers from federal budget[*]	4,248	+0.09	−22.53	−11.84
Avg. welfare gain/loss (%)	–	−0.03	+0.60	−0.52
PANEL C. MARRIED COUPLES				
Employment rate (%)				
Females	59.06	+3.20	+10.28	+41.36
Males	95.29	+0.72	+1.73	+4.09
Two-earner households (%)	54.35	+4.73	+14.20	+52.12
Avg. hours worked[‡]				
Females	1,665	−0.93	+0.29	−6.27
Males	2,087	−0.48	+2.37	−2.48
Avg. household earnings[‡]	50,807	+0.24	+3.40	+3.28
Avg. household disposable income	50,607	+0.18	+3.42	+4.27
Avg. household wealth	68,706	−0.44	+14.26	−9.48
Poverty rate (%)	18.49	−6.38	−64.31	−62.49
EITC recipients (%)	50.45	+8.47	−12.30	+64.59
EITC costs[*]	1,885	+3.14	−32.16	+81.54
SNAP + TANF costs[*]	1,443	−6.46	−39.41	−50.48
Net contrib. to federal budget[*]	2,274	+1.14	+12.83	−30.29
Avg. welfare gain/loss (%)				
Females	–	+0.02	+2.25	−0.17
Males	–	+0.29	+1.89	+3.41

Notes: [†]The new marriage rate is the number of new marriages in a given period divided by the number of unmarried mothers in that period. [‡]Conditioning on positive hours. [*]Per household in the relevant subpopulation.

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ONLINE APPENDIX FOR

Anti-poverty Income Transfers in the U.S.: A Framework for the Evaluation of Policy Reforms

Salvador Ortigueira and Nawid Siassi

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This appendix has four parts: Appendix A presents the parameter values of the 2013 U.S. tax-transfer system (federal income taxation, payroll taxes, the Earned Income Tax Credit, Child Tax Credit, Temporary Assistance for Needy Families and the Supplemental Nutrition Assistance Program). It also presents other parameters calibrated outside of the model. In appendix B we derive the transition functions introduced in the definition of the steady-state equilibrium. Appendix C presents the calibration of the fertility process. Appendix D presents federal income taxes, the Earned Income Tax Credit and the Child Tax Credit under the reform plan presented by Dave Camp in the "Tax Reform Act 2014".

Appendix A: Tax-transfer parameter values and other parameters calibrated outside of the model

In this Appendix we present the parameter values of the 2013 federal income tax schedule, payroll taxes, and the four transfer programs considered in our model, namely, the Earned Income Tax Credit, the Child Tax Credit, the Temporary Assistance for Needy Families and the Supplemental Nutrition Assistance Program. We also present the parameter values calibrated outside of the model.

Income and Payroll Taxes

TABLE A1—INCOME BRACKETS (ALL VALUES IN $)

Bracket	Parameter	Single $(j = s)$	Head of household $(j = \hbar)$	Married $(j = x)$
1	$b^{j,0}$	0	0	0
2	$b^{j,1}$	8,925	12,750	17,850
3	$b^{j,2}$	36,250	48,600	72,500
4	$b^{j,3}$	87,850	125,450	146,400
5	$b^{j,4}$	183,250	203,150	223,050
6	$b^{j,5}$	398,350	398,350	398,350
7	$b^{j,6}$	400,000	425,000	450,000

Source: 2013 income brackets for federal income taxes, from IRS website.

TABLE A2—INCOME AND PAYROLL TAX RATES

Description	Comment	Parameter	Value
Standard deduction (in $)	Single	d_T^s	6,100
Standard deduction (in $)	Head of household	$d_T^\hbar$	8,950
Standard deduction (in $)	Married	d_T^x	12,200
Personal exemption (in $)	Per person	ξ_T	3,900
Marginal tax rate	Bracket 1	τ_y^1	0.10
Marginal tax rate	Bracket 2	τ_y^2	0.15
Marginal tax rate	Bracket 3	τ_y^3	0.25
Marginal tax rate	Bracket 4	τ_y^4	0.28
Marginal tax rate	Bracket 5	τ_y^5	0.33
Marginal tax rate	Bracket 6	τ_y^6	0.35
Marginal tax rate	Bracket 7	τ_y^7	0.396
Social Security tax	Employee's share	$\tau_{p,SS}$	0.0620
Medicare tax	Employee's share	$\tau_{p,MA}$	0.0145
Social Security cap (in $)	Earnings cap	$\bar{e}$	113,700

Source: 2013 standard deductions, federal income tax rates and payroll taxes, from IRS website.

The Earned Income Tax Credit (EITC)

TABLE A3—EARNED INCOME TAX CREDIT: ELIGIBILITY

	Max. investment income, $\bar{\text{r}}\text{a}_I$ ($)	Max. total income, y_I^{jn} ($)	
	$j = s, \hbar, x$	$j = s, \hbar$	$j = x$
No children, $n = 0$	3,300	14,340	19,680
One child, $n = 1$	3,300	37,870	43,210
Two children, $n = 2$	3,300	43,038	48,378
Three children, $n = 3$	3,300	46,227	51,567

Source: Investment and total income limits for 2013 EITC eligibility, from IRS website.

TABLE A4—EARNED INCOME TAX CREDIT: CREDIT RATES AND EARNINGS THRESHOLDS

	Phase-in rate, κ_1^{jn} (%)	Earnings end phase-in, $\text{e}_{I_1}^{jn}$ ($)	Earnings beginning phase-out, $\text{e}_{I_2}^{jn}$ ($)		Phase-out rate, κ_2^{jn} (%)
	$j = s, \hbar, x$	$j = s, \hbar, x$	$j = s, \hbar$	$j = x$	$j = s, \hbar, x$
No children, $n = 0$	7.65	6,350	8,000	13,350	7.65
One child, $n = 1$	34.0	9,550	17,550	22,900	15.9
Two children, $n = 2$	40.0	13,400	17,550	22,900	21.0
Three children, $n = 3$	45.1	13,400	17,550	22,900	21.0

Source: Subsidy rates and earnings thresholds for 2013 EITC, from IRS website.

Earned Income Tax Credit
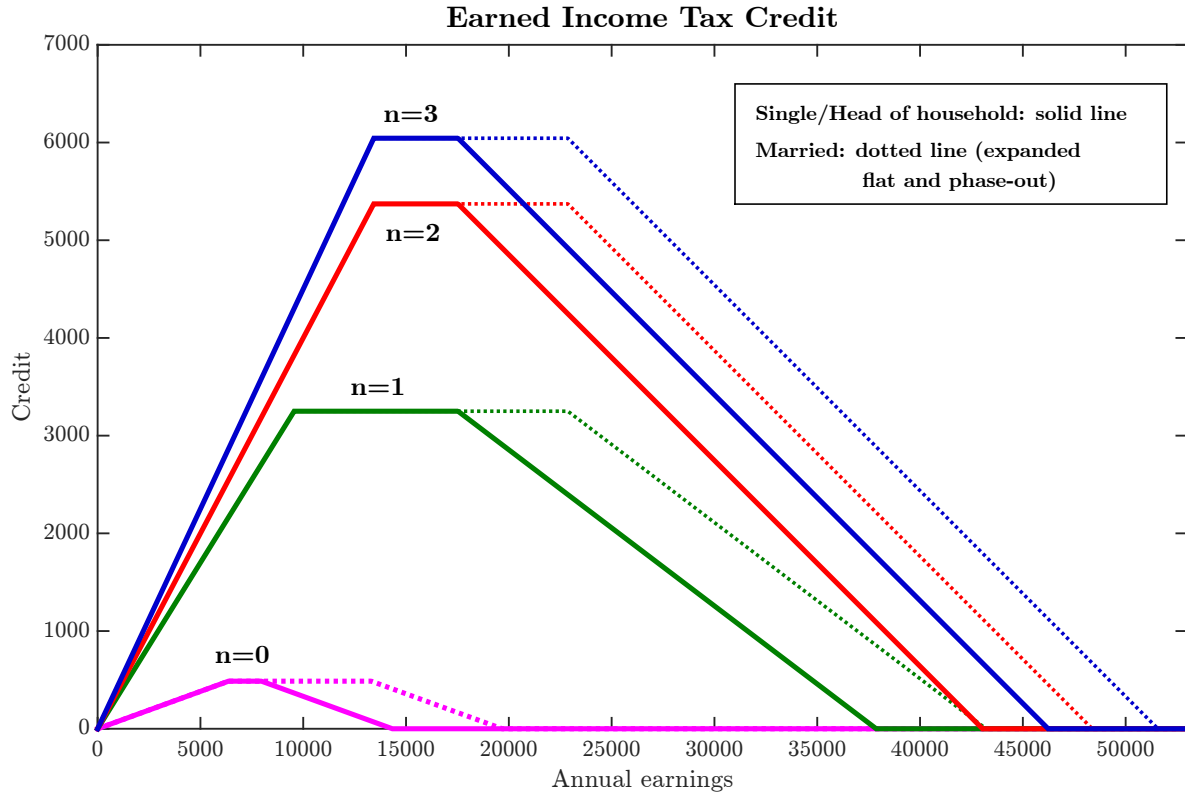
Notes: Earned Income Tax Credit by number of children and filing status: single/head of household (solid line) and married filing jointly (dotted line with expanded flat and phase-out region).

The Child Tax Credit and the Additional Child Tax Credit

TABLE A5—CHILD TAX CREDIT: CREDIT RATES & INCOME AND EARNINGS THRESHOLDS

| Description	Parameter	Value
Credit per child	θ	$1,000$
Phase-out income threshold ($j = s, \hbar$)	y_{CTC}^{j}	$75,000$
Phase-out income threshold ($j = x$)	y_{CTC}^{j}	$100,000$
Phase-out rate	η	5%
Earnings limit (ACTC)	δ	$3,000$
Weight on earnings gap (ACTC)	ϕ	0.15

Source: Credit rates and income thresholds for 2013 CTC and ACTC, from IRS website.

4

Temporary Assistance for Needy Families (TANF)

TABLE A6—TEMPORARY ASSISTANCE FOR NEEDY FAMILIES (TANF)

Description	Parameter	Size assistance unit				
		1 person	2 persons	3 persons	4 persons	5 persons
Standard of need	S^{jn}	638	855	1073	1290	1508
Work deduction (per worker)	d_{B1}	90	90	90	90	90
Child care deduction	d_{B2}	0.5	0.5	0.5	0.5	0.5
General deduction	d_{B3}	30	30	30	30	30
Maximum grant	$\bar{B}^{jn}$	201	270	338	407	475
Gross income test	y_{B1}^{jn}	1180	1581	1985	2386	2789
Net income test	y_{B2}^{jn}	638	855	1073	1290	1508
Asset test	a_B	2,000	2,000	2,000	2,000	2,000
Generosity	ς	0.5	0.5	0.5	0.5	0.5
Earned income disregard	σ_B	2/3	2/3	2/3	2/3	2/3

Source: Income and asset limits, deductions and benefits for 2013 TANF, from the state of Delaware's website. TANF is a monthly program and the dollar amounts in this table are monthly values. Since the length of a period in our model is one year, we annualize these values to fit our model.

Temporary Assistance for Needy Families
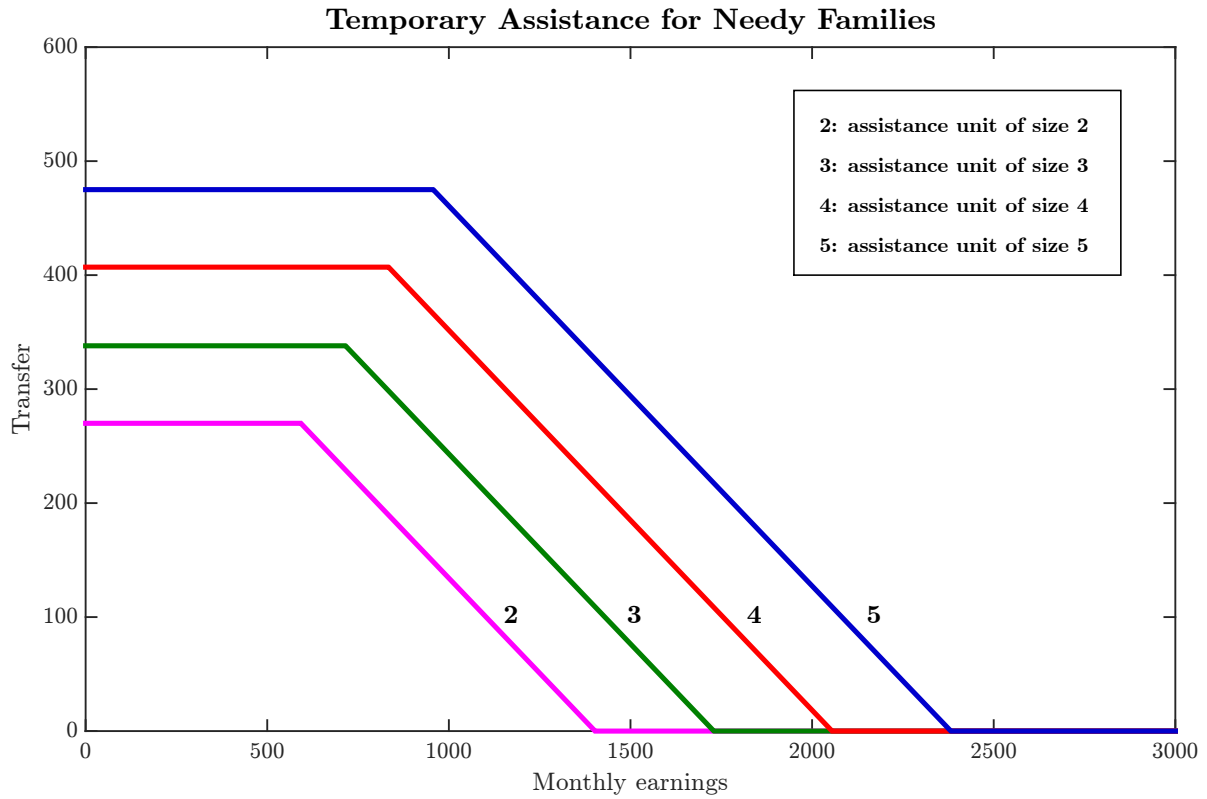
Notes: TANF income transfer by size of assistance unit. Since TANF transfers are a function of net income, we have made a number of assumptions to plot them in terms of earnings. In particular, it is assumed that: (i) the only source of income is labor earnings; (ii) the work deduction is applied once; (iii) deductible child care costs are set to zero; (iv) the asset test is passed.

Supplemental Nutrition Assistance Program (SNAP)

TABLE A7—SUPPLEMENTAL NUTRITION ASSISTANCE PROGRAM (SNAP)

Description	Parameter	Size assistance unit				
		1 person	2 persons	3 persons	4 persons	5 persons
Asset test	a_F	2,000	2,000	2,000	2,000	2,000
Gross income test	y_{F1}^{jn}	1,245	1,681	2,116	2,552	2,987
Net income test	y_{F2}^{jn}	958	1,293	1,628	1,963	2,298
Child care deduction	d_{F1}	0.5	0.5	0.5	0.5	0.5
Standard deduction	d_{F2}	152	152	152	163	191
Earned income disregard	σ_F	0.8	0.8	0.8	0.8	0.8
Maximum allotment	$\bar{F}^{jn}$	200	367	526	668	793
Weight on net income	χ	0.3	0.3	0.3	0.3	0.3
Minimum benefit	$\underline{F}^{jn}$	15	15	0	0	0

Source: Income and asset limits, deductions and benefits for 2013 SNAP, from the U.S. Department of Agriculture, Food and Nutrition Service's website. SNAP is a monthly program and the dollar amounts in this table are monthly values. Since the length of a period in our model is one year, we annualize these values to fit our model.
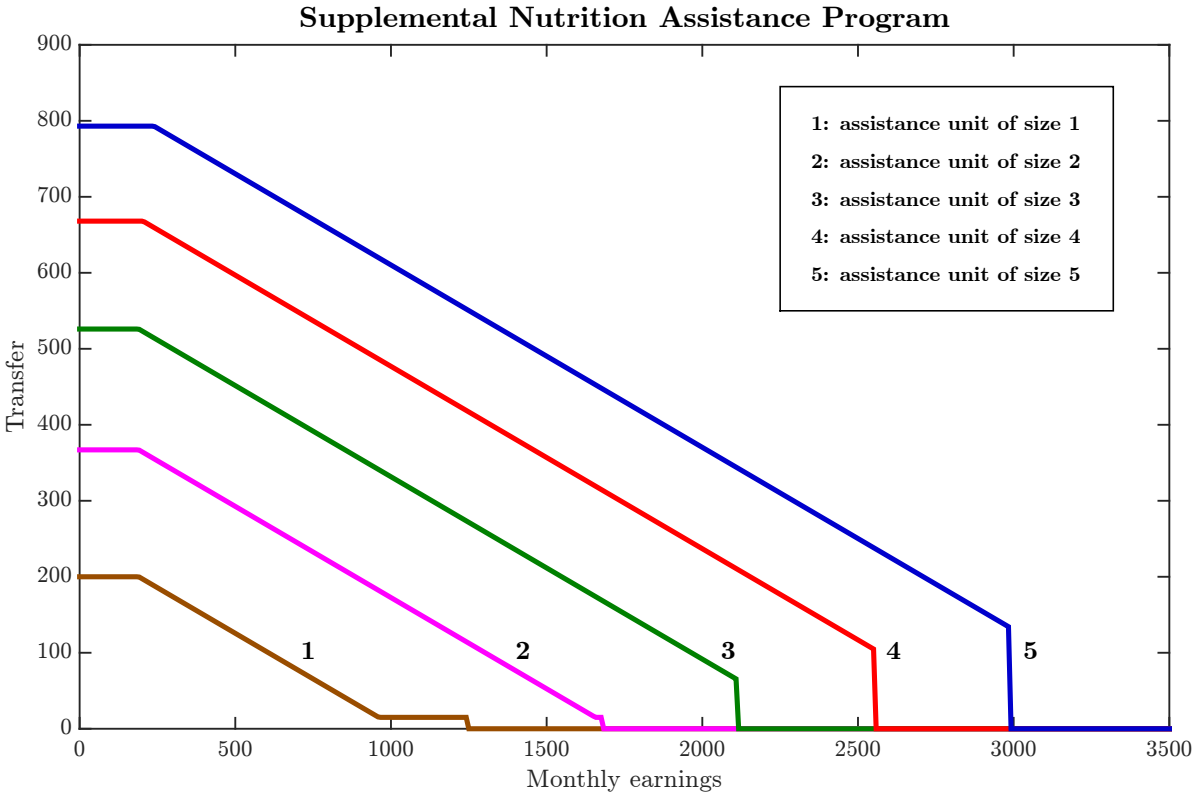
Supplemental Nutrition Assistance Program

Notes: SNAP income transfer by size of assistance unit. Since SNAP transfers are a function of net income, we have made a number of assumptions to plot them in terms of earnings. In particular, it is assumed that: (i) the only source of income is labor earnings; (ii) deductible child care costs are set to zero; (iii) the asset test is passed.

Parameter Values Calibrated Outside of the Model

TABLE A8—OTHER PARAMETERS CALIBRATED OUTSIDE OF THE MODEL

Description	Parameter	Value	Description	Parameter	Value
Risk-free rate of return	r	0.03	Consumption commitment	$\hat{c}_0^{\ell_s}$	\$1,000
Elasticity intertemp. subs.	σ	1.5	Consumption commitment	$\hat{c}_1^{\ell_s}$	\$500
Fertility process	$m_{0\emptyset}$	0.0410	Consumption commitment	$\hat{c}_1^{\ell_m}$	\$1,500
Fertility process	$m_{1\emptyset}$	0.0500	Work+care curvature	α	0.50
Fertility process	m_{01}	0.1935	Child support	ϑ	\$3,000
Fertility process	m_{02}	0.0065	Productivity process	ρ	0.914
Fertility process	m_{12}	0.0677	Productivity process	σ_ϵ	0.206
Fertility process	m_{13}	0.0023	Cross-correlation	ϱ	0.15
Fertility process	m_{23}	0.0223			

Appendix B: Transition Functions and Numerical Approach

B.1 Transition Functions

The state space of lone mothers is $Z^f \times A \times N$, where Z^f is the set of productivity levels for females. A is the set of asset holdings and $N = \{0, 1, 2, 3, \emptyset\}$ is the number of children. We denote by $\mathcal{B}^s$ the Borel σ-algebra on $Z^f \times A$. The projection of $B \in \mathcal{B}^s$ on Z^f is denoted by B_{z_f}, and the projection on A by B_a.

The state space of couples is $Z^f \times Z^m \times A \times N \times L \setminus \ell_s$, where Z^m is the set of productivity levels for males, and $L^c = \{\ell_{cp}, \ell_c, \ell_m\}$ is the set of living arrangements for couples. (Note that in our model the sets of productivity levels for males and females are the same. However, for notational convenience we distinguish them with a superscript.) We denote by $\mathcal{B}^c$ the Borel σ-algebra on $Z^f \times Z^m \times A$. The projection of $B \in \mathcal{B}^c$ on $Z^f \times Z^m$ is denoted by $B_{\mathbf{z}}$, the projection on Z^f is denoted by B_{z_f}, the projection on Z^m is denoted by B_{z_m} and the projection on A by B_a.

Lone mothers' transition function. The probability that a lone mother with labor productivity z_f, assets a_f, and n children will have productivity and assets lying in set $B \in \{\mathcal{B}^s \cup \mathcal{B}^c\}$, will have n' children and will move to living arrangement $\ell' \in L$ next period is denoted by $P^s(z_f, a_f, n; B, n', \ell')$.

The probability that a lone mother of n children, with labor productivity z_f and wealth a_f will transit next period to living arrangement $\ell \in L \setminus \ell_s$, their labor productivities and assets will lie in set B and the number of children will transit to n' is

$$
P^s(z_f, a_f, n; B, n', \ell) = m_{nn'} \pi_\ell \int_A \int_{B_{\mathbf{z}}} \mathbb{1}_{\{a'_m + a'_f \in B_a\}} \times
$$
$$
\mathbb{1}_{\{v_f^\ell(\mathbf{z}', a'_m + a'_f, n') \geq v_f^{\ell_s}(z'_f, a'_f, n')\}} f_{a_m}(da'_m) f_{z_m}(dz'_m) f_{z_f}(dz'_f | z_f),
$$

where π_ℓ is the probability that the lone mother gets an offer to form a living arrangement ℓ; a'_f are lone mother savings as given by her policy function evaluated at z_f, a_f, n; a'_m denotes the suitor's asset holdings; v_f^ℓ is the value for the female under living arrangement ℓ and $v_f^{\ell_s}$ is her value of remaining single and living alone; $f_{a_m}(\cdot)$ is the density function of the suitors asset holdings; $f_{z_m}(\cdot)$ is the unconditional density function of the suitors' labor productivity; $f_{z_f}(\cdot / z_f)$ is the lone mother's density function of next-period labor productivity conditional on current productivity z_f.

Finally, the probability that a lone mother at (z_f, a_f, n) will remain single and living alone

next period with labor productivity and assets in set B and n' children is

$$
\begin{aligned}
P^s(z_f, a_f, n; B, n', \ell_s) \; = \; & m_{nn'}(1 - \pi_{\ell_{cp}} - \pi_{\ell_c} - \pi_{\ell_m}) \mathbb{1}_{\{a'_f \in B_a\}} \int_{B_{z_f}} f_{z_f}(dz'_f | z_f) \; + \\
& m_{nn'} \sum_{\ell \in L \setminus \ell_s} \pi_\ell \mathbb{1}_{\{a'_f \in B_a\}} \int_A \int_{Z^m \times Z^f} \mathbb{1}_{\{v_f^\ell(z', a'_m + a'_f, n') < v_f^{\ell_s}(z'_f, a'_f, n')\}} \; \times \\
& \mathbb{1}_{\{z'_f \in B_{z_f}\}} f_{a_m}(da'_m) f_{z_m}(dz'_m) f_{z_f}(dz'_f | z_f)
\end{aligned}
$$

Couples' transition functions. The probability that a couple with productivities z^f and z^m, assets a, n children and in living arrangement ℓ will transit to productivities and assets lying in set $B \in \mathcal{B}^c$, will have n' children and will move to living arrangement $\ell' \in L \setminus \ell_s$ next period is denoted by $P^c(z_f, z_m, a, n, \ell; B, n', \ell')$.

The probability that a cohabiting couple in state $\ell \in \{\ell_{cp}, \ell_c\}$, with labor productivities z_f and z_m, assets a and n children will transit next period to marriage with productivities and assets in set B and n' children is

$$
P^c(z_f, z_m, a, n, \ell; B, n', \ell_m) = m_{nn'} \mathbb{1}_{\{a' \in B_a\}} \int_{B_z} \mathbb{1}_{\{V^{\ell_m}(z', a', n') \geq V^\ell(z', a', n')\}} f_z(dz' | z),
$$

where a' is the level of assets given by the policy function of the cohabiting couple evaluated at the current state; V^{ℓ_m} is the value of marriage for the couple, and V^ℓ is the value of living arrangement ℓ; and $f_z(\cdot / z)$ is the joint density of labor productivites conditional on current productivities z. The probability that the cohabiting couple will not marry next period and will remain cohabiting with productivities and assets in B and n' children is

$$
P^c(z_f, z_m, a, n, \ell; B, n', \ell) = m_{nn'} \mathbb{1}_{\{a' \in B_a\}} \int_{B_z} \mathbb{1}_{\{V^{\ell_m}(z', a', n') < V^\ell(z', a', n')\}} f_z(dz' | z).
$$

Finally, the probability that a married couple with productivites z, assets a and n children will have productivities and assets in set B and n' children is

$$
P^c(z, a, n, \ell_m; B, n', \ell_m) = m_{nn'} \mathbb{1}_{\{a' \in B_a\}} \int_{B_z} f_z(dz' | z).
$$

B.2 Our Numerical Approach to Compute the Steady-state Equilibrium

Computing a steady-state partial equilibrium in our model for a given set of parameters involves two main steps: [1] solving the dynamic programming problem of all household types and obtaining their optimal decision rules; and [2] given these optimal decision rules, computing the

stationary distribution over assets, labor productivities, living arrangements and number of children. While the solution method generally follows standard practices in this literature, we find it useful to provide some further details on our numerical implementation.

Sequence of household problem. We exploit the demographic structure of the model by solving the list of household decision problems recursively. Specifically, we start by solving the problem of married households (ℓ_m), then solve the problems of both types of cohabiting households (ℓ_{cp} and ℓ_c), and then solve the problem of single females (ℓ_s). For each type of living arrangement in that sequence, we first solve the decision problem for a household where the children have already left the nest ($n = \emptyset$). We then proceed by computing the solution for three children ($n = 3$), two children ($n = 2$), one child ($n = 1$) and zero children ($n = 0$), respectively. As is the case for living arrangements, the specification of the fertility process allows us to proceed recursively instead of having to look for a fixed point.

Solution of household problems. Embedding the tax-transfer system in our model yields complex budget constraints with many kinks and non-differentiabilities. Hence, we cannot rely on Euler equation methods, and we employ a discrete-state value function iteration approach instead. Importantly, we discretize the labor supply choices of all household members to capture the implied variations in taxes and transfers as accurately as possible. That is, for each combination of assets, labor productivity and hours worked – including zero –, we compute the exact value of taxes, credits and transfers. Then we compute the optimal consumption and savings choices given this combination; finally, we pick the optimal value for hours worked. In our implementation, we let single females (cohabiting/married couples) choose how many hours to work to within 2 hours (6 hours) a year. We have experimented with even finer grids and found our results to be unaffected. Asset holdings are discretized on a grid from zero to 1 million dollars. We use $n_k = 230$ nodes, with more nodes placed at the lower end of the domain. In addition, we allow the optimal decision rule for savings to lie off the grid by using piecewise-linear interpolation between grid points. The distribution of asset holding by single males making an offer is discretized into deciles as specified in Table 2. Finally, the labor productivity process is discretized using the method proposed by George Tauchen (1986). We set the number of nodes to $n_z = 101$ for single females and to $n_z = 765$ for couples.

Stationary distribution. We compute the stationary distribution by approximating the density functions on a discretized asset space. Our fixed-point algorithm iterates over the density functions for all household types using the transition functions constructed from all exogenous processes and the optimal decisions rules obtained from the solution of the household problems.

Appendix C: Calibration of fertility process

In this appendix, we describe how to pin down the seven parameters in the transition matrix M, namely $m_{0\emptyset}$, m_{01}, m_{02}, $m_{1\emptyset}$, m_{12}, m_{13}, m_{23}, using the seven moment conditions laid out in the main text. Let us start from moment condition (1): the expected number of years for a childless female until a child is born, conditional on having a child, is 5 years, that is

$$5 \ = \ \frac{1}{m_{01} + m_{02}} \qquad \Longrightarrow \qquad m_{01} + m_{02} \ = \ 0.2. \tag{A1}$$

Next, condition (7) imposes that the probability of remaining childless is 17 percent:

$$\frac{m_{0\emptyset}}{m_{01} + m_{02} + m_{0\emptyset}} \ = \ 0.17 \qquad \Longrightarrow \qquad m_{0\emptyset} \ = \ \frac{0.17 \cdot (m_{01} + m_{02})}{1 - 0.17}. \tag{A2}$$

Combining (A1) and (A2) determines the first probability:

$$m_{0\emptyset} \ = \ 0.0410. \tag{A3}$$

Next, we use that the conditional probability of having a twin birth is 0.0326, both for childless females and for mothers of one child, the two moment conditions in (4). Let us start with childless females

$$m_{02} \ = \ 0.0326 \cdot (m_{01} + m_{02}). \tag{A4}$$

Combine with (A1) to obtain

$$m_{01} \ = \ 0.1935 \qquad \text{and} \qquad m_{02} \ = \ 0.0065. \tag{A5}$$

Now, we use the moment condition for mothers of one child and obtain

$$m_{13} \ = \ 0.0326 \cdot (m_{12} + m_{13}). \tag{A6}$$

Moment condition (5) imposes that the expected duration until a household with children reaches the absorbing state is 20 years; thus,

$$m_{1\emptyset} \ = \ \frac{1}{20}. \tag{A7}$$

In order to pin down the remaining three probabilities, m_{12}, m_{13} and m_{23}, we need to describe the stationary population measures in the first four states in the Markov chain. Let us denote by μ_n the stationary measure of females in state $n \in \{0, 1, 2, 3\}$. Without loss of generality, we

normalize the total population of females in this subset of N to $\mu_0 + \mu_1 + \mu_2 + \mu_3 = 1$. It is then straightforward to derive the following population measure equations:

$$\mu_0 = m_{00}\mu_0 + \psi_0^s \tag{A8}$$

$$\mu_1 = m_{11}\mu_1 + m_{01}\mu_0 \tag{A9}$$

$$\mu_2 = m_{22}\mu_2 + m_{02}\mu_0 + m_{12}\mu_1 \tag{A10}$$

$$\mu_3 = m_{33}\mu_3 + m_{13}\mu_1 + m_{23}\mu_2, \tag{A11}$$

where ψ_0^s is the measure of newborn females who replace an equal measure of females that have transited to the absorbing state, i.e. $\psi_0^s = m_{0\emptyset}\mu_0 + m_{1\emptyset}(\mu_1 + \mu_2 + \mu_3)$. (We have made use of the assumption $m_{1\emptyset} = m_{2\emptyset} = m_{3\emptyset}$.) Rearranging (A8) yields:

$$\mu_0 = m_{00}\mu_0 + m_{0\emptyset}\mu_0 + m_{1\emptyset}(1 - \mu_0) \qquad \Longrightarrow \qquad \mu_0 = \frac{m_{1\emptyset}}{1 - m_{00} - m_{0\emptyset} + m_{1\emptyset}}, \tag{A12}$$

or,

$$\mu_0 = \frac{m_{1\emptyset}}{m_{01} + m_{02} + m_{1\emptyset}} = 0.2. \tag{A13}$$

Thus, our calibration of the fertility process implies that 20 percent of the population of females in states $N = \{0, 1, 2, 3\}$ are childless ($n = 0$), while the remaining 80 percent are mothers ($n = 1, 2, 3$). Recall that the latter subsample constitutes our actual population of interest, and that all statistics in the paper refer to that subsample. Now, to set values to the remaining three parameters m_{12}, m_{13} and m_{23}, we make use of the two moment conditions that have not been used so far, namely (2) and (3)

$$\frac{\mu_1}{\mu_1 + \mu_2 + \mu_3} = 0.4031 \tag{A14}$$

$$\frac{\mu_2}{\mu_1 + \mu_2 + \mu_3} = 0.4001. \tag{A15}$$

Combining (A9) and (A14) yields:

$$m_{11} = \frac{\mu_1 - m_{01}\mu_0}{\mu_1} = 0.8800, \tag{A16}$$

which in conjunction with (A6) implies

$$m_{12} = 0.0677 \qquad \text{and} \qquad m_{13} = 0.0023. \tag{A17}$$

Finally, combine (A15) with (A10) to pin down the last probability, m_{23}, as

$$\mu_2 = 0.4001 \cdot (1 - 0.2) = 0.3201 \qquad \Longrightarrow \qquad m_{23} = 1 - m_{22} - m_{2\emptyset} = 0.0223. \tag{A18}$$

Appendix D: Rep. Dave Camp (R) Tax Reform Plan

This Appendix presents the parameter values for the federal income tax schedule and for the Earned Income Tax Credit under the reform plan contained in the "Tax Reform Act of 2014" by Rep. Dave Camp (R).

TABLE A9—INCOME TAX BRACKETS UNDER DAVE CAMP PLAN

Bracket	Parameter	Single $(j = s)$	Head of household $(j = \hbar)$	Married $(j = x)$
1	$b^{j,0}$	0	0	0
2	$b^{j,1}$	$35,600$	$35,600$	$71,200$
3	$b^{j,2}$	$400,000$	$400,000$	$450,000$

Notes: This table presents income brackets under the Camp plan for taxable years beginning after 2017 (in 2013 dollars). Source: "Tax Reform Act of 2014", and Jim Nunns, Amand Eng and Lydia Austin (2014). The Tax Reform Act can be accessed from the Ways and Means Committee's website at http://waysandmeans.house.gov.

TABLE A10—STANDARD DEDUCTIONS & TAX RATES UNDER DAVE CAMP PLAN

Description	Comment	Parameter	Value
Standard deduction (in $)	Single	d_T^s	$11,000$
Standard deduction (in $)	Head of household	d_T^h	$16,500$
Standard deduction (in $)	Married	d_T^x	$22,000$
Personal exemption (in $)	Per person	ξ_T	0
Marginal tax rate	Bracket 1	τ_y^1	0.10
Marginal tax rate	Bracket 2	τ_y^2	0.25
Marginal tax rate	Bracket 3	τ_y^3	0.35

Notes: This table presents standard deductions and tax rates under the Camp plan for taxable years beginning after 2017. Standard deductions are in 2013 dollars. Source: "Tax Reform Act of 2014", and Nunns, Eng and Austin (2014). The Tax Reform Act can be accessed from the Means and Committee's website at http://waysandmeans.house.gov.

TABLE A11—EITC: CREDIT RATES AND EARNINGS THRESHOLDS UNDER DAVE CAMP PLAN

	Phase-in rate, $\kappa_1^{jn}(\%)$	Earnings end phase-in, $e_{I_1}^{jn}(\$)$		Earnings beginning phase-out, $e_{I_2}^{jn}(\$)$		Phase-out rate, $\kappa_2^{jn}(\%)$
	$j = s, \hbar, x$	$j = s, \hbar$	$j = x$	$j = s, \hbar$	$j = x$	$j = s, \hbar, x$
No children, $n = 0$	7.65	$1,307$	$2,615$	$8,000$	$13,350$	7.65
One child, $n = 1$	15.3	$15,686$	$15,686$	$20,000$	$27,000$	19.0
Two children, $n = 2$	15.3	$19,610$	$26,145$	$20,000$	$27,000$	19.0
Three children, $n = 3$	15.3	$19,610$	$26,145$	$20,000$	$27,000$	19.0

Notes: This table presents credit rates and earnings thresholds under the Camp plan for taxable years beginning after 2017. Earnings thresholds are in 2013 dollars. Source: "Tax Reform Act of 2014", and Nunns, Eng and Austin (2014). The Tax Reform Act can be accessed from the Ways and Means Committee's website at http://waysandmeans.house.gov.

References

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