(NOT INTENDED FOR PUBLICATION)
SUPPLEMENTARY APPENDIX FOR

The U.S. Tax-transfer System and Low-Income Households: Savings, Labor Supply, and Household Formation

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This appendix has four parts: Appendix A presents empirical evidence on a U-shaped relationship between husbands' earnings and the labor supply of their wives, along both the extensive and intensive margins. That is, both the employment rate and the hours worked by the wives are U-shaped with respect to husbands' earnings. Appendix B presents a detailed description of the tax and transfer programs included in our model. It also presents the formulas for the determination of income and payroll taxes, and for eligibility and benefits from the four transfer programs (the Earned Income Tax Credit, Child Tax Credit, Temporary Assistance for Needy Families and the Supplemental Nutrition Assistance Program). In Appendix C we present the transition functions needed to obtain the stationary distribution. Appendix D contains the parameters calibrated outside the model and the calibration of the fertility process.

Appendix A: The Labor Supply of Non-College Educated Husbands and Wives

This Appendix contains material supplementing our results presented in Section 2.

Wives' employment rate and husbands' earnings. We estimate the probit model for the wives' employment rate on husbands' earnings

$$\text{Prob}(\text{wife's hours worked } > 0) = \Phi\Big(\beta_0 + \sum_{i=1}^{K-1} \beta_i s_i\Big),$$

where $\Phi(\cdot)$ is the cdf of the standard normal; s_i for $i = 1, ...K-1$ are the variables containing a restricted cubic spline of husband's earnings; and K is the number of knots. The estimation results are presented in Table A1. The three variables s_1, s_2, s_3 containing the restricted cubic spline of husbands' earnings are statistically significant at 1 percent. The coefficients of s_1 and s_3 are negative, and the coefficient of s_2 is positive, yielding a U-shaped relationship between husbands' earnings and wives' employment.

TABLE A1—WIVES' EMPLOYMENT RATE AND HUSBANDS' EARNINGS

	All married couples	With one child	With two children	With three children
β_0	0.3834***	0.7536***	0.4156***	0.2033***
β_1	-1.81E-5***	-3.86E-5***	-2.47E-5***	-1.76E-5***
β_2	3.8E-5***	1.10E-5***	4.83E-5***	3.91E-5***
β_3	-3.06E-4***	-3.21E-4***	-3.91E-4***	-4.50E-4***

Significance levels: * significant at 10%; ** significant at 5%; *** significant at 1%.

We now conduct a number of exercises to test the robustness of this U-shaped relationship. First, we introduce a threshold of 260 hours in order to define a wife as employed. This is a threshold that has been used by some authors in the macro labor literature (e.g., Heathcote et al. 2010). Second, we restrict our sample of married couples in order to have an even more homogeneous sample in terms of educational attainment. Recall that our initial sample is made up of non-college educated married couples with children. We now remove couples where at least one spouse is a high school dropout, thus retaining only those where both spouses have a high school degree. The third exercise restricts our sample by imposing a maximum age of 50 years. Recall that our initial sample imposed a maximum age of 65. By focusing only on couples where both spouses are under 50 years of age we address any potential effect on the labor market decisions of husbands and wives stemming from proximity to retirement. Our results show that the U-shaped relationship between husbands' earnings and wives' employment is robust. Table A2 presents the parameter estimates from each of the three exercises individually, and from introducing all three jointly. (We also find that the relationship is robust when estimated by number of children. That is, the U-shaped relationship remains statistically significant under these checks within couples with one, two, and three children.)

TABLE A2—ROBUSTNESS CHECKS: WIVES' EMPLOYMENT RATE AND HUSBANDS' EARNINGS

	[1] Wife employed if hours worked over 260	[2] Both husband and wife hold high school diploma	[3] Both husband and wife under 50 years of age	[1]+[2]+[3]
β_0	0.3440***	0.5533***	0.3724***	0.5171***
β_1	-1.79E-5***	-1.37E-5***	-1.81E-5***	-1.44E-5***
β_2	3.83E-5***	2.73E-5***	3.79E-5***	2.9E-5***
β_3	-3.09E-4***	-2.26E-4***	-3.04E-4***	-2.41E-4***

Significance levels: * significant at 10%; ** significant at 5%; *** significant at 1%.

Husbands' employment rate and wives' earnings. We run a probit model for husbands' employment on variables containing a restricted cubic spline of wives' earnings, like the one we run above for wives' employment. The estimation results are presented in Table A3 below. As already stated in the main text of the paper, we obtain statistically significant U-shaped relationships between wives' earnings and husbands' employment, except among couples with one child.

We also performed robustness checks of this U-shaped relationship with respect to the 260 hours cutoff, the educational attainment of husbands and wives, and to their age. We find that this relationship is robust. However, when the sample is restricted so that husband and wife hold a high school diploma, the U-shaped relationship is significant only among couples with two children.

Wives' hours worked and husbands' earnings. To uncover the relationship between wives' hours

TABLE A3—HUSBANDS' EMPLOYMENT RATE AND WIVES' EARNINGS

	All married couples	With one child	With two children	With three children
β_0	1.6946***	1.6362***	1.8077***	1.5712***
β_1	-1.34E-5**	-6.5E-6	-1.88E-5***	-1.07E-5***
β_2	1.3E-5***	8.49E-6	2.1E-5***	2.07E-5**

Significance levels: * significant at 10%; ** significant at 5%; *** significant at 1%.

worked and husbands' earnings we estimate the model

$$\text{Wife's hours worked } = \alpha_0 + \sum_{i=1}^{K-1} \alpha_i s_i,$$

where, as already state in the main text of the paper, the variables s_i contain the restricted cubic spline of husbands' earnings. Estimation results are presented in Table A4.

TABLE A4—WIVES' HOURS WORKED AND HUSBANDS' EARNINGS

	All married couples	With one child	With two children	With three children
α_0	1713***	1701***	1754***	1695***
α_1	-0.0073***	-0.0083**	-0.0099***	-0.0114***
α_2	0.0313***	0.0699***	0.0333***	0.0462***
α_3	-0.1071***	-0.1341***	-0.0953***	-0.1297***

Significance levels: * significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix B: Taxes and Means-tested Transfers

In this section we describe the U.S. federal income tax scheme, payroll taxes, two tax credits and two transfer programs to assist low-income households. This is the tax-transfer scheme that is embedded into our benchmark model.

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 filing 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}.

Table B1 presents the 2013 income brackets for federal income taxes.

TABLE B1—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.

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. Table 2 contains the 2013 standard deductions, federal income tax rates and payroll taxes

TABLE B2—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)

The Earned Income Tax Credit is a refundable credit which cost the government 68 billion dollars in 2013. Eligibility is determined by the following conditions: (i) Investment income, ra, cannot exceed a level, say $\bar{\mathrm{ra}}_I$; (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

$$\{ra \leq \bar{\mathrm{ra}}_I\} \cap \{e + ra \leq \mathrm{y}_I^{jn}\}. \tag{1}$$

We denote the amount of the credit by $I^j(a, e, n)$. If (a, e, n) are not in the eligible set then $I^j(a, e, n) = 0$. Provided eligibility, the credit is

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

where κ_1^{jn} is the earnings subsidy rate in the phase-in region and κ_2^{jn} is the phase-out rate. The thresholds, $\mathrm{e}_{I_1}^{jn}$ and $\mathrm{e}_{I_2}^{jn}$, 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 $\kappa_1^{jn} \mathrm{e}_{I_1}^{jn}$. 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, $\mathrm{r\bar{a}}_I$, does not depend on either of the two.

Table B3 contains the 2013 EITC investment and total income limits.

TABLE B3—EARNED INCOME TAX CREDIT: ELIGIBILITY

	Max. investment income, $\mathrm{r\bar{a}}_I$ (\$)	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 B4 presents the 2013 EITC subsidy rates and earnings thresholds.

TABLE B4—EARNED INCOME TAX CREDIT: CREDIT RATES AND EARNINGS THRESHOLDS

	Phase-in rate, κ_1^{jn}(%)	Earnings end phase-in, $\mathrm{e}_{I_1}^{jn}$(\$)	Earnings beginning phase-out, $\mathrm{e}_{I_2}^{jn}$(\$)		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.

Figure B1 displays the EITC by number of children and filing status.

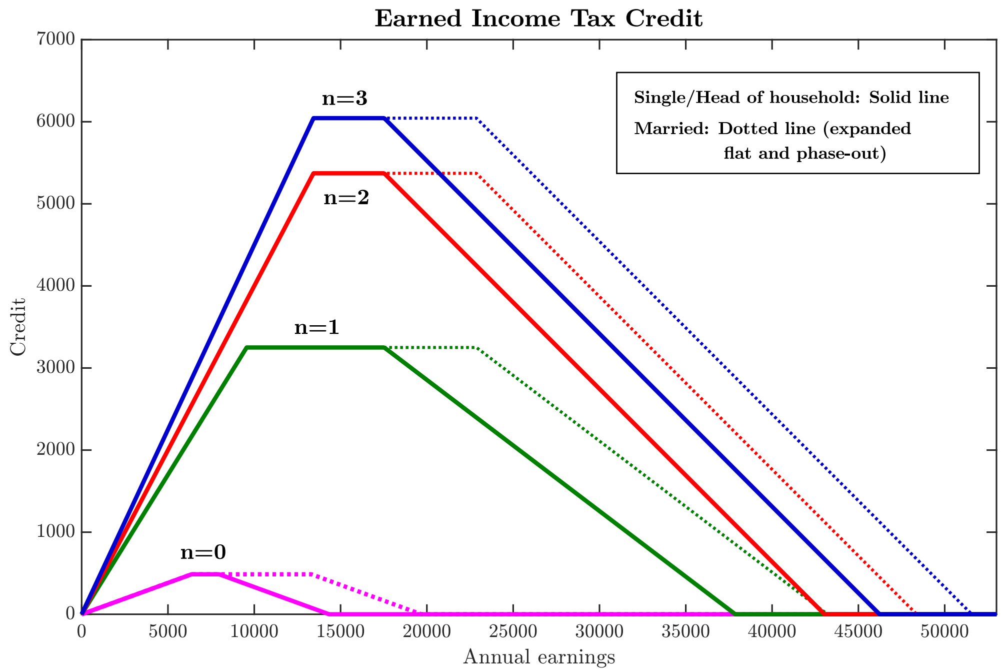

FIGURE B1: Earned Income Tax Credit by number of children and filing status: single/head of household (solid line) and married filing jointly (dotted line with expanded flat and phase-out region).

The Child Tax Credit (CTC)

The Child Tax Credit, and its refundable part, the Additional Child Tax Credit, cost the government $57 billion in 2013. The (non-refundable) child tax credit for a tax filer under status j, income y and n qualifying children is

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

where θ is the subsidy per child and y^j_{CTC} is the income level at which the child tax credit starts being phased out. Parameter ϱ 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 particular on whether it is two or less, or larger than two. The amount of this tax credit is

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

where ϕ and δ are parameters.

Table B5 presents the 2013 CTC and ACTC credit rates and income thresholds.

TABLE B5—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^j_{CTC}	$75,000$
Phase-out income threshold ($j = x$)	y^j_{CTC}	$100,000$
Phase-out rate	ϱ	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.

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 some variation, 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 children's 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) Assets (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 $\mathrm{y}^{\jmath n}_{B_1}$, say, where $\jmath = u, \nu$. Gross income includes earned and non-earned income, such as interests and child support income. (iii) Net family income cannot exceed $\mathrm{y}^{\jmath n}_{B_2}$. Net income for the purpose of determining TANF eligibility is computed as

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

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.

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

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

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 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 B2 in Supplementary Appendix B 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.

Table B6 presents the 2013 TANF income and asset limits, deductions and benefits.

TABLE B6—TEMPORARY ASSISTANCE FOR NEEDY FAMILIES (TANF)

Description	Parameter	Size assistance unit				
		1 person	2 persons	3 persons	4 persons	5 persons
Standard of need	$S^{\jmath n}$	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	$\bar{B}^{\jmath n}$	201	270	338	407	475
Gross income test	$\mathrm{y}_{B1}^{\jmath n}$	1180	1581	1985	2386	2789
Net income test	$\mathrm{y}_{B2}^{\jmath n}$	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.

Figure B2 displays the 2013 TANF.

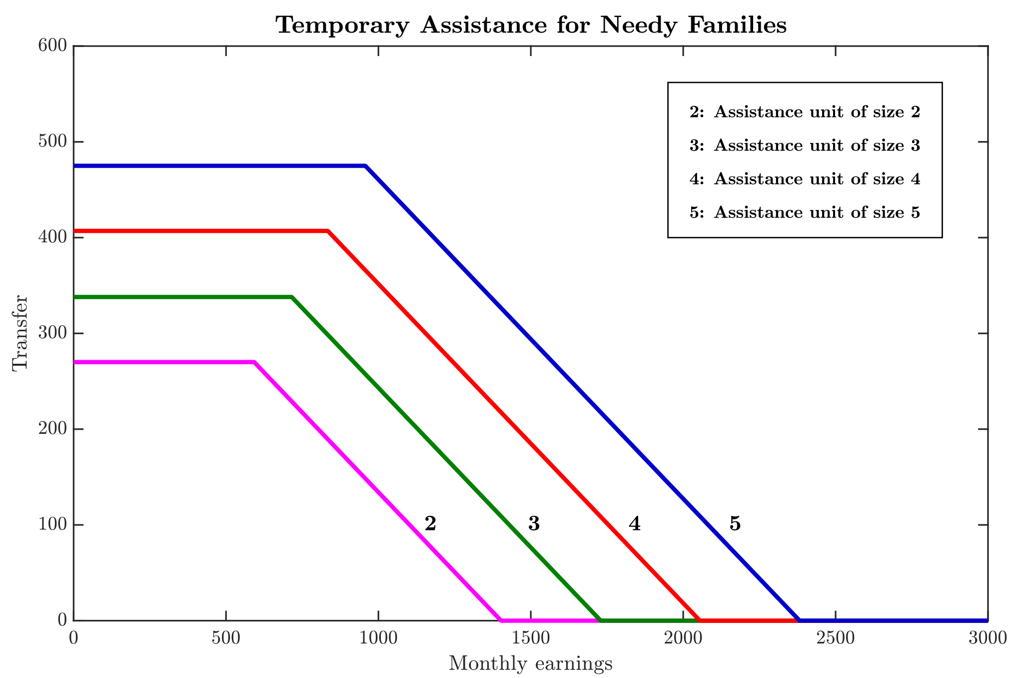

FIGURE B2: TANF income transfer by size of assistance unit. Since TANF transfers are a function of net income, we have made a number of assumptions to plot them in terms of earnings. In particular, it is assumed that: (i) the only source of income is labor earnings; (ii) the work deduction is applied once; (iii) deductible child care costs are set to zero; (iv) the asset test is passed.

Supplemental Nutrition Assistance Program (SNAP)

SNAP is a federal program that provides monthly food assistance to nearly 23 million U.S. households, with total benefits amounting to about \$76 billion.[1] 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, a_F, which is independent of household size; (ii) a gross income limit, $\mathrm{y}_{F_1}^{\jmath n}$, 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, $\mathrm{y}_{F_2}^{\jmath n}$. 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

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

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

$$\{a \le \mathrm{a}_F\} \cap \{e + ra + \vartheta n + B^{\jmath}(a,e,n) \le \mathrm{y}_{F_1}^{\jmath n}\} \cap \{\iota_F^{\jmath}(a,e,n) \le \mathrm{y}_{F_2}^{\jmath n}\}. \tag{7}$$

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 B3 in Supplementary Appendix B shows the 2013 SNAP schedule.)

Table B7 presents the 2013 SNAP income and asset limits, deductions and benefits.

[1] 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.

TABLE B7—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	$\mathrm{y}_{F1}^{\jmath n}$	1,245	1,681	2,116	2,552	2,987
Net income test	$\mathrm{y}_{F2}^{\jmath n}$	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	$\bar{F}^{\jmath n}$	200	367	526	668	793
Weight on net income	χ	0.3	0.3	0.3	0.3	0.3
Minimum benefit	$\underline{F}^{\jmath n}$	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.

Figure B3 displays the 2013 SNAP.

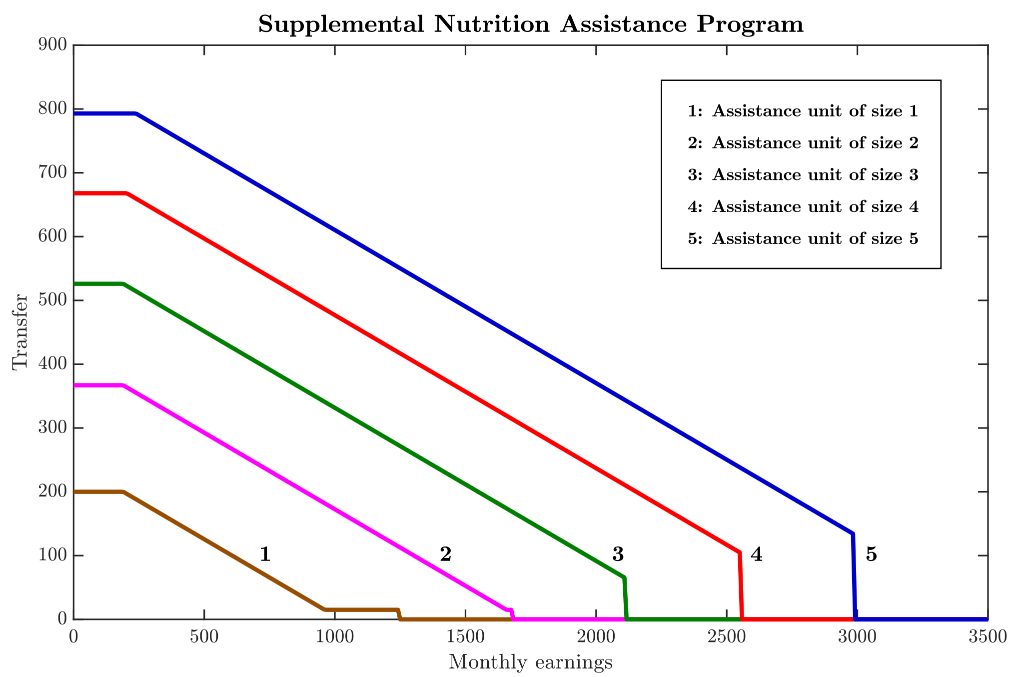

FIGURE B3: SNAP income transfer by size of assistance unit. Since SNAP transfers are a function of net income, we have made a number of assumptions to plot them in terms of earnings. In particular, it is assumed that: (i) the only source of income is labor earnings; (ii) deductible child care costs are set to zero; (iii) the asset test is passed.

Appendix C: Transition Functions and Numerical Approach

C.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 $B_{\boldsymbol{z}}$, 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

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

where $\pi_{\ell,n}$ 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

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

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

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

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 $f_{\boldsymbol{z}}(\cdot/\boldsymbol{z})$ is the joint density of labor productivites conditional on current productivities $\boldsymbol{z}$. 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

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

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

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

C.2 Our Numerical Approach to Solve the Household Decision Problems and the Stationary Distributions

Our computations involve 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 problems. 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 lone mothers (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.

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 $v_f^{\ell_m}(\boldsymbol{z}, a, n) = U_f(c_f^*, l_f^*) + \beta \mathbb{E} v_f^{\ell_m}(\boldsymbol{z}', a'^*, n')$, where $\{c_f^*, l_f^*\}$ are married females' policy functions for consumption and leisure, and a'^* is the policy function for married households' savings. Further, the computation of the value functions for cohabiting females must also embed the policy functions for filling status and marriage.

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 individuals) choose hours worked from a quasi-continuous, fine grid where two adjacent nodes lie only 2 hours (6 hours) apart from each other. Given an annual time endowment of 5,475 hours, in effect, this implies more than 2,500 different options for single females and almost 1,000 options for workers in couple households. 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 3. Finally, the labor productivity process is discretized using the method proposed by Tauchen (1986). We set the number of nodes to $n_z = 101$ for single females and to $n_{\boldsymbol{z}} = 765$ 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.

Computation of welfare effects. In order to quantify the welfare consequences of the reform of the EITC, we compute a measured based on consumption equivalent units. Let $\mathbb{E}_0[v^{\ell_s}_{f,bench}]$ denote expected lifetime utility of a newborn single female in the benchmark economy, before drawing the initial productivity shock. Similarly, let $\mathbb{E}_0[v^{\ell_s}_{f,reform}]$ be the expected lifetime utility of a newborn female in the economy where the EITC deduction has been put in place. The welfare effect in consumption equivalent units, CEV, is the value that solves

$$\mathbb{E}_0[v^{\ell_s}_{f,bench}; CEV] = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\big((1+CEV)c_{t,bench}, l_{t,bench}\big) = \mathbb{E}_0[v^{\ell_s}_{f,reform}],$$

where $\mathbb{E}_0[v^{\ell_s}_{f,bench}; CEV]$ is the expected lifetime utility for a given value of CEV, and $c_{t,bench}$ and $l_{t,bench}$ denote the decision rules for consumption and leisure, both in the benchmark economy. That is, CEV measures the percentage increase in consumption at each date and in each state in the benchmark economy that would leave a newborn female indifferent between remaining in the benchmark and living in the reformed economy. Importantly, due to the separability assumption in our specification of the utility function, it is not possible to solve for CEV in closed form based merely on the value functions. Instead, we have to find CEV numerically by computing the left-hand side for different values of CEV until we find the value that solves that equation. To this end, we proceed as explained in the previous subsection by solving the sequence of Bellman equations recursively. It is important to note that, throughout these computations, we must apply the optimal policy functions of the benchmark economy, including the cohabitation and marriage decision. The algorithm succeeds once we have found the value of CEV such that the expected lifetime utilities (approximately) coincide.

Appendix D: Parameters Calibrated Outside the Model and Calibration of fertility process

Parameter Values Calibrated Outside of the Model

TABLE B8—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			

Calibration of the fertility process

This appendix explains how to pin down the parameters in the transition matrix M. 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. $m_{1\emptyset} = m_{2\emptyset} = m_{3\emptyset}$. The remaining seven parameters, namely $m_{0\emptyset}$, m_{01}, m_{02}, $m_{1\emptyset}$, m_{12}, m_{13}, m_{23}, are calibrated 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

$$5 \; = \; \frac{1}{m_{01} + m_{02}} \qquad \Longrightarrow \qquad m_{01} + m_{02} \; = \; 0.2. \tag{D1}$$

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

$$\frac{m_{0\emptyset}}{m_{01} + m_{02} + m_{0\emptyset}} \; = \; 0.17 \qquad \Longrightarrow \qquad m_{0\emptyset} \; = \; \frac{0.17 \cdot (m_{01} + m_{02})}{1 - 0.17}. \tag{D2}$$

Combining (D1) and (D2) determines the first probability:

$$m_{0\emptyset} \; = \; 0.0410. \tag{D3}$$

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

$$m_{02} \; = \; 0.0326 \cdot (m_{01} + m_{02}). \tag{D4}$$

Combine with (D1) to obtain

$$m_{01} \;=\; 0.1935 \qquad \text{and} \qquad m_{02} \;=\; 0.0065. \tag{D5}$$

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

$$m_{13} \;=\; 0.0326 \cdot (m_{12} + m_{13}). \tag{D6}$$

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

$$m_{1\emptyset} \;=\; \frac{1}{20}. \tag{D7}$$

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:

$$\mu_0 \;=\; m_{00}\mu_0 + \psi_0^s \tag{D8}$$

$$\mu_1 \;=\; m_{11}\mu_1 + m_{01}\mu_0 \tag{D9}$$

$$\mu_2 \;=\; m_{22}\mu_2 + m_{02}\mu_0 + m_{12}\mu_1 \tag{D10}$$

$$\mu_3 \;=\; m_{33}\mu_3 + m_{13}\mu_1 + m_{23}\mu_2, \tag{D11}$$

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 (D8) yields:

$$\mu_0 \;=\; m_{00}\mu_0 + m_{0\emptyset}\mu_0 + m_{1\emptyset}(1 - \mu_0) \qquad \Longrightarrow \qquad \mu_0 \;=\; \frac{m_{1\emptyset}}{1 - m_{00} - m_{0\emptyset} + m_{1\emptyset}}, \tag{D12}$$

or,

$$\mu_0 \;=\; \frac{m_{1\emptyset}}{m_{01} + m_{02} + m_{1\emptyset}} \;=\; 0.2. \tag{D13}$$

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)

$$\frac{\mu_1}{\mu_1 + \mu_2 + \mu_3} \;=\; 0.4031 \tag{D14}$$

$$\frac{\mu_2}{\mu_1 + \mu_2 + \mu_3} \;=\; 0.4001. \tag{D15}$$

Combining (D9) and (D14) yields:

$$m_{11} = \frac{\mu_1 - m_{01}\mu_0}{\mu_1} = 0.8800, \tag{D16}$$

which in conjunction with (D6) implies

$$m_{12} = 0.0677 \qquad \text{and} \qquad m_{13} = 0.0023. \tag{D17}$$

Finally, combine (D15) with (D10) to pin down the last probability, m_{23}, as

$$\mu_2 = 0.4001 \cdot (1 - 0.2) = 0.3201 \qquad \Longrightarrow \qquad m_{23} = 1 - m_{22} - m_{2\emptyset} = 0.0223. \tag{D18}$$

Appendix E: Further Results from the Model

Employment rates and wealth over the life cycle

In Figure E1 we plot the model-generated life-cycle profiles for employment and wealth. To generate these profiles, we run a Monte Carlo simulation of 10,000 entering single female and track their behavior over time. The sample includes females in all five fertility states $\{0, 1, 2, 3, \emptyset\}$, and for wealth we consider total household assets. As can be seen in the left panel, the employment rate follows a U-shaped pattern, with declining employment rates between ages 18 and 32 and a partial reversion thereafter. The right panel shows that wealth increase with age: while mean asset holdings rise to almost \$60k within the first 15 years, median assets start to rise only gradually after a couple of years and then flatten out at about \$25k.

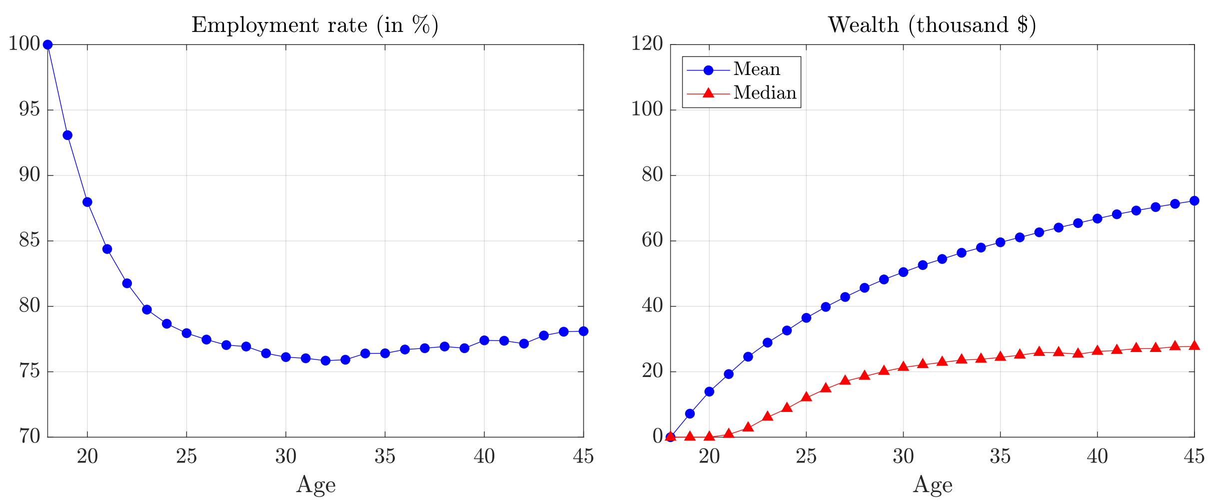

FIGURE E1. EMPLOYMENT RATE AND WEALTH OVER LIFE CYCLE

Further results on lone mothers' cohabitation and marriage acceptance decisions

Figure E2 presents lone mothers' acceptance rates as a function of the characteristics of a single male making a cohabitation or marriage offer. As can be seen in the figure, acceptance rates are increasing in the labor productivity of the male (left panel) and in his wealth (right panel). Interestingly, the gradient is much higher for productivity than for wealth which suggests that his earnings potential plays a substantially larger role for acceptance decisions than the level of assets that a potential suitor brings into the household. Furthermore, we find that proposals to cohabit from a male who is not the father of the children have the highest acceptance rates across all levels of productivity and wealth. This result is consistent with our analysis in the main text where we have plotted acceptance rates as a function of the productivity of the female. In a similar vein, lone mothers are slightly more likely to accept cohabitation than marriage proposals from the father of her children.

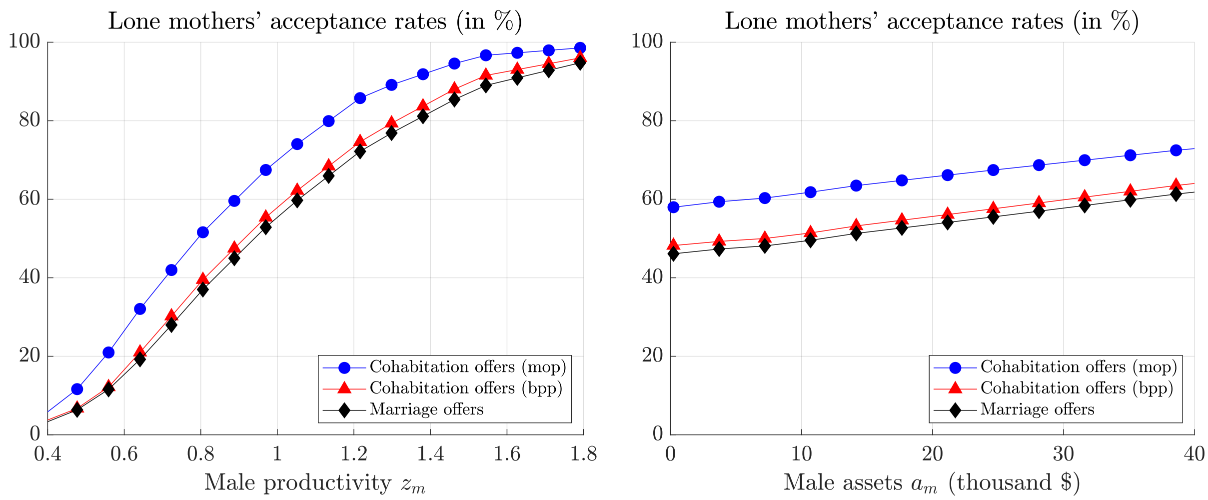

FIGURE E2. LONE MOTHERS' ACCEPTANCE RATES BY MALE CHARACTERISTICS

Figure 11 in the main text ("Lone mothers' acceptance rates") and Figure E2 suggest that the model generates endogenously a pattern of assortative mating through lone mothers' acceptance behavior. Since both of those figures entail some degree of aggregation over individual characteristics, we find it useful to dissect acceptance decisions at an even more disaggregate level. To this end, Figure E3 depicts threshold productivities for a single male making a cohabitation or marriage proposal, as a function of the lone mother's current productivity. We focus on two scenarios. In the first scenario (left panel), we consider a lone mother of one child with no assets receiving a proposal from a male with relatively few assets. In this case, forming a couple household would maintain asset eligibility for the purpose of receiving TANF and SNAP. In the second scenario (right panel), we consider a lone mother of one child holding \$4,000 of wealth receiving a proposal from a male who has above-median wealth in the distribution of this group (cf. Table 3). In the second scenario, asset eligibility for TANF and SNAP should play a substantially smaller role for acceptance decisions than in the first scenario.

There are several outcomes worth noting. First, the figure shows an increasing profile of threshold productivities, implying that more productive lone mothers are also pickier in terms of the productivity of the potential suitor; in other words, there is assortative mating in the model. Second, the figure confirms our previous findings that proposals to cohabit coming from a male who is not the father of the children are generally associated with the lowest threshold productivities for acceptance. Finally, marriage proposals are typically associated with the highest productivity thresholds, with the exception of very unproductive mothers receiving an offer such that the couple still maintains eligibility for TANF and SNAP. This result is consistent with our discussion of Figure 3 in the main text, where we emphasize the relevance of the type of living arrangement for net transfers.

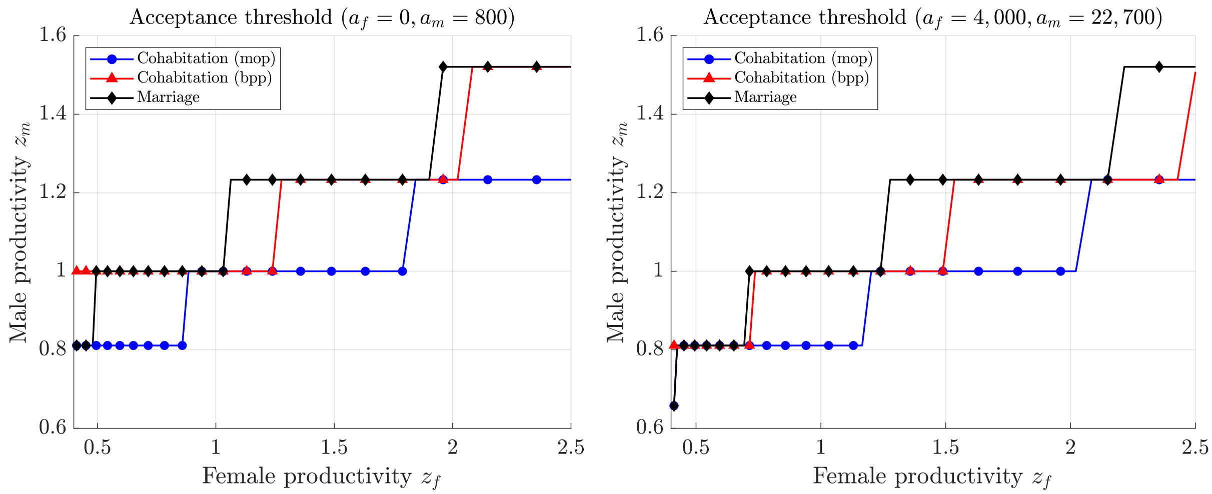

FIGURE E3. LONE MOTHERS' ACCEPTANCE THRESHOLD PRODUCTIVITIES

Notes: Minimum male productivity to accept cohabitation/marriage proposal as a function of lone mother's productivity. The left panel shows acceptance thresholds for a lone mother of one child with $a_f = 0$ receiving an offer from a single male with $a_m = \$800$ (2nd decile in the asset distribution; cf. Table 3), such that the prospective couple passes the asset test for SNAP/TANF. The right panel shows acceptance thresholds for a lone mother of one child with $a_f = \$4,000$ receiving an offer from a single male with $a_m = \$22,700$ (7th decile).

References

Heathcote, J., Storesletten, K., and G. L. Violante 2010. "The Macroeconomic Implications of Rising Wage Inequality in the United States." *Journal of Political Economy,* 118(4): 681–722.

Tauchen, G. 1986. "Finite State Markov-chain Approximations to Univariate and Vector Autoregressions." *Economics Letters,* 20(2): 177–181.