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ORIGINAL PAPER

# Parental leave policies, intra-household time allocations and children's human capital

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**Abstract** This paper uses a general equilibrium model of marriage and divorce to assess how public policies on parental leave and leave benefits affect intra-household decision making, family structure, intergenerational mobility, and the distribution of income. The benchmark economy is calibrated to US data to replicate some characteristics relevant to the interaction between the marriage and labor markets. The effects of unpaid leave, paid leave benefits, and mandated leave on human capital investment, distribution of income, and welfare are then analyzed.

**Keywords** Parental leave · Human capital investment · Income distribution

**JEL Classification** J1 · J2

## 1 Introduction

In recent literature about women's labor force participation and intra-household time allocation decisions, the issue is no longer whether women should work or not nor the analysis of the determinants of women's labor participation. In fact, it is assumed that women work and will work throughout their life cycle. The focus has shifted to the ways in which public policy can help to reconcile family and

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work responsibilities and, hence, have significant beneficial effects on women's employment continuity, female earnings, time investments in children's human capital, and more generally on social welfare. The United States provides among the least generous levels of parental job protection following the birth of a child. A study by the International Labor Organization (1999) reports that Australia, New Zealand, and the United States are the only industrialized countries that do not provide paid maternity leave by law. Most policies implemented in the United States have focused on generating and maintaining equal labor opportunities for men and women but have not been specifically designed to address the issue of the presence of children in a household in which both parents are expected to work. Indeed it was not until 1993 that the Family and Medical Leave Act (FMLA) was approved in the United States. The approved period of unpaid maternity leave, equivalent to 12 weeks, is the lowest within the set of Organisation for Economic Co-operation and Development (OECD) countries, with the exception of Switzerland, and covers only women who work in mid-size or large companies.

The issue of whether a parental leave after childbirth contributes to women's labor market outcomes and parental investments in children's human capital remains an issue in policymaking debates in the United States. Yet, it has received very little attention in the literature, and there is still no consensus about the consequences of changes in the length of the parental leave or the introduction of mandated paid benefits (either paid by employers or some kind of social security provision) on female labor market outcomes, intra-household decision-making, and the production of children's human capital. In this paper, we calibrate and simulate a general equilibrium model of marriage and divorce (in the spirit of Aiyagari et al. 2000 and Greenwood et al. 2003) to assess how public policies on maternity and paternity leave and leave benefits affect parental investments in children's human capital, intra-household time allocation decisions, and the distribution of income.

Several public policies can be thought of as family policies aimed at alleviating some of the issues related to the presence of children in a household: parental leave, promotion of child care, flexible working hours, progressive reduction of daily hours of work, and tax relief for workers with family responsibilities. There are several reasons why we are interested in parental leave policies in particular. First, women participating in the labor force have to find ways of reconciling market and family responsibilities. A parental leave policy[1] gives the opportunity to both, mothers and fathers, to take time off for childrearing, so that it can be an effective tool for promoting female labor participation.[2] Second, previous literature has provided evidence that parental time investment in children is a crucial input in the production of children's human capital.[3] Furthermore, the link between the level of human capital investments and income inequality has been recognized before. Consequently, parents' decisions related to the amount of time to be spent with their

[1]Parental leave can be used by either mother or father, whereas paternity leave is explicitly directed to fathers.

[2]The European Parliament's Committee on Women's rights and Equal Opportunities has suggested, for example, that the success of Sweden in increasing women labor force participation is partly due to forty percent of the fathers using their right to paternity leave.

[3]See Bernal (2007); Bernal and Keane (2006); Phipps et al. (1998).

children and the extent to which public policy can affect these decisions become relevant in understanding the distribution of income and welfare persistence among generations. Finally, despite being a controversial issue in policymaking debates and its recurrent presence in the political arena, it has received very little attention in the literature as opposed to topics such as child care and tax credit incentives for parents.

In this paper, we extend the general equilibrium model of marriage and divorce developed by Aiyagari et al. (2000) by introducing frictions into the labor market. An (unpaid) parental leave policy is desirable, as it allows one or both parents to take an extended period away from their employer without losing rights to claim the job. Thus, to capture the value of a leave policy, one needs a framework with some type of labor market friction. In particular, individuals entering the labor market face a constant probability $\lambda$ of receiving a job offer in a given time period, and the wage offer is a deterministic function of the individual's productivity. Each period, individuals have to decide how much time and resources to spend in their children and, if they receive and accept an offer, how much to work. If an agent decides to work in a given period, then he/she has guaranteed access to the same job the following period. If an individual does not receive an offer or receives an offer but chooses to decline it, then in the following period, she/he will remain unemployed with probability $(1 - \lambda)$ . An important element of our model is that, to participate in the labor market upon receiving an offer, an individual has to commit to a minimum amount of time in the workplace. The presence of this constraint implies that, for example, agents might be induced to reject wage offers that would optimally lead to low labor supply (lower than the minimal labor supply requirement) and high amount of time with children.

In this context, a parental leave is modeled as a reduction in the minimal time required for an individual to keep a job. Thus, an individual who was not willing to take a job at the initial minimal time requirement might accept it if this time is reduced by the parental leave policy. The labor market thus modeled exhibits a clear mechanism that allows employees to hang on to job offers they would otherwise have to give up if they spent more time in the household. In this sense, it captures the key role of a parental leave policy: it reduces the cost of participating in the market in terms of the time available for leisure and child care. We use this model to simulate the effects of several parental leave policies, including the introduction of an unpaid maternity leave, the introduction of paid parental leave benefits, and the implementation of a mandatory leave, on female labor market outcomes, intra-household time allocation decisions, parental time investments in children, and the production of children's human capital, and the distribution of income.

The main results of the paper are: (1) The introduction of an unpaid maternity leave is associated with an improvement in the income and utility distributions of men and women due primarily to changes in household income induced by an increase in the fraction of working women as well as an increase in the proportion of working married men that work full-time. This happens because women who chose not to work in the benchmark economy, given that their optimal labor supply fell below the minimum time requirement, can now work given that the introduction of a maternity leave implies a reduction of this requirement. In addition, there is a modest increase in average human capital of 4% with respect to the benchmark economy completely associated with an increase in household income, whereas total parental time investments in children remain unchanged. (2) The introduction of paid leave benefits for both, mothers and fathers, is associated with higher expected income and expected utility of women than in the benchmark model. This is the result of increased household income and increased children's human capital in the case of married couples and mostly due to increased leisure time at no monetary cost in the case of single and divorced mothers. Household income increases because a higher fraction of women work than in the benchmark economy, the average amount of working hours increases, and because of the availability of parental leave benefits. Children's average human capital increases as a consequence of both, higher household income and higher parental time investments in children. (3) Once a mandated leave is introduced, agents have to decide how to allocate this time between child care and leisure. The results indicate that parents use part of their freed time to increase time investments in children. As a consequence, average human capital increases by as much as 9% with respect to the benchmark economy.

The paper is structured as follows. In the next section, we present a brief review of related literature. In Section 3, we lay out the model by describing the environment and the equilibrium. In Section 4, we describe how the model is calibrated, present results for the benchmark model, and report several computational experiments. Concluding remarks are presented in the final section.

## 2 Related literature

Job retention seems to be a very important determinant of workers' wage profiles. Indeed, Stokey (1998) illustrates that women who maintained employment continuity over childbirth were more likely to have higher pay at age 30 than women who left the labor force around childbirth. O'Connell (1990) finds that, in Canada, interruptions to paid work involving a change in job upon return result in a downward shift in earnings profiles greater than would occur from lost experience alone, whereas a return to the old job has no additional cost than the return to experience.

There is some evidence that leave entitlements have a positive effect on return to previous job. OECD (2004) finds that women with employer provided maternity leave are more likely to return to work after childbirth than women without this benefit. Hofferth (1996) finds that the availability of unpaid leave, a flexible spending account, permission to work at home, and child care at the workplace are statistically significant predictors of whether a mother will return to work. Glass and Riley (1998) show that the amount of leave and the ability to avoid overtime hours are significant employer-based variables in job retention. Stokey (1998) indicates that women who were covered by a formal maternity leave policy and returned to their original employer had higher subsequent wages. Waldfogel (1997) sees the lack of job-protected maternity leave as a "family barrier" that might prevent women with children from competing on an equal footing in the labor market. Indeed, she finds that, in the US, women who were covered by maternity leave policies were more likely to return to work for their employer after birth, and this in turn has a positive effect on wages.

In terms of the effects of parental leave policies on children, there are two sets of results. The first finds a negative effect on children's welfare. In particular, Erosa et al. (2005) develop a general equilibrium model in which firms and workers match and are free to agree on temporary separations. The introduction of parental leave policies leads to significant aggregate welfare losses for newly born individuals because these policies subsidize inefficient matches and encourage too much leave taking by fertile women. The second finds a positive effect on children's health and cognitive development. Phipps et al. (1998) investigates the effect of a paid parental leave on children's health. Using a panel of 16 European countries from 1969 to 1994, he finds a strong negative relationship between leave durations and postneonatal or child fatalities. The magnitudes of the estimated effects are substantial, especially for those outcomes where a causal effect of parental leave is most plausible (postneonatal mortalities or fatalities between the first and fifth birthday). Baum (2003) finds a negative effect of maternal marketplace work in the initial months of an infant's life on the child's cognitive development. However, these negative effects are partially offset by positive effects of increased family income. Berger et al. (2005) find a considerable association between early returns to work and children's outcomes and suggest a causal relationship between early returns to work and reductions in breastfeeding and immunizations. Galtry (2000) finds that parental leaves also lead to longer periods of breastfeeding and less maternal stress. Bernal (2007) finds that maternal full-time work after childbirth has significant and rather sizeable effects on children's achievement scores by ages 3 to 6.

## 3 The model

To analyze some of the issues outlined in Section 1, we extend the model developed by Aiyagari et al. (2000). We use an overlapping generations model with two types of individuals, women and men, characterized by the following main features. First, marriage and divorce decisions are modeled along the lines of Loury (1981) Mortensen's 1988 search-theoretic models of marriage. Second, decisions within marriage are modeled using a Nash equilibrium approach, in which each member of the couple maximizes his/her own utility function, taking as given the actions of his/her partner. Third, following Becker and Tomes (1986) and International Labor Organization (1999) and Loury (1981), parents are assumed to decide how much time and goods to invest in their children. These parental investments determine the labor market productivity of a child when he/she grows up. Finally, to capture the key features of a parental leave, we introduce frictions in the labor market: An agent receives a job offer with probability $\lambda$ and to accept the offer, he/she has to commit a minimum amount of time $s$ to work to keep the job. A parental leave is modeled as a reduction of this minimal labor supply requirement; that is, if workers are entitled to a parental leave of length $\tau$ then they have to supply a minimum amount of time $s-\tau$ to keep the job. Hence, the model captures a key feature of a parental leave in that it allows employees to hang on to job offers they would otherwise have to give up to spend more time in the household.

The steady state equilibrium of the model will yield the composition of the economy in terms of marital status and determine the equilibrium income distribution. We then use this model economy to assess the effects of changes in the length of the leave (maternity leave only and both, maternity and paternity leave), the introduction of paid benefits (for both mothers and fathers), and the implementation of a mandated parental leave on women's labor market outcomes, intra-household time allocation decisions, parental time investments in children, and the production of children's human capital, and hence the distribution of income.

### 3.1 Timing, decisions and the environment

Agents live four periods: two as children living with their parents, and two as adults. Each time period corresponds to 10 years. Time periods are labeled $-2, -1, 1$, and 2, so that an individual of age 2 is an old adult. During childhood (age $-2$ and $-1$), individuals do not make any choices but accumulate human capital given their parents' decisions (in terms of time and goods investments). This human capital stock determines the individual's labor market productivity upon entering adulthood. Each adult is then characterized by a productivity type. We will let $X = \{x_1, ..., x_K\}$ ($Z = \{z_1, ..., z_K\}$) be the set of possible productivity types that characterize women (men). Each adult woman has two children, one woman female and one man male. Note that fertility is exogenous as women cannot choose how many children to have. The potential effects of endogenous fertility could be significant particularly in the presence of parental leave policies. For example, more generous parental leave policies may promote fertility.[4] This could, in turn, imply that parents may substitute away from quality of their offspring toward quantity. Given the discrete nature of fertility decisions, these effects could be quite significant. That is, a small change in the costs of fertility (due to the possibility of job continuity) can shift a household's choices by one child. However, parental leave policies in the United States are not motivated by the need to address declining fertility rates. Hence, as a first attempt to assess the potential effects of changes in parental leave policies and for the sake of computational simplicity, we chose to keep the model simple and leave the possibility of introducing fertility as an additional choice variable for future work.

At the beginning of each period, young adults (age = 1) enter the marriage market and take a draw from the pool of potential mates. If an agent accepts a marriage proposal, he or she remains married for the current period. Otherwise, the agent remains single for both periods of adulthood (we do not allow for a marriage market in the second period). At the beginning of the second period of adulthood, married agents decide whether they want to remain married or get divorced. As in Aiyagari et al. (2000), for technical convenience we assume that agents can match only with people of the same generation or age.

Young adults have to decide how to split their unit of time between work, child care, and leisure. With probability $\lambda$, agents receive a wage offer, which is a deterministic function of the individual's productivity type. The individual then has to decide whether to take the job, which would imply a minimum amount of labor supply equal to $s$. By accepting a job in the first period of adulthood, the individual has access to the same job with probability one in the second period. If the individual decides to keep the same job during the second period, then he/she receives a new wage draw from the same wage distribution.[5] Married agents derive utility from the consumption of a public household good, from their children's human capital, from leisure, and from marital status. Parents treat their children equally. Married men and women decide their level of consumption, the human capital investment in their

[4] In fact, some developed countries have implemented more generous parental leave policies as part of pro-fertility plans that aim at stopping the rapid decline in fertility rates.

[5] Alternatively, we could have allowed for on-the-job search, that is, have the worker draw from a distribution truncated at the level of wage of his/her current job.

children, and their allocations of time by taking their partners' decisions as given. Divorced men cannot invest time in their children given the physical separation. For this reason, old divorced men need only make choices about how much to work and how much leisure to enjoy. In addition, they have to pay child support to their ex-wives. Finally, divorced mothers must decide on their own how much time and money to invest in their children, given the child support payments received from their ex-husbands.

### 3.2 Preferences

Let the current-period utility function for agents be represented by:

$$\begin{aligned} i(c, h, 1 - l_i - t_i, \gamma) &= u(c) + \delta_i v(h) + \phi_i r(1 - l_i - t_i) + n(\gamma), \quad i = f, m \\ &= \frac{c^{\zeta i}}{\zeta_i} + \delta_i \frac{h^{\eta_i}}{\eta_i} + \phi_i \frac{(1 - l_i - t_i)^{\varphi_i}}{\varphi_i} - \gamma, \quad i = f, m \end{aligned} \tag{1}$$

where $i = f$ stands for females and $i = m$ for males. In addition, $l_i$ represents the number of units of time allocated to work, $t_i$ is the number of units of time allocated to child care, $c$ is the consumption out of household production, which is a public good for the family, and $h$ is human capital investment in children. $\gamma$ represents the quality of the match between a man and a woman. $\gamma \in G = \{\gamma_1, \gamma_2, ..., \gamma_W\}$ is a discrete random variable with the distribution function $\Gamma(\gamma_h) = \Pr\left[\gamma = \gamma_h\right]$. The quality of the match is drawn immediately after entry into marriage. $\delta_i$ reflects the degree of altruism of men and women toward their children.

Single (unmarried) agents will have the following utility functions: $f(c, h, 1 - l_f - t_f, 0)$ and $m(c, 0, 1 - l_m, 0)$ for women and men, respectively. That is, single women derive utility from consumption, children's human capital, and leisure, whereas single men derive utility only from consumption and leisure given that they do not have children.

### 3.3 Household production

Let $p$ be the number of parents in a household. Then consumption will be given by:

$$c = \Omega(p)[y(l_f, l_m; x, z)] \tag{2}$$

where

$$\Omega(p) = \left(\frac{1}{p}\right)^{\eta} \qquad \text{with } 0 < \eta < 1$$

is a function that translates household production into the consumption realized by family members, and $x$ and $z$ represent the productivity of women and men, respectively.

Household income is given by $y(l_f, l_m; x, z)$, which depends upon wages and labor supply choices. In particular:

$$y(l_f, l_m; x, z) = \begin{cases} w_f(x) \cdot l_f + w_m(z) \cdot l_m & \text{for a married couple} \\ w_f(x) \cdot l_f & \text{for a single woman} \\ w_m(z) \cdot l_m & \text{for a single man} \end{cases} \tag{3}$$

where $w_f(x)$ corresponds to the wage of a female type $x$, $w_m(z)$ corresponds to the wage of a male type $z$, and $l_i$ represents the number of units of time allocated to work by each agent. Wage offers are given by a deterministic function of the individual's type. In particular, we assume that wages are equal to productivity types.

### 3.4 Human capital formation

Human capital investment in children is given by:

$$h = q(t_f, t_m, c) = (t_f + t_m)^{\alpha} c^{1-\alpha}. \tag{4}$$

The function $q(.)$ transforms the child-care time of the mother, $t_f$, of the father, $t_m$, and the amount of the home produced good, $c$, into children's human capital $h$. Note that this specification implies that time investments of the parents are perfect substitutes in human capital production of the child. This seems like a reasonable assumption, although we acknowledge that there is little empirical evidence that this is the case. One can argue that the degree of substitutability between maternal and paternal time varies over time after childbirth.[6] However, given that a period in the model is equivalent to 10 years, the assumption that both time investments are perfect substitutes during this time seems more plausible. This substitutability assumption might be associated with some of the results presented below, and hence, it would be worthwhile exploring different specifications of the human capital production in future research. Children are taken care of during the two periods of childhood. The productivity level they are endowed with as they become adults depends upon the human capital investments received during childhood.

The productivity levels for women and men during the first period of adulthood are drawn from the following distributions:

$$\begin{aligned} \Theta\left(x_i|h_{-2}+h_{-1}\right) &= \Pr\left[x = x_i|h_{-2}+h_{-1}\right] \\ \Lambda\left(z_j|h_{-2}+h_{-1}\right) &= \Pr\left[z = z_j|h_{-2}+h_{-1}\right] \end{aligned} \tag{5}$$

where $h_{-2}$ and $h_{-1}$ indicate the human capital investments during the two periods of childhood. The conditional distributions $\Theta$ and $\Lambda$ are stochastically increasing in $h_{-2}+h_{-1}$, in the sense of first order stochastic dominance. This implies that higher human capital investment in children by parents increases the likelihood of success of young adults.[7]

[6]For example, maternal time might seem more important during the first months after childbirth given that only she can breastfeed the child.

[7]The conditional distributions $\Theta$ and $\Lambda$ are represented by discrete approximations to lognormal distributions with means $\mu_{x|h}$ and $\mu_{z|h}$ and standard deviations $\sigma_{x|h}$ and $\sigma_{z|h}$, respectively. Let the conditional means be given by:

$$\mu_{x|h} = \mu_{z|h} = \varepsilon_1(h_{-2}+h_{-1})^{\varepsilon_2} \text{ with } \varepsilon_2 \in (0,1)$$

where $\varepsilon_2$ is the parameter governing the technology that maps human capital investment into productivity levels.

After the first period of adulthood, an individual's productivity level ($x$ or $z$) evolves according to the following transition functions:

$$X[x_j|x_i] = \Pr\left[x' = x_j|x = x_i\right]$$
$$Z[z_j|z_i] = \Pr\left[z' = z_j|z = z_i\right] \tag{6}$$

where $x$ and $z$ are productivity types during the first period of adulthood, and $x'$ and $z'$ are productivity types in the second period of adulthood for women and men, respectively. The conditional distributions $X$ and $Z$, represented by a discrete approximation à la Tauchen (1986), are described by the following stochastic process:

$$x' = Ax^{\rho}\exp(\kappa\xi) \qquad \text{with } \xi \sim N(0, 1) \tag{7}$$

where $\rho$ measures persistence of wages.

## 3.5 Decision making

The basic framework of the model is directly derived from Aiyagari et al. (2000) and Greenwood et al. (2003). For this reason we will leave most of the details to the Appendix. In this section, we lay out the basic components of the problem faced by each type of agent, i.e., single, divorced, and married, and present an example to clarify some of the main aspects of the model. Crucial to the model are the frictions we introduce into the labor market, which as we have mentioned before, capture a key feature of a parental leave in that these allow employees to hang on to job offers they would otherwise have to give up to spend more time in the household. In particular, in each period, the probability of receiving an offer is equal to $\lambda$, and if an agent accepts a job offer, he/she has to work a minimum amount of time $s$.[8] A parental leave is modeled as a reduction of this minimum labor supply requirement.

### *3.5.1 Single agents*

*Single old agents* An old single woman who receives an offer has to decide whether to accept the job or not which would imply that she has to supply at least $s$ units of work, how much to work ($l_f$), how much time to devote to child care ($t_f$), and the optimal amount of leisure to maximize her utility function (Eq. 1) subject to the constraints. Similarly, old single men who receive a job offer have to decide whether to accept the job or not which would imply that supplying at least $s$ units of work, how much to work ($l_m$) but do not have to make time investments in children, as they do not father any. The constraints are given by Eqs. 3 and 4 in addition to the minimum amount of work requirement, $l_i \geqslant s$ for $i = f, m$.

[8]Note that assuming that an individual will get a job offer with probability $\lambda$ during each period of adulthood (of which there are two) is problematic in the sense that if a period in the model is equivalent to 10 years, most individuals will actually get a job offer with probability one. Notwithstanding, this approach might still be a reasonable one in the general equilibrium framework that we use.

To decide whether or not to accept/keep this offer, an agent compares the maximum utility derived from working at least $s$ units of time with the maximum utility derived from not working. For example, an old single woman will compare:[9]

$$\begin{aligned} F_2^s(x)' &= \max_{l_f, t_f} f(c, h, 1 - l_f - t_f, 0) \\ \text{s.t. } c &= \Omega(p)\left[\bar{c} + w(x).l_f\right] \\ h &= q(t_f, 0, c) \\ l_f &\geqslant s \end{aligned} \tag{8}$$

with

$$\begin{aligned} F_2^s(x)'' &= \max_{t_f} f(c, h, 1 - t_f, 0) \\ \text{s.t. } c &= \Omega(p).\bar{c} \\ h &= q(t_f, 0, c) \end{aligned} \tag{9}$$

where labor supply is set to zero in Eq. 9, and the agent chooses only the optimal amount of leisure and child-care time. If $F_2^s(x)' \geq F_2^s(x)''$, then the single old woman will choose $l_f^{'}$ and $t_f^{'}$ that solve Eq. 8; otherwise, she will not work and choose $t_f^{''}$ that solves Eq. 9.

An old agent receives an offer in period 2 with probability $\lambda$ if he/she did not work in period 1 and with probability one if he/she worked in period 1. In this case, if he/she decides to keep her period-1 job, then he/she gets a new wage draw from the same wage distribution. An old agent who did not work in period 1 does not receive an offer in period 2 with probability $1 - \lambda$, in which case he/she automatically faces Eq. 9.[10] Hence, the expected utility of a single old woman who did not work in period 1 is given by the weighted average of $\max\{F_2^s(x)', F_2^s(x)''\}$ and $F_2^s(x)''$, where weights are the probabilities of receiving and not receiving a job offer in period 2, respectively [i.e., $\lambda$ and $(1 - \lambda)$], and analogously for single old men. The expected utility of a single old woman who worked in period 1 is given by $\max\{F_2^s(x)', F_2^s(x)''\}$, as she will face a job offer in period 2 with probability one, and analogously for single old men.

*Single young agents* If a young adult does not receive a job offer in period 1, he/she only chooses how to split his/her time between child care (in the case of young women only) and leisure to maximize his/her current utility (given by Eq. 1) plus his/her continuation value subject to Eqs. 2 and 4. In turn, the continuation value will be given by the discounted present value of the maximum utility derived by a single old agent who did not work in period 1 (given that he did not receive a job offer in period 1), i.e., $F_2^s(x) = \lambda. \max\{F_2^s(x)', F_2^s(x)''\} + (1 - \lambda).F_2^s(x)''$ in the case of women,

[9]The lower case superscripts denote the individual's marital status. In this case, s stands for single, and in what follows, m will represent married and d divorced. The numbers in the subscript indicate the time period.

[10]An old single agent who worked in period 1 always receives a job offer with probability one.

weighted by all the possible transitions from productivity type-$x_i$ in period 1 to type-$x_j$ in period 2 given by $X(x_j|x_i)$ in Eq. 6. More formally:

$$F_1^s(x_i)'' = \max_{t_f} \left[ f(c, h, 1 - t_f, 0) + \beta \sum_{j=1}^{K} F_2^s(x_j) X(x_j|x_i) \right]$$

$$\text{s.t. } c = \Omega(p)\bar{c}$$

$$h = q(t_f, 0, c) \tag{10}$$

where $x_i$ is the woman's productivity type in period 1, $X(x_j|x_i)$ is the transition function according to which female productivity evolves from period 1 to period 2, $K$ is the total number of female productivity types, and $\beta$ is the discount factor.

If a single young agent receives an offer in period 1, which happens with probability $\lambda$, then he/she has to decide whether to accept the offer or not, how much to work [$l_i$ for $i = f(\text{emale}), m(\text{ale})$], how much time to invest in children ($t_f$) in the case of women, and how much leisure to enjoy to maximize current utility Eq. (1) plus the continuation value subject to the constraints 2 and 4, and the minimum amount of work requirement $l_i \geqslant s$ (for $i = f, m$). The continuation value will depend upon whether the agent accepts the job offer in period 1 or not. If he/she does, the continuation value will be given by the discounted present value of the maximum utility derived by a single old agent who worked in period 1, e.g., $\max\{F_2^s(x)', F_2^s(x)''\}$ in the case of women, weighted by all the possible transitions from type-$x_i$ in period 1 to type-$x_j$ in period 2 given by $X(x_j|x_i)$ in Eq. 6. Alternatively, if the single agent does not accept the offer in period 1, then the continuation value will be identical to the continuation value in Eq. 10. Whether the single young agent accepts the job offer in period 1 or not depends on which of the two alternatives yields the highest utility.[11]

In sum, the unconditional value function of a single young agent is given by the weighted average of the maximum utility attained if the agent receives an offer and the maximum utility attained if the agent does not receive an offer in period 1, where the weights are $\lambda$ and $1 - \lambda$, respectively.

### *3.5.2 Divorced agents*

The decision-making process of divorced women is basically the same faced by single old women except for the fact that divorced women receive child support payments from their ex-husbands. That means that the budget constraint in Eqs. 8 and 9 now includes this additional transfer, which corresponds to a percentage $a$ of the ex-husband's labor earnings: $a.w(z).L_m^{\mathrm{d}}$, where $w(z)$ is her ex-husband's wage given his type $z$, and $L_m^{\mathrm{d}}$ corresponds to his optimal labor supply in period 2.

The decision-making process of divorced men is similar to that of divorced women except for the fact that divorced men do not make time investment decisions in children because they do not coreside with their offspring and, in addition, must pay child support to their ex-wives.

[11] Details can be found in the Appendix.

### 3.5.3 Married agents

Decisions within marriage are assumed to be the solution to a Nash equilibrium problem in which each member of the couple maximizes his/her own utility function taking as given the action of his/her partner. For example, a wife will maximize her utility function subject to the constraints 2 and 4 and the minimum amount of work requirement (in case a job offer has been received) taking her husband's working and child-care decision rules as given. The details are relegated to Section 7.2 in the Appendix. The key feature to note is that in solving his/her maximization problem, the agent takes the optimal choices of his/her spouse (denoted by capital letters $L_i$ and $T_i$ for $i = f, m$) as given. Computationally, the solution is then obtained by solving a fixed point problem.

The assumption of noncooperative behavior within the household is important and deserves some discussion. If married agents behave cooperatively, then only divorces that are efficient for the family take place. This implies that a change from bilateral to unilateral divorce laws should have no effect on the decision to divorce if agents behave cooperatively because total family resources do not change (but rather property rights within the household are relocated). Thus, the finding according to which unilateral divorce laws have a significant effect on divorce rates in the United States (Friedberg 1998 and Gruber 2004) provides evidence of noncooperative behavior in married households. In this sense, the assumption of noncooperative behavior in our model seems like a reasonable one. However, the assumptions of unilateral divorce decisions and no side payments might not be innocuous, a point that we further discuss in Section 3.5.4.

In addition, it is important to emphasize that the decision-making process is slightly more complicated than in the case of single agents, as it now depends upon all combinations of husband–wife job offer arrivals, and also, optimal labor supply and child-care choices in period 2 will depend upon all combinations of husband–wife labor market histories (e.g., whether both worked in the first period, only the wife worked, only the husband worked, or neither worked).

*Old married agents* If an old married agent receives a job offer, then he/she will choose whether to work or not, how much to work, and how much time to invest in his/her children to maximize his/her utility (Eq. 1) subject to constraints 2 and 4, and $l_i \geqslant s$ (for $i = f, m$) taking as given the optimal actions of his/her partner. Recall that the probability of a job arrival depends upon whether the agent worked or not during the previous period. Thus, the labor market histories of husband and wife matter for choices made during the second period of adulthood. For example, if both husband and wife worked in period 1, then in period 2, they would both have a job with probability one. If only one of the two worked in period 1, then only the one who worked will receive a job offer in the second period for sure, whereas the other will receive one with probability $\lambda$. Finally, if neither the woman nor the man worked in period 1, then each one will receive an offer in period 2 with probability $\lambda$.

If an old married agent does not receive a job offer, then he/she has to decide how much time to devote to child care and how much leisure to enjoy given his/her partner's optimal choices.

*Young married agents* If a young married agent receives a job offer in period 1, then he/she will choose whether to work or not, how much to work, and how much time to invest in children to maximize his/her current utility (Eq. 1) plus the continuation value subject to constraints 2 and 4 and $l_i \geqslant s$ (for $i = f, m$) taking as given the optimal actions of his/her partner. The continuation value will be given by the maximum between the utility derived from staying married and the utility attained in case of a divorce. In either case, period-2 maximum utility will depend upon whether the offer received in period 1 is accepted or not because that will be associated with the employment status of the individual in period 2.

Similarly, if a young married agent does not receive a job offer in period 1, then he/she will just choose how much time to invest in children to maximize his/her current utility (Eq. 1) plus the continuation value subject to Eqs. 2 and 4 taking as given the optimal actions of his/her partner. The continuation value is given by the maximum between the utility derived from staying married in period 2 and the utility attained if the couple divorces. Each of these depends, in turn, on the employment status of each partner in period 1. The details are relegated to the Appendix.

### *3.5.4 Matching process*

In the first period of adulthood, individuals enter the marriage market. The probability of finding a woman of type $x_i$ will be given by:

$$\Phi_1(x_i) \;\text{ with }\; \Phi_1(x_i) > 0 \text{ and } \sum_{i=1}^{K} \Phi_1(x_i) = 1 \tag{11}$$

where $K$ is the number of female productivity types. Similarly, let $\Phi_2(z_i)$ be the probability of meeting a single young man of type $z_i$.

A young man/woman will decide to get married if his/her expected utility of getting married is larger than the utility level attained from staying single. Thus, marriage decision rules in period 1 are given by the following indicator functions which make exactly that comparison:

$$I_1(x,z,\gamma) = \begin{cases} 1 \;\text{ if } \sum_{h=1}^{G} \Gamma(\gamma_h) M_1^{\mathrm{m}}(x,z,\gamma_h) \geqslant M_1^{\mathrm{s}}(z;\Phi_1,\Phi_2) \\ 0 \;\text{ otherwise} \end{cases}$$

$$J_1(x,z,\gamma) = \begin{cases} 1 \;\text{ if } \sum_{h=1}^{G} \Gamma(\gamma_h) F_1^{\mathrm{m}}(x,z,\gamma_h) \geqslant F_1^{\mathrm{s}}(x;\Phi_1,\Phi_2) \\ 0 \;\text{ otherwise.} \end{cases} \tag{12}$$

where $M_1^{\mathrm{m}}(x_i, z_j, \gamma_h)$ and $F_1^{\mathrm{m}}(x_i, z_j, \gamma_h)$ correspond to optimal utility levels of married young men and women, respectively (defined in the Appendix), and $x_i$ is the female's type, $z_j$ is the male's type, and $\gamma_h$ is the quality of the match. $F_1^{\rm s}(x_i)$ and $M_1^{\rm s}(x_i)$ represent the unconditional value functions of single young women and single young men, respectively (also defined in the Appendix). $\Gamma(\gamma_h)$ represents the probability that the quality of the match is $\gamma_h$ and $G$ is the total number of possible values of $\gamma$. For marriage to occur, it must be mutually agreeable, which requires that $I_1(x, z, \gamma).J_1(x, z, \gamma) = 1$. Note that this means that divorce is unilateral, in the sense that it is enough for one of the spouses to prefer divorce for the couple to get a divorce. This might have important implications that we discuss below.

There is no marriage market for single or divorced old adults. Married old adults decide whether to remain married or not at the beginning of the period and then sample the labor market. An old married adult makes this choice based upon the comparison between the expected utility of staying married and the expected utility of getting divorced. The divorce decision rules thus obtained are detailed in the Appendix.

Finally, it is important to mention that, although assuming noncooperative behavior within the household is not an implausible assumption, the lack of side payments might be quite restrictive. If one allows side payments, then divorces are efficient, which implies that changes between unilateral and bilateral divorce laws have no real effects on divorce rates.[12] However, because we do not allow for side payments in our model, then the divorce rate in equilibrium is sensitive to the unilateral divorce assumption and, thus, has nonnegligible effects on the results of our calibration and simulation exercises, particularly given our findings that the effects of parental leave policies have differential effects on individuals according to their marital status.[13]

## 3.6 Equilibrium

### *3.6.1 Steady state matching probabilities*

The matching probabilities $\Phi_1(x)$ and $\Phi_2(z)$ are nothing but the measures of each type in the marriage market in period 1. In particular, the number of young women of type $x_s$ is given by:

$$\begin{aligned}\Phi_1(x_s) = &\sum_{i,j,k,l,h,u} \Theta(x_s | H_1^{\rm m}(x_i, z_j, \gamma_h) + H_2^{\rm m}(x_k, z_l, \gamma_u)) Y^{\rm m,m}(x_i, z_j, x_k, z_l, \gamma_h, \gamma_u) \\ &+ \sum_{i,j,k,h} \Theta(x_s | H_1^{\rm m}(x_i, z_j, \gamma_h) + H_2^{\rm d}(x_k)) Y^{\rm m,d}(x_i, z_j, x_k, \gamma_h) \\ &+ \sum_{i,k} \Theta(x_s | H_1^{\rm s}(x_i) + H_2^{\rm s}(x_k)) Y^{\rm s,s}(x_i, x_k) \qquad (13)\end{aligned}$$

[12] For example, the effect of a change from bilateral to unilateral divorce laws would be the reallocation of property rights in favor of the individual who prefers the divorce state.

[13] However, Brown and Flinn (2006) find very small differences in predicted behavior of individuals (in terms of parents' incomes, determinants of marriage quality, and determinants of child quality and marital status) in a model in which time investments and marital status matters for children's human capital regardless of whether one assumes bilateral or unilateral divorce laws and regardless of whether one allows for side payments or not. They conclude that it is hard to construct a model (cooperative or noncooperative) in which the distinction between unilateral and bilateral matters.

where:

| Variable | Description |
|---|---|
| $Y^{\mathrm{m,m}}(x_i, z_j, x_k, z_l, \gamma_h, \gamma_u)$ | Number of young men or women who grew up in a single-parent household in their entire childhood, with married parents who moved from state $(x_i, z_j, \gamma_h)$ to $(x_k, z_l, \gamma_u)$. |
| $Y^{\mathrm{m,d}}(x_i, z_j, x_k, \gamma_h)$ | Number of young men or women who lived half their childhood in a two-parent household and experienced a mid-childhood divorce. |
| $Y^{\mathrm{s,s}}(x_i, x_k)$ | Number of young men or women who grew up in a single-parent household in their entire childhood, with a mother who moved from state $x_i$ to $x_k$. |
| $H_t^{\mathrm{m}}(x_i, z_j, \gamma_h)$ | Human capital investment by a couple of type $(x_i, z_j, \gamma_h)$ in period $t$ |
| $H_t^{\mathrm{d}}(x_i)$ | Human capital investment by a divorced mother of type $x_i$ in period $t$ |
| $H_t^{\mathrm{s}}(x_i)$ | Human capital investment by a single mother of type $x_i$ in period $t$ |

Clearly human capital investments by parents in the second period (e.g., $H_2^{\mathrm{m}}(x_k, z_l, \gamma_u)$) will depend upon parents' labor market decisions. See the Appendix for details.

Each term of the sum in Eq. 13 is simply saying that, conditional on the human capital investments of a particular type of household $a, b$ (where $a, b = m, m$ in the case of intact households during both periods, $a, b = m, d$ in the case of two-parent households that experience a divorce in the second period, and $a, b = s, s$ in the case of households with a single parent during both periods), there is a probability that the female child will be of type $s$, and there is a total amount $Y^{a,b}$ of households of that type in the economy. Hence, that provides the measure of total women of type $s$ that emerge from households of type $a, b$. The number of young men of type $s$ $(\Phi_2(z_s))$ is given by an analogous expression.

Expressions for $Y^{\mathrm{m,m}}$, $Y^{\mathrm{m,d}}$, and $Y^{\mathrm{s,s}}$ are specified in the Appendix.

## 3.7 Stationary equilibrium

A stationary matching equilibrium is a set of allocation rules, i.e., labor supply $[L_{i,t}^{j}(x, z, \gamma)$ where $i = f$(emale), $m$(ale), $t = 1, 2$ and $j = s$(ingle), $m$(arried), $d$(ivorced)], child-care time $[T_{i,t}^{j}(x, z, \gamma)]$,[14] leisure $[1 - L_{i,t}^{j}(x, z, \gamma) - T_{i,t}^{j}(x, z, \gamma)]$,

[14]Note that child-care decisions by single and divorced men are not part of the set of allocation rules, as they either do not father children or do not coreside with their offspring.

human capital $[H^j_{i,t}(x,z,\gamma)]$, marriage $[I_1(x,z)$ and $J_1(x,z)]$ and divorce decisions $[I_2(x,z,\gamma)$ and $J_2(x,z,\gamma))]$, and matching probabilities $\Phi_1(x)$, $\Phi_2(z)$ such that

1. The functions $L^j_{i,t}(x,z,\gamma)$, $T^j_{i,t}(x,z,\gamma)$, and $H^j_{i,t}(x,z,\gamma)$ describe an equilibrium for the maximization problem faced by individual of gender $i$ and marital status $j$ in period $t$. These are described in detail in the Appendix.
2. Single agents' marriage decisions $I_1(x,z)$, $J_1(x,z)$ are given by Eq. 12. In other words, indicator functions that result from comparing the maximum utility level attained if the agent remains single (after substituting optimal allocation rules described in 1) with the maximum utility level attained in case of marriage.
3. Married agents' divorce decisions $I_2(x,z,\gamma)$ and $J_2(x,z,\gamma)$ are given by Eq. 32 in the Appendix. In other words, indicator functions that result from comparing the maximum utility level attained if remaining married (after substituting optimal allocation rules described in 1) with the maximum utility level attained in case of divorce.
4. Finally, the matching probabilities $\Phi_1(x)$, $\Phi_2(z)$ are governed by the stationary distributions described by Eq. 13. In other words, after each simulated individual chooses his/her marital status, one can construct the amounts $Y^{\mathrm{m,m}}$, $Y^{\mathrm{m,d}}$ and $Y^{\mathrm{s,s}}$ described in Section 3.6, together with human capital investments $H^j_{i,t}(x,z,\gamma)$, and find $\Phi_1(x)$ and $\Phi_2(z)$ that satisfy Eq. 13.

## 4 Computational results

### 4.1 Calibration of the model

To analyze some of the issues outlined in Section 1, the model described in the previous section is solved numerically. The values assigned to the parameters of the model are described in Table 1. Most of the parameters are picked to generate an equilibrium that displays several desired features of the data. Some of them will be discussed below.

The benchmark equilibrium is parameterized to match various relevant statistics from the Panel Study of Income Dynamics (PSID) and the Current Population

**Table 1** Parametrization of the benchmark model

| | Values |
|---|---|
| Tastes | $\zeta_f = 0.27$, $\delta_f = 0.9$, $\eta_f = 0.3$, $\theta_f = 3.8$, $\varphi_f = 0.35$ |
| | $\zeta_m = 0.3$, $\delta_m = 0.8$, $\eta_m = 0.33$, $\theta_m = 3.3$, $\varphi_m = 0.33$ |
| | $\beta$=0.67 |
| Technology | $\eta = 0.5$ |
| | $\alpha = 0.2$ |
| | $\varepsilon_1 = 6.7$, $\varepsilon_2 = 0.5$ |
| Stochastic structure | $\mu_{x\|h} = \mu_{z\|h} = ln[\varepsilon_1(h_2+h_1)^{\varepsilon 2}]$, $\sigma_{x\|h} = \sigma_{z\|h} = 0.45$ |
| | $\rho_x = \rho_z = 0.7$, $\kappa = \sigma_x(1-\rho_x^2)^{1/2}$ |
| | $G = 2$, $\gamma_1 = 1.4$, $\gamma_2 = 0.4$, $\Gamma(\gamma_1) = 0.6$, $\Gamma(\gamma_2) = 0.4$ |
| Simulation control | $K = 11$ |
| Policy variables | $s = 0.16$ |

Survey (CPS), such as marital status, wage distributions, income inequality, and labor supply. Regarding the choice of functional forms and parameters, we have in some cases estimates in the literature that can guide the decisions, whereas in other cases, we will have to choose parameters to match certain facts.

The following parameters are chosen to match the data:

- To construct the grids of the productivity levels $X = \{x_1, ..., x_K\}$ and $Z = \{z_1, ..., z_K\}$, we use the mean and standard deviation of the logarithm of wages for men and women considering only full-time workers in nonfarm activities and salary employees aged 18–65 from the 1988 PSID. The means are approximately 2.3 and 2.0, respectively, whereas both standard deviations stand around 0.55. The lowest value in the grid corresponds to two standard deviations below the mean, and the highest value is two standard deviations above the mean.
- In the case of the scale factor function:

$$\Omega(p) = \left(\frac{1}{p}\right)^{\eta}$$

  Cutler and Katz (1992) report ranges for the parameter $\eta$. We set it to $\eta = 0.5$ in the middle of this range.
- Given the fact that a model period is 10 years, the discount factor $\beta = 0.67$ if we assume an interest rate of 4%.

Most of the remaining parameters are chosen to match statistics on marital status, wage distributions, income inequality, and labor supply:

- We choose the number of match quality types $G$ to be equal to two for ease of computation. In particular, the quality of the match parameters and conditional probabilities $\gamma_1$, $\gamma_2$, $\Gamma(\gamma_1)$, and $\Gamma(\gamma_2)$ are chosen to match the proportions of single, married, and divorced people in the data. Other features of the model, such as productivity shocks (wage growth), are not enough to generate observed rates of divorce. These quality match parameters are thus crucial to match marital status rates. Marriage has a positive effect on utility given that consumption is higher, as it is a public good in the household, and married agents derive utility from children, which are also a public good. Hence, we need to add a counteracting force to induce people to divorce.
- Although the human capital production function for children is a crucial feature of this model, there is little empirical evidence that can help us in determining the value of the parameter $\alpha$. We set it at 0.2. Changes in this parameter affect the trade-off between working and child care. A higher $\alpha$, given the other parameters, would imply that parents' time with children is more productive and, hence, parents may want to reduce their time at work to spend more time with children. Thus, together with the other preference parameters, it is chosen to match the features of the labor market observed in the data. Admittedly, it would be interesting to assess how the main results change for different values of $\alpha$. However, it was difficult to find another combination of $\alpha$ and utility parameters that would fit the data at least as well as our baseline calibration. In any event, it is important to note that the chosen value of $\alpha$ is rather low, giving more weight to consumption goods investments in the production of human capital. The effects of the policy experiments on child-care time would be stronger for

higher values of $\alpha$ given that these would imply that parental time investments are more valuable for children.[15]

- In the case of the parameters that map childhood investment into productivity levels, $\Theta(x_i|h_{-2}+h_{-1})$ and $\Lambda\left(z_j|h_{-2}+h_{-1}\right)$, we use the following log-linear approximation:

$$\log(x) = \log\left[6.7(h_{-2}+h_{-1})^{0.5}\right]$$

  where 6.7 is just a scaling factor. $\varepsilon_2 = 0.5$ corresponds to the curvature parameter. Both, $\varepsilon_2$ and the standard deviation used for the approximation (0.45) are set to obtain distributions of young adult types $\Phi_1$ and $\Phi_2$ that look lognormal with means and standard deviations that correspond to those used to create the initial grid of productivity types.
- Parameters in the utility function are basically selected to match labor supply levels in the data.
- $s$ represents the minimum amount of labor supply required to keep an accepted job offer. We set it to 0.16, which would be equivalent to working part-time (5.6 hours a day for 5 days a week, 50 weeks per year).[16]
- The parameters $\rho_x$ and $\rho_z$ capture the persistence of wages. We set them both at 0.7 (as in Aiyagari et al. 2000) to match the growth of wages.

### 4.2 Benchmark equilibrium

As discussed in the previous section, our model is calibrated to match certain features of the data. In particular, we want our benchmark equilibrium to replicate some characteristics relevant to the interaction between the marriage and labor markets. For this reason, we aim to match the following moments: marital status of the population, life-cycle pattern of labor supply, and composition of the labor force between full-time and part-time workers. The results of the calibration are presented in Table 2, and it can be observed that the model performs quite well in these three dimensions. About 71% of the population (20–40) is married in the benchmark economy, whereas this percentage is close to 73% in the data according to the CPS (2002).

The labor supply numbers line up well with the data. These numbers correspond to the 1948–1957 cohort from the PSID. Single men work less in the first period but more in the second in our benchmark economy than in the data, whereas married men seem to work slightly less in the model than in the data. Married women work more in the model and in the first period in particular. This might be associated with the presence of a minimum labor supply requirement and the fact that a model time-period is equal to 10 years. In reality, a woman can choose to work intermittently during 10 years and, thus, accumulate a total amount of work that is less than the

[15] If parental time investments are more valuable, then the effect of the externality would be stronger and, hence, the potential effect of public policy because children would like their parents to make higher investments than they actually choose.

[16] In the data, hours are very concentrated at 20 and 40 per week. It is very likely that much of the variation away from those figures is just measurement error. Thus, allowing for a minimum labor supply requirement lower than part-time would be implausible.

**Table 2** Calibration results for benchmark economy

| Statistic | Data | Model | Source |
|---|---|---|---|
| Marital status of population | | | |
| Married (%) | 73 | 71 | CPS 2002 age 20 to 40 |
| Single (%) | 27 | 28 | |
| Labor supply (% of time period) | | | |
| Single men | | | |
| 20–29 | 33 | 29 | PSID cohort 48–57 |
| 30–39 | 33 | 34 | |
| Single women | | | |
| 20–29 | 24 | 24 | |
| 30–39 | 25 | 27 | |
| Married men | | | |
| 20–29 | 41 | 37 | |
| 30–39 | 43 | 42 | |
| Married women | | | |
| 20–29 | 19 | 24 | |
| 30–39 | 24 | 25 | |
| Full-time workers/Total workers (%) | | | |
| Women | 68 | 66 | CPS 2002 age 20 to 40 |
| Men | 85 | 91 | |

equivalent of working part-time during the entire period. In spite of these differences, it can be said that life-cycle labor supply patterns are matched satisfactorily.

Table 3 provides a more detailed description of individuals' time allocations in the benchmark economy. As can be observed, married and single women work, on average, a similar amount of time, but married women can, on average, invest more time on their children, whereas divorced women, while working on average less than single women, spend a similar amount of time with their children. Married women can spend more time with their children, as they do not face the same trade-off: Some married women can actually work more given that their husbands can spend time with the children. In the last panel of Table 3, we show the percentage of workers who work full-time. All single men work full-time, whereas a smaller percentage of married and divorced parents do. Clearly, married men spend some time investing

**Table 3** Time allocations and labor market participation decisions in the benchmark economy

| | Married | Single | Divorced |
|---|---|---|---|
| Female time allocation (% total time) | | | |
| Market work | 24.5 | 25.4 | 22.7 |
| Child care | 4.6 | 3.4 | 4 |
| Male time allocation (% total time) | | | |
| Market work | 39.3 | 31.2 | 35.2 |
| Child care | 3.9 | – | – |
| Full time workers/total workers (%) | | | |
| Woman | 55.9 | 94.9 | 65.8 |
| Man | 88.1 | 100 | 90.6 |

in their children's human capital, whereas divorced parents reduce their labor supply due to the fact that they derive utility from their children's human capital but do not have to incur the associated costs.

The amount of time that married women devote to their children is considerably larger than the amount of time devoted to children by single or divorced mothers. On average, a married woman spends 6% of each time period investing in her children's human capital. This corresponds to approximately 7.2 months given that a model period is 10 years. On the other hand, single and divorced women devote 3.8% of their time to their children, which is approximately equivalent to 4.6 months in a 10-year period. This, of course, implies that total investments in human capital are smaller for children being raised in one-parent households than for those who lived their childhood in a two-parent household. Specifically, the average human capital of children being raised in a household that experiences a divorce is 64% of the average human capital of children that grow in a two-parent household, whereas in the case of children that spend all their childhood in a single-parent family, this ratio is equivalent to 52%.

## 5 Policy experiments

Family-friendly policies are defined by the OECD as "those employment-oriented social policies that facilitate the reconciliation of work and family life by fostering adequacy of family resources and child development, favor the parental choice about work and care, and promote gender equality in employment opportunities".[17] Among these policies, a prominent role is played by leave policies We will examine the effect of two types of policies: leave without pay and paid leave. First, we will examine the case of maternity leave only. We will then discuss how the results change when fathers are also allowed to take a parental leave. Second, we will look at paid parental leave. Finally, we will discuss a possible implementation of mandated leave in our model. We will evaluate the effects of the different leave policies on individuals' labor market outcomes, intra-household decision-making, and children's human capital. In this section, we briefly explain how each experiment is implemented and discuss the results implied by our calibrated model. In Table 4 we compare the stationary equilibrium under the benchmark model and the different policy scenarios.

### 5.1 Implementation of a maternity leave

The benchmark economy is characterized by a minimum work requirement. In other words, if an individual accepts a job offer, he/she has to provide at least an amount $s$ of time to be able to keep the job. We model the implementation of a (maternity) leave as a reduction of this minimum time requirement. In particular, under this policy scenario, women who accept a wage offer need only provide an amount $s - \tau$ of time to keep the job. The parameter $\tau$ is chosen such that the total amount of

[17] http://www.ecd.org.department/0,2688,en_2649_34819_1_1_1_1_1,00.html

**Table 4** Simulated equilibrium under different policy scenarios

| Statistic | Data | Benchmark | Maternity leave | Maternity and paternity leaves | Paid leave | Mandatory |
|---|---|---|---|---|---|---|
| Marital status of population | | | | | | |
| Married (%) | 73 | 71 | 70 | 70 | 94 | 64 |
| Single (%) | 27 | 28 | 30 | 30 | 6 | 36 |
| Labor supply (% of time period) | | | | | | |
| Single men | | | | | | |
| 20–29 | 33 | 29 | 30 | 28 | 28 | 28 |
| 30–39 | 33 | 34 | 33 | 33 | 34 | 34 |
| Single women | | | | | | |
| 20–29 | 24 | 24 | 23 | 23 | 16 | 19 |
| 30–39 | 25 | 27 | 26 | 26 | 18 | 21 |
| Married men | | | | | | |
| 20–29 | 41 | 37 | 38 | 37 | 33 | 35 |
| 30–39 | 43 | 42 | 42 | 42 | 41 | 48 |
| Married women | | | | | | |
| 20–29 | 19 | 24 | 22 | 22 | 23 | 21 |
| 30–39 | 24 | 25 | 23 | 24 | 31 | 21 |
| Full-time workers/total workers (%) | | | | | | |
| Women | 68 | 66 | 69 | 69 | 58 | 79 |
| Men | 85 | 91 | 90 | 93 | 94 | 93 |

leave is equivalent to 3 months.[18] This policy may help women maintain favorable job matches and avoid the cost of having to search again. Hence, a woman can spend more time with the children and, at the same time, keep her job. This type of policy, or variations of it, has been implemented in many countries, and it clearly treats men and women differently. In the case of married couples, the availability of this leave for women can create an incentive for specialization: Women can still participate in the labor force but, at the same time, they can spend more time with children. Lost income, due to a lower amount of hours spent working, can be made up by the husband who will have an incentive to work more.

This intuition is confirmed by the results of our simulation. In Table 5, we see that married women work less time, on average, and invest slightly more time in their children than in the benchmark economy. In addition, the percentage of women working increases by 2.5% with respect to the benchmark economy (Table 6). The reason is that some women who could not work in the baseline scenario because their optimal amount of work would be below the minimum requirement $s$ can now work given that this requirement has been reduced as a result of the maternity leave.[19] This is associated with increased household income in a sizable fraction of households. At the same time, married men allocate more time to market work (see Table 5) and reduce time investments in children by a small amount (3.9% to 3.8%).

In terms of average human capital accumulation, there is a slight increase with respect to the benchmark model. Average human capital levels are 4% higher once an unpaid maternity leave is introduced (see Table 7). This comes about as a result of increased household income (given that more women work) rather than an increase in total time investments in children. However, the disadvantage of children from divorced or single headed households with respect to their counterparts who grew up in intact households is stronger once the policy is introduced compared to the benchmark economy (see Table 8). For example, children growing up in single-parent households have on average only 30% of the total human capital level of children being raised in two-parent households during both periods of childhood, whereas this fraction was around 32% in the benchmark economy. This is because there is a differential response (both in terms of time investments and employment choices) to the introduction of an unpaid leave policy between two-parent households and single-parent households as we previously discussed. It is important to emphasize that these differential effects by marital status might be overstated by our model given our exogenous fertility assumption. The reason is that in reality, single and divorced women are likely to have fewer children than those who are married, whereas in our model, we assume all women produce two children.

[18] This is exactly the length of the (unpaid) parental leave provided in the United States under the FMLA.

[19] Furthermore, a higher fraction of working married and divorced women work full-time (57.6% of working married women work full-time once the maternity leave is introduced compared to 56% in the benchmark economy) under the policy than in the benchmark economy. This is a result of the way in which part-time and full-time work are measured in our model and the particular way in which the policy is implemented. In particular, we define part-time work to be exactly $s$, the minimum work requirement. Given that a maternity leave is implemented by reducing this minimum requirement to $s - \tau$, the definition of part-time changes in the policy scenario. All the women that work more than $(s - \tau)$ are now counted as full-time workers, and thus, the fraction of full-time workers can increase even if the average amount of working time decreases.

**Table 5** Time allocations and labor market participation decisions under maternity leave *only* and maternity and paternity leave

| | | Maternity leave *only* | | | Maternity *and* paternity leaves | | |
|---|---|---|---|---|---|---|---|
| | | Married | Single | Divorced | Married | Single | Divorced |
| Woman | Market work | 22.7 | 24.5 | 21.6 | 22.86 | 24.52 | 21.7 |
| | Child care | 4.7 | 3.4 | 4 | 4.7 | 3.4 | 4 |
| Man | Market work | 40 | 30.3 | 35.2 | 39.55 | 30.26 | 33 |
| | Child care | 3.8 | – | – | 3.8 | – | – |
| Full time workers/total workers (%) | Woman | 57.6 | 94.9 | 69.3 | 59.6 | 95.3 | 69.3 |
| | Man | 88.2 | 100 | 90.2 | 89.1 | 100 | 98.2 |

**Table 6** Average female labor participation in different experiments relative to benchmark[a]

| Female employment | | |
|---|---|---|
| Maternity leave | Both unpaid | Both paid |
| 1.025 | 1.025 | 1.18 |

[a]Numbers are labor participation rate under policy scenario divided by labor participation rate under benchmark.

In the upper panel of Fig. 1, we compare the distribution of expected income for women by type in the benchmark model with the case in which an unpaid maternity leave is introduced. Although there is not a very marked difference between the two, one can observe that the income distribution with maternity leave first order stochastically dominates the income distribution in the benchmark economy. This kind of policy affects mainly women who choose to work exactly $s$ in the benchmark economy or women who did not work because their optimal labor supply was right below $s$. The introduction of an unpaid leave of length $\tau$ allows them to accept job offers that they would have had to turn down otherwise, and this, in turn, increases household income for a nonnegligible subset of households.

In the lower panel of Fig. 1, we present a similar comparison for females' expected utility by type in the benchmark model and the case of unpaid maternity leave. As can be observed, the distribution of females' expected utility with maternity leave also first order stochastically dominates the distribution in the benchmark economy, which means that women are better off with the policy than without the policy for reasons we discussed above. In particular, women who could not work in the benchmark economy because their optimal labor supply fell right below $s$ can now work. This is associated with increased household income and, thus, an increase in children's human capital investments (even if time investments remain unchanged). Both of these are associated with higher levels of females' utility.

Similar patterns can be observed for men, both in the case of expected income and expected utility distributions. In Fig. 2, we show the distributions of men's expected income and expected utility by type, respectively, under the benchmark economy and under the policy scenario.

The results do not differ significantly when a paternity leave is introduced along with a leave for mothers, i.e., a reduction of the minimal time requirement for men as well (see Table 5). The reason is that most men are already working full-time, and hence, the lower bound is not binding. Thus, lowering $s$ does not change the optimal decision except for a very small percentage of married men, and in the aggregate, results are not very different.

**Table 7** Average human capital levels for different experiments relative to benchmark[a]

| Benchmark | Maternity leave | Both unpaid | Both paid | Mandatory |
|---|---|---|---|---|
| 1 | 1.04 | 1.06 | 1.35 | 1.09 |

[a]Average human capital in policy scenario divided by average human capital in benchmark economy.

**Table 8** Human capital accumulation in different experiments[a]

| | m –> m[b] | m –> d | s –> s |
|---|---|---|---|
| Baseline model | 1 | 0.76 | 0.32 |
| Maternity leave scenario | 1 | 0.76 | 0.30 |
| Unpaid maternity and paternity leave | 1 | 0.76 | 0.30 |
| Paid maternity and paternity leave | 1 | 0.82 | 0.20 |
| Mandated maternity leave | 1 | 0.81 | 0.34 |

[a]Numbers are stock of human capital at beginning of adulthood in each case divided by stock of human capital of children being raised in intact families both periods.
[b] m –> m means intact family (married in both periods); m –> d means divorced household in the second period; s –> s means single-parent household

## 5.2 Introduction of paid benefits

As we have discussed, an unpaid (maternity) leave has differential effects on married and single agents. Indeed, it favors married agents disproportionately more because married women can spend more time with the children without having to suffer a disproportionate loss in income, as their husbands can compensate by working more. Again, this differential effect might be overstated by our model given our exogenous fertility assumption. In addition, both husband and wife can increase labor supply as a result of the policy, thus significantly increasing household income. We have also seen that the introduction of an unpaid leave for men is not very effective in increasing human capital accumulation,as it does not alter significantly the optimal choices of individuals. For this reason, we now turn to the analysis of the case of the introduction of paid benefits for both parents. The leave is financed through taxes and, thus, does not imply a direct cost to employers.

The US family policies (so called family-friendly policies) differ with respect to similar policies in most industrialized countries in that, although they guarantee a 12-week period of leave after childbirth, they do not mandate paid benefits during this time. Heymann et al. (2004) report that out of 168 countries in their study, 163 guaranteed paid leave to women in connection with childbirth. The United States is one of the five countries that do not offer complete or partial compensation during the leave, and together with Australia, the only two industrialized countries in this group.[20] In this section, we assess the effects of introducing paid benefits for mothers and fathers. The availability of paid benefits allows mothers (and fathers if they take a parental leave) to work less and invest more in their children without incurring high costs in terms of foregone income. We assume that leave benefits are financed through general taxation. In particular, all agents pay a fraction *tax* of their labor income, and total tax revenues are used to pay the benefits of those who choose to take a parental leave. As leave provisions may have broader social benefits (as reduced child mortality rate, Phipps et al. (1998)), then it is plausible to assume that these could be publicly provided by the way of labor income taxes or payroll taxes.[21]

[20]A paid family leave insurance program has become effective in California in January 2004, and it provides up to 6 weeks of benefits to individuals who must take time off to care for a seriously ill relative or to bond with a new minor child.

[21]In fact, leave benefits in many countries are actually paid by the Social Security System (see Waldfogel (1997)) and only in very few cases partially by employers.

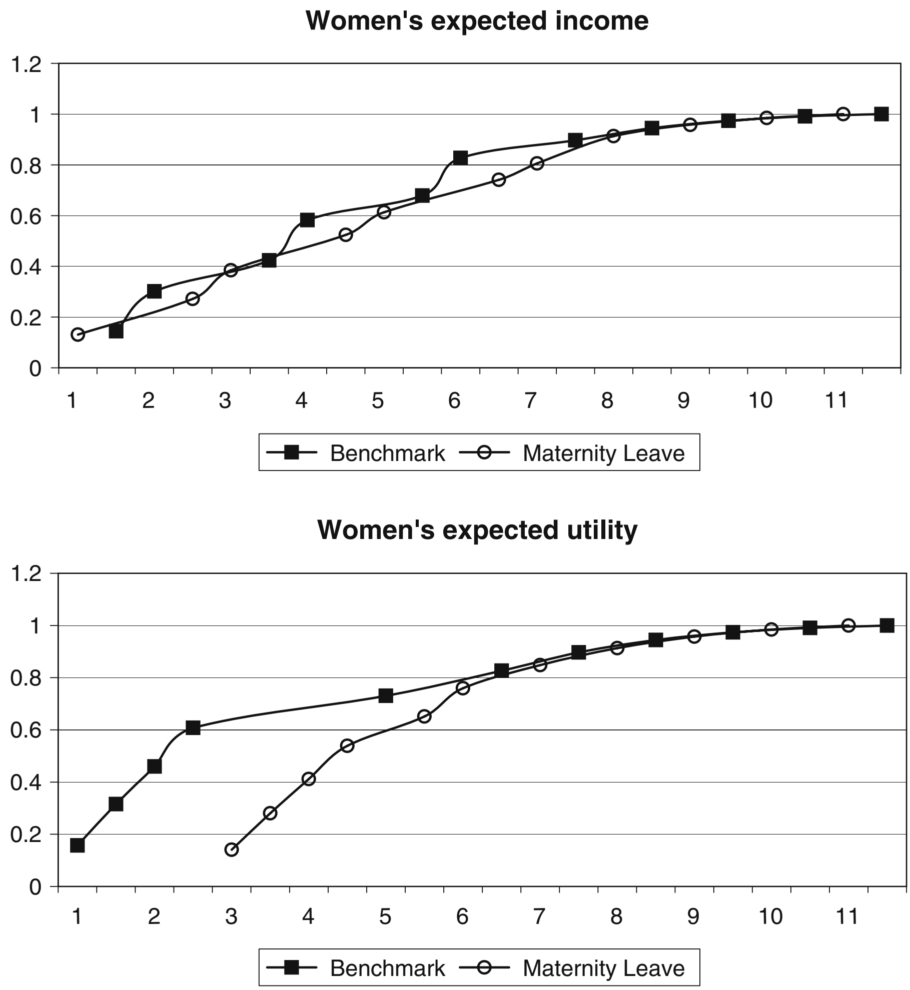


**Fig. 1** Women's expected income and utility in benchmark economy vs introduction of unpaid maternity leave

To illustrate the way in which we implement this particular policy, we layout the decision problem faced by women, in particular, single old women. Given the optimal labor supply of agent $i$ in the benchmark economy, $l^*_{i,B}$, the problem faced by a single old woman is:

$$\begin{aligned} F^s_{2,Oa}(x, l^*_B) &= \max_{l_f,t_f} f(c, h, 1 - l_f - t_f, 0) \\ \text{s.t. } c &= \Omega \cdot \left[\bar{c} + (1-\text{tax}) \cdot w.l_f + \text{ben} \cdot \left[I_\tau \cdot w \cdot (l^*_B - l_f) + (1 - I_\tau) \cdot w \cdot \tau\right]\right] \\ h &= q(t_f, 0, c) \\ l_f &\geqslant s - \tau \end{aligned} \quad (14)$$

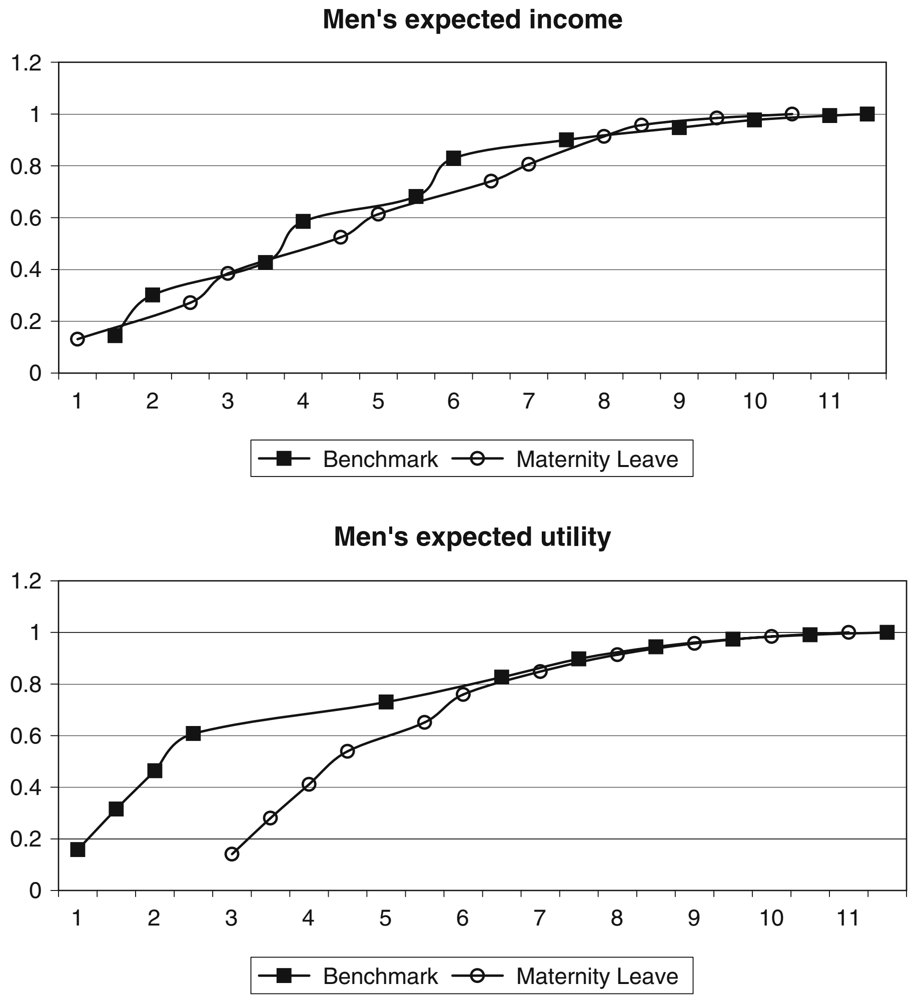


**Fig. 2** Men's expected income and utility in benchmark economy vs introduction of unpaid maternity leave

where ben is the replacement rate (the fraction of total wage that the woman receives during her leave), tax is the labor income tax rate, $\tau$ is the reduction in the minimum time requirement (and represents the availability of a leave), and $I_\tau$ is an indicator function given by:

$$I_\tau = \begin{cases} 1 \text{ if } l_B^* - l_f \leq \tau \\ 0 \text{ if } l_B^* - l_f > \tau \end{cases} \tag{15}$$

This means that we define $l_B^*$ as the upper bound on the work choice of agents who receive paid leave. Thus, the total amount of leave that agent $i$ takes up is the difference between the upper bound (think of it as full-time work) and the agent's work choice given the availability of a paid leave, $l_f$. Note that parental leave is a

**Table 9** Time allocations and labor market participation decisions in the case of introduction of paid leave benefits

| | Married | Single | Divorced |
|---|---|---|---|
| Female time allocation (% total time) | | | |
| Market work | 27.3 | 17.1 | 19.7 |
| Child care | 4.4 | 3.3 | 3.3 |
| Male time allocation (% total time) | | | |
| Market work | 36.8 | 31.1 | 33.4 |
| Child care | 4.5 | – | – |
| Full time workers/total workers (%) | | | |
| Woman | 60.7 | 94.9 | 67.5 |
| Man | 93.7 | 100 | 90.6 |

subsidy on nonmarket activities. However, the allocation of nonwork time between child care and leisure is unobservable by employers and policymakers. Therefore, eligibility for benefits and the total amount of benefits should be determined based upon a choice observable by policymakers, which is the amount of time allocated to market work. If an agent's leave time, defined as the difference between $l^*_B$ and $l_f$, is lower than the maximum amount $\tau$, then benefits (fraction ben of wage) are paid for the entire period. However, if the agent's leave time exceeds $\tau$, then benefits will only be paid up to $\tau$ and the remainder of the leave time will be unpaid.

We set ben $= 0.5$, which means that leave benefits amount to 50% of her/his wage, up to a maximum amount of time equal to $\tau$. Clearly, if ben were equal to 100, then all agents would work exactly $s - \tau$, as they would have the same income as in the benchmark economy but more time for childrearing and leisure. If ben is lower than 100, then agents will face a trade-off: They can work less and spend more time with children and/or have more leisure but at the expense of lower household income. Note, however, that the trade-off will be less strong in this case than in the case of unpaid leave presented in the previous section.

The results of this simulation are presented in Table 9. In terms of average time allocations, married women work more than in the benchmark economy, whereas married men work less and on average devote more time to child care. In addition, 18% more women work in this scenario with respect to the benchmark (Table 6), and there is an increase of about 6% in those that work full time female full-time workers. This implies that the availability of a paid leave has a positive effect on married women's labor market continuity, allowing them to accumulate more working experience.[22] This arises from the fact that intra-household choices can be adjusted in such a way that women can increase market work at no cost in terms of children's human capital given that their husbands can also take advantage of the availability of a paid leave. Note, however, that the same is not true in the case of single or divorced women. These women are using a paid leave to increase their leisure time while reducing market work at the expense of investments in

[22] Although not explicitly allowed in our model, one could easily think of an extension of our benchmark economy in which cumulative work experience during the first period of adulthood determines the individual's productivity type and, hence, wages during the second period of adulthood.

children's human capital. Child-care time is practically unchanged with respect to the benchmark economy in the case of single mothers (3.4% in the benchmark economy vs 3.3% in the case of paid parental leave) and reduced in the case of divorced women (4% in the benchmark vs 3.3% in the case of paid leave).

In terms of human capital accumulation, we observe in Table 7 that average human capital levels are significantly larger than in the benchmark model. In particular, average human capital is 35% higher. In addition, the disadvantage of children who suffered a parental divorce during childhood is significantly mitigated with the introduction of the policy. As can be observed in Table 8, although these children accumulated only 76% of the average human capital levels of children being raised in two-parent households in the benchmark economy, this fraction increases to 82% once paid benefits are available for both parents. Note, however, that the opposite happens in the case of children being raised in single-parent households during both periods of childhood (average human capital is 20% of that of children raised in two-parent households compared to 32% in the benchmark economy). This is due to the fact that single-parent households benefit less from the policy given that there are no gains from intra-household redistribution of tasks. In particular, note that the increase in children's human capital in two-parent households is due to both (1) increased total time investments by parents from 8.5% of time to 8.9% of time and (2) increased household income due to received benefits by leave takers and higher female labor supply. On the other hand, single parents increase their leisure time as a result of the availability of benefits at the expense of time investments in children. This result must be interpreted with caution, as in reality, single women tend to have less children than married women, whereas in our model, we assume that both have the same number of children.

All in all, women's expected income and utility (by type) is higher in this case than in the benchmark economy as can be observed in Fig. 3. This is the result of increased household income and increased children's human capital in the case of married couples and, mostly, due to increased leisure time at no monetary cost in the case of single and divorced mothers.

Something different happens in the case of men (Fig. 4). As can be observed, the distribution of income (and utility) in the benchmark economy seems to be less disperse than the distribution of income (and utility) in the case of paid parental leave.[23] This is the result of the fact that married men and single/divorced men face different incentives under the implementation of a parental leave. In particular, married men and divorced/single men make very different choices because divorced men cannot choose to make time investments in their children. Thus, the presence of a parental leave policy exacerbates these differences in the sense that although single and divorced men have to pay social security taxes, they cannot accrue any of the benefits associated with the presence of a paid leave, as they do not make time investments in children. That means that the availability of this policy generates more dispersion among unmarried men, and this leads to a less favorable distribution of income.

[23] In other words, the income distribution in the benchmark economy second order stochastically dominates the income distribution under the policy.

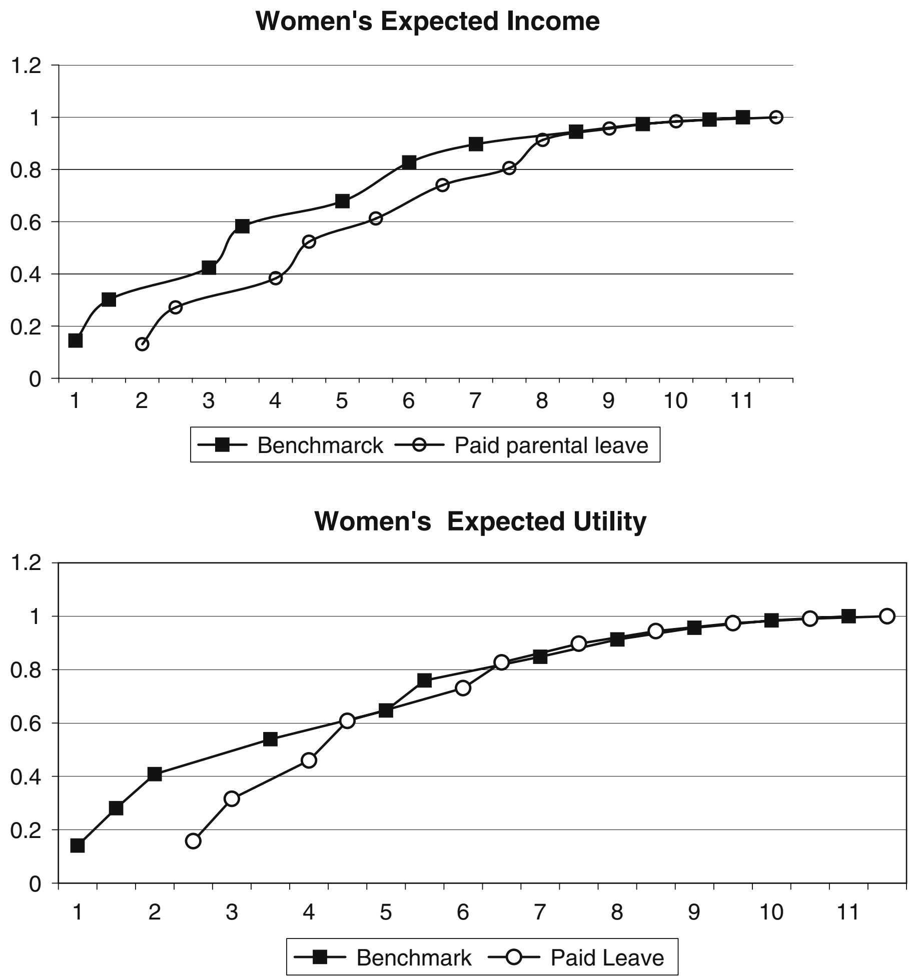


**Fig. 3** Women's expected income and utility in benchmark economy vs introduction of paid parental leave benefits

## 5.3 Mandated parental leave

Mandated leave policies for mothers are present in several European countries. In this section, we present the results obtained from the enactment of a policy that limits the amount of time that agents can work. Clearly, the policymaker cannot enforce a policy that alters the amount of time that parents spend with their children but can force a reduction in the amount of time that workers are allowed to work. Thus, we assume that, given the optimal choices in the benchmark equilibrium, individuals now have to reduce the amount of time spent working by a given amount, which represents the mandated leave. Hence, the main difference with the previous policy experiment is that, in this case, agents are not free to choose how much time to take off of work but are forced to take up the whole length of the leave. We also

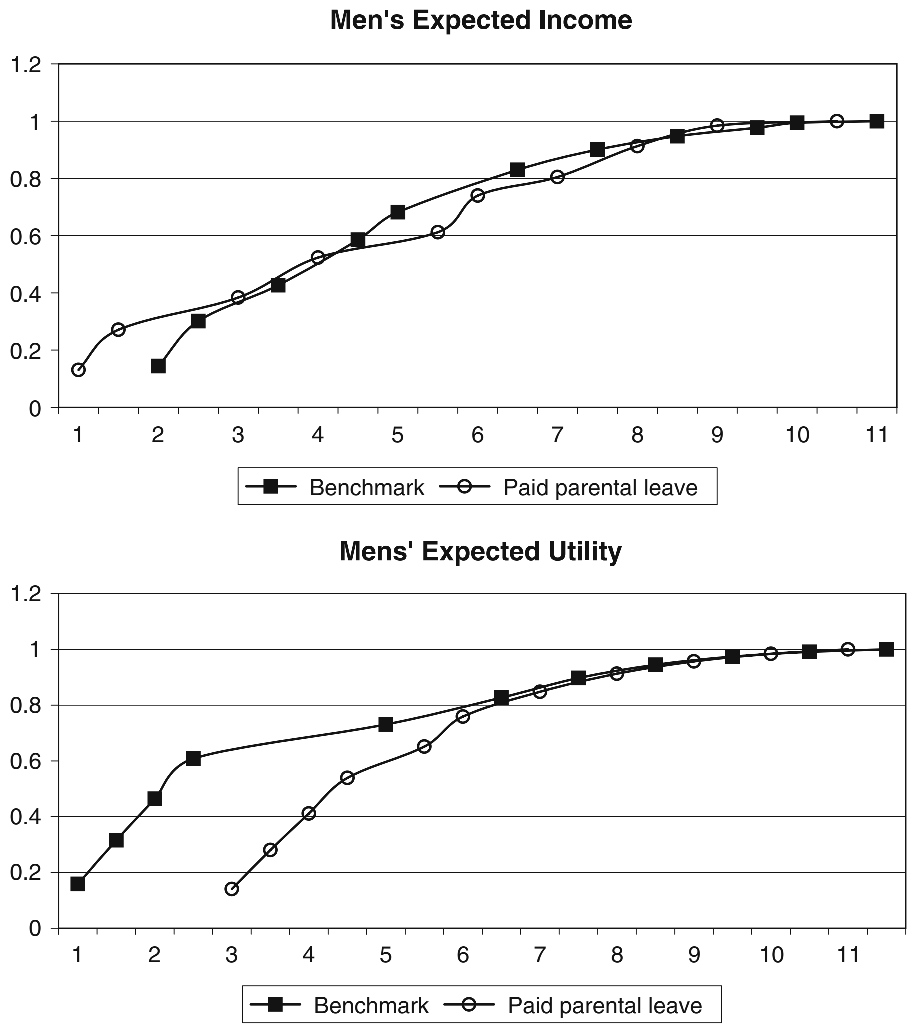


**Fig. 4** Men's expected income and utility in benchmark economy vs introduction of paid parental leave benefits

assume that the leave is paid. To illustrate the way in which we implement this particular policy, as we did before, we layout the decision problem faced by single old women. Given the optimal labor supply of agent $i$ in the benchmark economy, $l^*_{i,B}$, the problem faced by a single old woman is:

$$F^s_{2,Oa}(x, l^*_B) = \max_{t_f} f(c, h, 1 - \left(l^*_B - \tau\right) - t_f, 0)$$
$$\text{s.t. } c = \Omega \cdot \left[\bar{c} + (1 - \text{tax}) \cdot w \cdot \left(l^*_B - \tau\right) + \text{ben} \cdot [w \cdot \tau]\right]$$
$$h = q(t_f, 0, c) \tag{16}$$

where ben is the replacement rate (the fraction of total wage that the individual receives during her leave), tax is the labor income tax rate, and $\tau$ is the length of the mandated leave.

By construction, agents spend on average a smaller fraction of their time working (see Table 10) once a mandated leave is introduced. As a result, there is an increase in parents' time investments in children, which are nonetheless lower than the length of the mandated leave. This implies that parents use part of the leave to increase their leisure time. Under this policy, we observe an increase in the average human capital of children with respect to the benchmark economy of around 9% (see Table 7), due mainly to the increase in time that parents devote to child care. Agents' income is reduced, given the restrictions to the amount of labor supply that is only partially compensated by the benefits. In terms of utility, there is no clear dominance of one distribution over the other. For low-type women, the utility is higher under this policy experiment, but for higher types, the utility is higher in the benchmark. For men, the expected utility is lower under the mandatory leave for low types. However, the distributions then cross twice.

### 5.4 Sensitivity of the policy simulations

In this section, we discuss the results obtained from running some additional experiments to assess the sensitivity of the results to perturbations of the policy. In particular, we assess changes in several outcomes in the model with respect to the paid benefits case presented in Section 5.2 in the following cases: (1) an increase of 50% in the length of the paid leave, i.e., an increase in $\tau$; that implies that the total period of paid parental leave increases from 3 to 6 months, which might be in line with recent changes in European countries; and (2) an increase of 20 percentage points in the rate of replacement, i.e., the percentage of salary that is paid during the parental leave (keeping the length of the leave constant). That means that the replacement rate changes from 50 to 70% (of the salary). In Fig. 5, we show the expected utility for men and women in the different cases.

Both these policy changes are supposed to encourage an increase in take up of parental leave and both imply an increase in household income. However, as they are implemented in different ways, they have very different consequences. On one hand, by increasing the amount of paid benefits received by the agent during the same

**Table 10** Time allocations and labor market participation decisions in the case of mandated maternity leave

| | Married | Single | Divorced |
|---|---|---|---|
| Female time allocation (% total time) | | | |
| Market work | 20.6 | 19.8 | 18.6 |
| Child care | 4.8 | 3.5 | 4.1 |
| Male time allocation (% total time) | | | |
| Market work | 35.7 | 30.8 | 32.7 |
| Child care | 4.0 | – | – |
| Full time workers/total workers (%) | | | |
| Woman | 72 | 92.6 | 78.1 |
| Man | 92.9 | 100 | 95.2 |

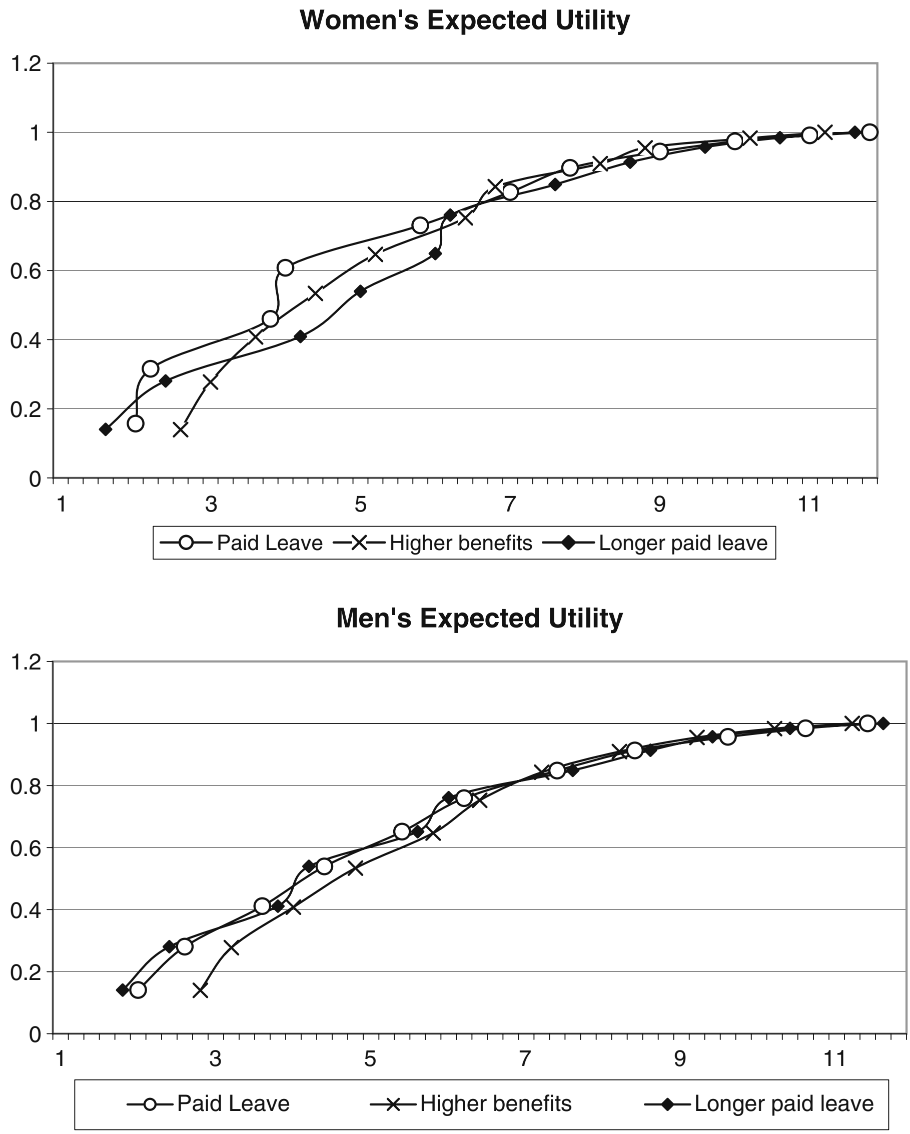


**Fig. 5** Expected utility with longer parental leave and higher paid benefits

length of parental leave, policy 2 changes the opportunity cost of taking up a leave by reducing foregone earnings. On the other hand, policy 1 changes the incentives to take up a parental leave for people in the margin by increasing the length of the leave but keeping the replacement rate constant; that is, there will be some people who would have not been able to work at leave policy $\tau$ but can now work at new $\tau'$ because the maximum utility attained by working $s - \tau'$ is higher than not working whereas that was not the case when the minimum work requirement was set at $s - \tau$. That means that the effects of this policy change are not expected to work through increased household income but rather through the changing behavior of people in the margin.

The results indicate that, in the case of higher paid benefits (keeping the length of the leave constant), there is an improvement in low-type females' welfare albeit a slight reduction in high-type females' expected utility. This is due to the fact that the change in policy does achieve an increase in average human capital (with respect to the paid leave scenario in Section 5.2) associated to both, increased child-care time, and increased household income. However, this comes at the cost of increased taxes, which seems to be more detrimental for agents in the upper tail of the distribution.

On the other hand, an increase in the length of the paid parental leave (keeping the replacement rate constant) has a very small effect on the expected utility of men and a significant effect on women's expected utility. This comes about as a result of a slight increase in average human capital that does not compensate for males' increase in labor supply and the reduction of household income, both of which are associated to the fact that women take up longer periods of parental leave under the new policy (not all of which is translated into increased child-care time).

It is worth emphasizing, at this point, that a policy like 1, i.e., an increase in the length of the leave, would tend to benefit married couples more because they can adjust intra-household allocations to offset potential household income reductions associated to extended periods of parental leave by one or both members of the couple. For example, one of the members can increase labor supply to compensate for an increase in child-care time by the other member. On the other hand, an increase in the replacement rate, i.e., the fraction of wages paid during the parental leave, can also have beneficial effects on single-headed households that cannot take advantage of intra-household reallocations. In addition, the consequences associated to these policies will also depend upon whether the constraint that prevents an agent from taking up longer periods of leave and/or working more is associated to current household income or the need to hang on to a given job.

## 6 Conclusions

In this paper, we calibrate and simulate a general equilibrium model of marriage and divorce (in the spirit of Aiyagari et al. 2000 and Greenwood et al. 2003) to assess how public policies on maternity and paternity leave and leave benefits affect parental investments in children's human capital, intra-household time allocation decisions, and the distribution of income. In particular, we extend the general equilibrium model of marriage and divorce developed by Aiyagari et al. (2000) by introducing frictions into the labor market. An (unpaid) parental leave policy is desirable if it allows one or both parents to take an extended period away from their employer without losing rights to claim the job. Thus, to capture the value of a leave policy, one needs a framework with some type of labor market friction. We model a labor market in which individuals face a constant probability $\lambda$ of receiving a job offer in a given time period, and the wage offer is a deterministic function of the individual's productivity. If an individual does not receive an offer or receives an offer but chooses to decline it, then in the following period, she/he will remain unemployed with probability $(1 - \lambda)$. An important element of our model is that, to participate in the labor market upon receiving an offer, an individual has to commit to a minimum amount of time in the workplace. The presence of this constraint implies that, for example, agents might be induced to reject wage offers that would optimally lead to low labor supply (lower than the minimal labor supply requirement) and high amount of time with children.

In this context, a parental leave is modeled as a reduction in the minimal time required for an individual to keep a job. Thus, an individual who was not willing to take a job at the initial minimal time requirement might accept it if this time is reduced due to the parental leave policy. The labor market thus modeled exhibits a clear mechanism that allows employees to hang on to job offers they would otherwise have to give up if they spent more time in the household. In this sense, it captures the key role of a parental leave policy: It reduces the cost of participating in the market, in terms of the time available for leisure and child care. We use this model to simulate the effects of several parental leave policies, including the introduction of an unpaid maternity leave, the introduction of paid parental leave benefits, and the implementation of a mandatory leave on agents' labor market outcomes, intra-household time allocation decisions, parental time investments in children, the production of children's human capital, and the distribution of income.

We first calibrate our benchmark model to fit certain features of the data, and in particular, some characteristics relevant to the interaction between the marriage and labor markets. We parameterize the model to match the following moments: marital status of the population, life-cycle pattern of labor supply, and composition of the labor force between full-time and part-time workers. The calibrated benchmark model performs quite well in these three dimensions.

We use our model to examine the effects of three different types of parental leave policies. First, we examine the case of maternity leave only. We then discuss how the results change when fathers are also allowed to take a parental leave. Second, we look at paid parental leave. Finally, we discuss a possible the implementation of a mandated leave in our model. We evaluate the effects of the different leave policies on individuals' labor market outcomes, intra-household decision making, and children's human capital.

The results indicate that the introduction of an unpaid maternity leave is associated with an improvement in the income and utility distributions due primarily to changes in household income induced by an increase in the fraction of working women as well as an increase in the proportion of working married men that work full-time. This happens because women who could not work in the benchmark economy, as their optimal labor supply fell below $s$, can now work given that the introduction of a maternity leave reduces the minimal time requirement from $s$ to $s - \tau$. In addition, there is a modest increase in average human capital of 4% with respect to the benchmark economy completely associated with an increase in household income, as total parental time investments in children remain unchanged. However, the disadvantage of children from divorced or single-headed households, with respect to their counterparts who grew up in intact households in terms of human capital accumulation, is stronger once the policy is introduced compared to the benchmark economy. This is because most of the gains from the policy are derived from changes in intra-household time allocations between husbands and wives, so the extent to which the policy can affect single mothers is considerably lower. It is important to emphasize that these differential effects by marital status might be overstated by our model given our exogenous fertility assumption. The reason is that, in reality, single and divorced women are likely to have fewer children than those who are married, whereas in our model, we assume all women produce two children.

We then assess the effect of introducing paid benefits for both mothers and fathers who take a parental leave. In particular, we calculate the length of the leave as the difference between the optimal labor supply choice in the benchmark economy and the agent's work choice, given the availability of a paid leave, and calculate the paid benefits based upon this amount of time. Note that a paid parental leave is a subsidy of nonmarket activities. However, the allocation of nonwork time between child care and leisure is unobservable by employers and policymakers. Therefore, eligibility for benefits and the total amount of benefits should be determined based upon an observable choice by policymakers, which is the amount of time allocated to market work.

The results of this simulation indicate that expected income and expected utility of women are both higher under this policy scenario than in the benchmark model. This is the result of increased household income and increased children's human capital in the case of married couples and mostly due to increased leisure time at no monetary cost in the case of single and divorced mothers. Household income increases because a higher fraction of women work than in the benchmark economy, the average amount of working hours increases as well, and because of the availability of parental leave benefits. Children's human capital increases as a consequence of both, higher household income and higher parental time investments in children. In addition, the disadvantage of children who suffered a parental divorce during childhood is significantly mitigated with the introduction of the policy. In particular, although these children accumulated only 76% of the average human capital levels of children being raised in two-parent households in the benchmark economy, this fraction increases to 82% once paid benefits are available for both parents. However, the opposite happens in the case of children being raised in single-parent households during both periods of childhood (average human capital is 20% of that of children raised in two-parent households compared to 32% in the benchmark economy). This is due to the fact that single-parent households benefit less from the policy given that there are no gains from intra-household redistribution of tasks.

The availability of paid leave leads to a less favorable distribution of income in the case of men. This is the result of the fact that married men and single/divorced men face different incentives under the implementation of a parental leave. In particular, married men and divorced/single men make very different choices because divorced men cannot choose to make time investments in their children. Thus, the presence of a parental leave policy exacerbates these differences in the sense that, although single and divorced men have to pay social security taxes, they cannot accrue any of the benefits associated with the presence of a paid leave, as they do not make time investments in children.

Finally, we assess the effects of implementing a mandated leave. In particular, we do this by limiting the amount of time agents can work. Thus, we simply assume that, given the optimal choices in the benchmark equilibrium, individuals have to reduce the amount of time spent at work by a given amount, which represents the mandated leave. The main difference with the previous policy other two policy experiments is that, in this case, agents are not free to choose how much time to take off of work but are forced to take up the whole length of the leave. The agents then decide how to distribute this leave between child care and leisure. We assume that they receive paid benefits during the leave. The results indicate that parents use part of their freed time to increase time investments in children. As a consequence, average human capital increases by as much as 9% with respect to the benchmark economy.

## Appendix

## 7 Decision-making process

### 7.1 Single agents

*Single old women who did not work in period 1* In the beginning of the second period of adulthood, a single woman who did not work in the previous period receives a job offer with probability $\lambda$. If she does, she has to decide whether to accept it (which implies she has to supply at least $s$ units of work) or not, how much to work ($l_f$) if she does, how much time to devote to child care ($t_f$), and hence, the optimal amount of leisure, to maximize her utility subject to the constraints. That means that she will compare the maximum utility that arises from participating in the labor market with the maximum utility she derives if she does not. The former is given by:[24]

$$\begin{aligned} F^{\mathrm{s}}_{2,\mathrm{O}a}(x) &= \max_{l_f,t_f} f(c,h,1-l_f-t_f,0) \\ \text{s.t. } c &= \Omega(p)\left[\bar{c}+w(x).l_f\right] \\ h &= q(t_f,0,c) \\ l_f &\geqslant s \end{aligned} \tag{17}$$

where $w(x)$ is her wage given her productivity type $x$ and $\bar{c}$ is nonlabor income, which is equivalent to Eq. (8). The maximum utility from nonparticipation is given by:

$$\begin{aligned} F^{\mathrm{s}}_{2,\mathrm{O}b}(x) &= \max_{t_f} f(c,h,1-t_f,0) \\ \text{s.t. } c &= \Omega(p).\bar{c} \\ h &= q(t_f,0,c) \end{aligned} \tag{18}$$

The maximum utility of a single old woman who does not work in period 1 will depend on whether she receives an offer or not; that is, it can be defined as

$$\begin{aligned} F^{\mathrm{s}}_{2,\mathrm{O}}(x) &= \max\{F^{\mathrm{s}}_{2,\mathrm{O}a}(x), F^{\mathrm{s}}_{2,\mathrm{O}b}(x)\} && \text{if she receives an offer} \\ F^{\mathrm{s}}_{2,\mathrm{N}}(x) &= F^{\mathrm{s}}_{2,\mathrm{O}b}(x) && \text{if she does not receive an offer} \end{aligned} \tag{19}$$

[24]Lower case superscripts, s, m, and d, indicate the woman's marital status (single, married or divorced); upper case subscripts, O and N, indicate whether she receives a job offer or not in the current period, respectively.

Hence, the expected utility of a single old woman who did not work in period 1 is given by:[25]

$$F^{\mathrm{s}}_{2,\mathrm{n}}(x) = \lambda F^{\mathrm{s}}_{2,\mathrm{O}}(x) + (1-\lambda) F^{\mathrm{s}}_{2,\mathrm{N}}(x) \tag{20}$$

Let $L^{\mathrm{s}}_{f,2,\mathrm{n}}$ be the optimal amount of time that a single old woman devotes to work (if she did not work in period 1) and $T^{\mathrm{s}}_{f,2,\mathrm{n}}$ be the optimal amount of time that the single old mother devotes to her children (if she did not work in period 1).

*Single old women who worked in period 1* In the beginning of the second period of adulthood, a single woman who worked in the first period of adulthood has access to a job with probability one. Hence, she faces the same problem as a woman who did not work in period 1 but receives a job offer in period 2. That means that she solves Eq. 17, and if her optimal labor supply is less than $s$ she then compares the utility derived from working exactly $s$ units of time with the utility of not working at all (i.e., Eq. 18). Thus, the maximum utility of a single old woman who worked in period 1, $F^{\mathrm{s}}_{2,\mathrm{w}}(x)$, is given by:

$$F^{\mathrm{s}}_{2,\mathrm{w}}(x) = F^{\mathrm{s}}_{2,\mathrm{O}}(x) \tag{21}$$

Let $L^{\mathrm{s}}_{f,2,\mathrm{w}}$ be the optimal amount of time that a single old woman devotes to work (if she worked in period 1) and $T^{\mathrm{s}}_{f,2,\mathrm{w}}$ be the optimal amount of time that the single old mother devotes to her children (if she worked in period 1).

*Divorced old women* The decision-making process of divorced old women is basically the same faced by single old women except for the fact that divorced women receive child support payments from their ex-husbands. That means that the budget constraint in Eqs. 17 and 18 now includes this additional transfer that corresponds to a percentage $a$ of the ex-husband's labor earnings: $a.w(z).L^{\mathrm{d}}_{m}$, where $w(z)$ is her ex-husband's wage given his type $z$, and $L^{d}_{m}$ corresponds to his optimal labor supply in period 2. We define $F^{\mathrm{d}}_{2,\mathrm{n}}(x)$ to be the maximum utility attained by a divorced old woman if she did not work in period 1 and $F^{\mathrm{d}}_{2,\mathrm{w}}(x)$ if she worked in period 1.

The decision-making process of unmarried men in period 2 is similar to that of unmarried women except for the fact that old single men do not have children and, hence, do not have to make time investment decisions in children, whereas divorced men do not make time investments in children but must pay child support to their ex-wives. We define the maximum utility of single old men and divorced old men who worked in period 1 to be $M^{\mathrm{s}}_{2,\mathrm{w}}$ and $M^{\mathrm{d}}_{2,\mathrm{w}}$, respectively, and $M^{\mathrm{s}}_{2,\mathrm{n}}$ and $M^{\mathrm{d}}_{2,\mathrm{n}}$ in case they did not work in period 1.

*Single young women* Finally, we now briefly review the decision-making process facing a single young woman. If she does not receive a job offer (N) in period 1, which

[25] Lower case subscripts, n and w, indicate the woman's labor market choice in period 1 (did not work and worked, respectively); as before, upper case superscripts, O and N, indicate whether in the current period she received an offer or not, respectively.

happens with probability $1 - \lambda$, she only chooses how to split her time between child care and leisure to maximize:

$$F^{s}_{1,N}(x_i) = \max_{t_f} \left[ f(c, h, 1 - t_f, 0) + \beta \sum_{j=1}^{K} F^{s}_{2,n}(x_j) X(x_j | x_i) \right]$$
$$\text{s.t. } c = \Omega(p)\overline{c}$$
$$h = q(t_f, 0, c) \tag{22}$$

where $F^{s}_{2,n}(x_j)$ is the maximum utility of a single old woman who did not work in period 1 (previously defined), $x_i$ is the woman's productivity type in period 1, $X(x_j|x_i)$ is the transition function according to which female productivity evolves from period 1 to period 2, $K$ is the total number of female productivity types, and $\beta$ is the discount factor.

If the woman receives an offer (O) in period 1, then she has to decide whether to accept the offer or not, how much to work ($l_f$) if she does, how much time to invest in her children ($t_f$), and how much leisure she wants to enjoy to maximize her utility subject to the constraints. If she accepts the job offer, her utility will be given by:

$$F^{s}_{1,Oa}(x_i) = \max_{l_f, t_f} \left[ f(c, h, 1 - l_f - t_f, 0) + \beta \sum_{j=1}^{K} F^{s}_{2,w}(x_j) X(x_j | x_i) \right]$$
$$\text{s.t. } c = \Omega(p) \left[ \overline{c} + w(x_i).l_f \right]$$
$$h = q(t_f, 0, c)$$
$$l_f \geqslant s \tag{23}$$

where $F^{s}_{2,w}(x_j)$ is the maximum utility of a single old woman who worked in period 1 (previously defined) and $\beta \sum_{j=1}^{K} F^{s}_{2,w}(x_j) X(x_j|x_i)$ is the continuation value given that she will have a job offer in period 2 with probability one. If she does not accept the offer, the problem is equivalent to Eq. 22. Consequently, the value function of a single young woman who received an offer is given by:

$$F^{s}_{1,O}(x_i) = \max\{F^{s}_{1,Oa}(x_i), F^{s}_{1,N}(x_i)\} \tag{24}$$

Finally, the unconditional value function of single young women is given by:

$$F^{s}_{1}(x_i) = \lambda F^{s}_{1,O}(x_i) + (1 - \lambda) F^{s}_{1,N}(x_i) \tag{25}$$

Let $L^{s}_{f,1}$ be the optimal amount of work supplied by single young woman and $T^{s}_{f,1}$ the optimal amount of time that single young mothers devote to children. Note that the decision-making process of unmarried men in period 1 is similar to that of unmarried women except for the fact that young single men do not have children and, hence, do not have to make time investment decisions in children. We define the unconditional value function of single young men as $M^{s}_{1}(z_i)$.

### 7.2 Married agents

*Old married couples* The problem solved by married couples will depend upon the arrival rate of job offers and on current labor supply choices of both husband and wife. We can classify the different maximization problems facing married couples into four cases. The first one corresponds to the case in which both spouses participate in the labor market, the second and third correspond to cases in which either the husband or the wife does not participate in the labor market, and finally, the fourth corresponds to the case in which neither husband nor wife choose to participate:

Case 1: Both, husband and wife, participate in the labor market

$$
\begin{aligned}
F_{2a}^{\mathrm{m}} &= \max_{l_f, t_f} f(c, h, 1 - l_f - t_f, \gamma) \\
\text{s.t.} \quad c &= \Omega(p)\left[\bar{c} + y\left(l_f, L_m(x, z); x, z\right)\right] \\
h &= (t_f + T_m)^{\alpha} c^{1-\alpha} \\
l_f &\geq s \\
\\
M_{2a}^{\mathrm{m}} &= \max_{l_m, t_m} m(c, h, 1 - l_m - t_m, \gamma) \\
\text{s.t.} \quad c &= \Omega(p)\bar{c} + y\left(L_f(x, z), l_m; x, z\right) \\
h &= (t_m + T_f)^{\alpha} c^{1-\alpha} \\
l_m &\geq s
\end{aligned} \tag{26}
$$

where $L_i$ and $T_i$ are, respectively, the optimal amounts of time devoted to work and child care by agent $i$, which are taken as given by the spouse.

Case 2: Husband participates in the labor market but wife does not

$$
\begin{aligned}
F_{2b}^{\mathrm{m}} &= \max_{t_f} f(c, h, 1 - t_f, \gamma) \\
\text{s.t.}\ c &= \Omega(p)\left[\bar{c} + y\left(L_m(x, z), 0; x, z\right)\right] \\
h &= (t_f + T_m)^{\alpha} c^{1-\alpha} \\
\\
M_{2b}^{\mathrm{m}} &= \max_{l_m, t_m} m(c, h, 1 - l_m - t_m, \gamma) \\
\text{s.t.}\ c &= \Omega(p)\left[\bar{c} + y\left(0, l_m; x, z\right)\right] \\
h &= (t_m + T_f)^{\alpha} c^{1-\alpha} \\
l_m &\geq s
\end{aligned} \tag{27}
$$

Case 3: Wife participates in the labor market but husband does not

$$
\begin{aligned}
F_{2c}^{\mathrm{m}} &= \max_{l_f, t_f} f(c, h, 1 - l_f - t_f, \gamma) \\
\text{s.t.} \quad c &= \Omega(p)\left[\bar{c} + y\left(l_f, 0; x, z\right)\right] \\
h &= (t_f + T_m)^{\alpha} c^{1-\alpha} \\
l_f &\geq s \\
\\
M_{2c}^{\mathrm{m}} &= \max_{t_m} m(c, h, 1 - t_m, \gamma) \\
\text{s.t.} \quad c &= \Omega(p)\left[\bar{c} + y\left(L_f(x, z), 0; x, z\right)\right] \\
h &= (t_m + T_f)^{\alpha} c^{1-\alpha}
\end{aligned} \tag{28}
$$

Case 4: Neither husband nor wife participate in the labor market

$$\begin{aligned} F^{\mathrm{m}}_{2d} &= \max\nolimits_{t_f} f(c, h, 1 - t_f, \gamma) \\ \text{s.t.} \quad c &= \Omega(p)\,[\overline{c}] \\ h &= (t_f + T_m)^{\alpha} c^{1-\alpha} \\ \\ M^{\mathrm{m}}_{2d} &= \max\nolimits_{t_m} m(c, h, 1 - t_m, \gamma) \\ \text{s.t.} \quad c &= \Omega(p)\,[\overline{c}] \\ h &= (t_m + T_f)^{\alpha} c^{1-\alpha} \end{aligned} \tag{29}$$

To be able to write the value function for an old married woman, one must take into account that her choices will depend on whether or not she receives a job offer and also on whether or not her husband receives one. This will, in turn, depend upon the couples' choices during the first period of adulthood. Thus, it is useful to define the following four functions conditional on each of the possible states at the beginning of period 2 (i.e., whether or not the wife receives a job offer and whether or not her husband does):[26]

$$\begin{aligned} F^{\mathrm{m}}_{2,\mathrm{OO}} &= \max\left\{F^{\mathrm{m}}_{2a}, F^{\mathrm{m}}_{2b}, F^{\mathrm{m}}_{2c}, F^{\mathrm{m}}_{2d}\right\} \\ F^{\mathrm{m}}_{2,\mathrm{ON}} &= \max\left\{F^{\mathrm{m}}_{2c}, F^{\mathrm{m}}_{2d}\right\} \\ F^{\mathrm{m}}_{2,\mathrm{NO}} &= \max\left\{F^{\mathrm{m}}_{2b}, F^{\mathrm{m}}_{2d}\right\} \\ F^{\mathrm{m}}_{2,\mathrm{NN}} &= F^{\mathrm{m}}_{2d} \end{aligned} \tag{30}$$

where $F^{\mathrm{m}}_{2a}$, $F^{\mathrm{m}}_{2b}$, $F^{\mathrm{m}}_{2c}$, and $F^{\mathrm{m}}_{2d}$ are defined by Eqs. 26, 27, and 28, respectively.

Note that the probability that an individual receives a job offer during the second period of adulthood depends upon the first-period labor supply decision. For example, if both spouses worked during the first period, then they will have a job offer with probability one during the second period. However, if a woman's husband did not work in period 1 (either because he did not receive an offer or because at the wage offer it was not optimal to supply more than $s$ units of work), then with probability $\lambda$, they will both have a job offer in period 2, and with probability $(1-\lambda)$, only the woman will receive one. Hence, we can define the value functions for married old women in each case to be:

$$\begin{aligned} F^{\mathrm{m}}_{2,\mathrm{ww}} &= F^{\mathrm{m}}_{2,\mathrm{OO}} \\ F^{\mathrm{m}}_{2,\mathrm{nw}} &= \lambda.F^{\mathrm{m}}_{2,\mathrm{OO}} + (1-\lambda).F^{\mathrm{m}}_{2,\mathrm{NO}} \\ F^{\mathrm{m}}_{2,\mathrm{wn}} &= \lambda.F^{\mathrm{m}}_{2,\mathrm{OO}} + (1-\lambda).F^{\mathrm{m}}_{2,\mathrm{ON}} \\ F^{\mathrm{m}}_{2,\mathrm{nn}} &= \lambda^2 F^{\mathrm{m}}_{2,\mathrm{OO}} + \lambda(1-\lambda)\left[F^{\mathrm{m}}_{2,\mathrm{NO}} + F^{\mathrm{m}}_{2,\mathrm{ON}}\right] + (1-\lambda)^2 F^{\mathrm{m}}_{2\mathrm{NN}} \end{aligned} \tag{31}$$

where lower case subscripts indicate the couples' labor market history (where the first letter corresponds to the wife's first-period labor supply choice and the second

[26] Recall that capitalized subscripts refer to whether or not the individual receives a job offer in the current period (O and N), respectively, numerical subscripts indicate the time period and lower case superscripts indicate the marital status of the individual (e.g., m stands for married in this case).

corresponds to the husband's choice), e.g., ww indicates that both spouses worked during the first period of adulthood; numerical subscripts indicate the time period and superscripts corresponds to the individual's marital status (e.g., m corresponds to married).

Similarly, we can find the value functions for old married men by defining the symmetric problems 30 and 31.

Given the value functions for old divorced agents defined by Eqs. 17 and 18, we can then define the matching decision rules of old agents.

In the case in which both members of the couple worked in period 1:[27]

$$I_{2,\mathrm{ww}}(x,z,\gamma)=\begin{cases}1 & \text{if} \quad \sum_{h=1}^{G}\Gamma(\gamma_h)M^{\mathrm{m}}_{2,\mathrm{ww}}(x,z,\gamma_h)\geqslant M^{d}_{2,w}(z)\\ 0 & \text{otherwise}\end{cases} \tag{32}$$

$$J_{2,\mathrm{ww}}(x,z,\gamma)=\begin{cases}1 & \text{if} \quad \sum_{h=1}^{G}\Gamma(\gamma_h)M^{\mathrm{m}}_{2,\mathrm{ww}}(x,z,\gamma_h)\geqslant M^{\mathrm{d}}_{2,\mathrm{w}}(z)\\ 0 & \text{otherwise}\end{cases}$$

where $F^{\mathrm{m}}_{2,\mathrm{ww}}$ ($M^{\mathrm{m}}_{2,\mathrm{ww}}$) is the maximum utility of a married old woman (man) who worked in period 1 and is married to a man (woman) who also worked in period 1, and $F^{\mathrm{d}}_{2,\mathrm{w}}$ ($M^{\mathrm{d}}_{2,\mathrm{w}}$) is the maximum utility attained by a divorced old woman (man) who worked in period 1.

In the case in which the wife did not work in period 1 but the husband did:

$$I_{2,\mathrm{nw}}(x,z,\gamma)=\begin{cases}1 & \text{if} \quad \sum_{h=1}^{w}\Gamma(\gamma_h)M^{\mathrm{m}}_{2,\mathrm{nw}}(x,z,\gamma_h)\geqslant M^{\mathrm{d}}_{2,\mathrm{w}}(z)\\ 0 & \text{otherwise}\end{cases} \tag{33}$$

and

$$J_{2,\mathrm{nw}}(x,z,\gamma)=\begin{cases}1 & \text{if} \quad \sum_{h=1}^{w}\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{nw}}(x,z,\gamma_h)\geqslant F^{\mathrm{d}}_{2,\mathrm{n}}(x)\\ 0 & \text{otherwise}\end{cases} \tag{34}$$

In the case in which the wife worked in period 1 but the husband did not:

$$I_{2,\mathrm{wn}}(x,z,\gamma)=\begin{cases}1 & \text{if} \quad \sum_{h=1}^{w}\Gamma(\gamma_h)M^{\mathrm{m}}_{2,\mathrm{wn}}(x,z,\gamma_h)\geqslant M^{\mathrm{d}}_{2,\mathrm{n}}(z)\\ 0 & \text{otherwise}\end{cases} \tag{35}$$

and

$$J_{2,\mathrm{wn}}(x,z,\gamma)=\begin{cases}1 & \text{if} \quad \sum_{h=1}^{w}\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{wn}}(x,z,\gamma_h)\geqslant F^{\mathrm{d}}_{2,\mathrm{w}}(x)\\ 0 & \text{otherwise}\end{cases} \tag{36}$$

[27] In $I_{2,\mathrm{ww}}$, the first w indicates the labor market choice of the woman in period 1, and the second w represents the male's labor market decision in period 1. Similarly for $J_{2,\mathrm{ww}}$.

In the case in which neither wife nor husband worked in period 1:

$$I_{2,\mathrm{nn}}(x,z,\gamma)=\begin{cases}1 & \text{if } \sum_{h=1}^{w}\Gamma(\gamma_h)M^{\mathrm{m}}_{2,\mathrm{nn}}(x,z,\gamma_h)\geqslant M^{\mathrm{d}}_{2,\mathrm{n}}(z)\\ 0 & \text{otherwise}\end{cases} \tag{37}$$

and

$$J_{2,\mathrm{nn}}(x,z,\gamma)=\begin{cases}1 & \text{if } \sum_{h=1}^{w}\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{nn}}(x,z,\gamma_h)\geqslant F^{\mathrm{d}}_{2,\mathrm{w}}(x)\\ 0 & \text{otherwise}\end{cases} \tag{38}$$

*Young married couples* Young married couples will make choices to maximize the current period utility plus the continuation value. These continuation values will depend on whether or not agents worked during period 1. In particular, it is useful to define the following functions conditional on first-period working histories:[28]

1. If both spouses work in the first period

$$\mathrm{CV}_{\mathrm{ww}}=\sum_{k=1}^{K}\sum_{k=1}^{K}\max\left\{\sum_h\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{ww}}.I_{2,\mathrm{ww}},F^{\mathrm{d}}_{2\mathrm{w}}\right\}X(x_k|x_i)Z(z_l|z_j) \tag{39}$$

2. If the husband works in period 1 but the wife does not

$$\mathrm{CV}_{\mathrm{nw}}=\sum_{k=1}^{K}\sum_{k=1}^{K}\max\left\{\sum_h\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{nw}}.I_{2,\mathrm{nw}},F^{\mathrm{d}}_{2\mathrm{n}}\right\}X(x_k|x_i)Z(z_l|z_j) \tag{40}$$

3. If the husband does not work in period 1 but the wife does

$$\mathrm{CV}_{\mathrm{wn}}=\sum_{k=1}^{K}\sum_{k=1}^{K}\max\left\{\sum_h\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{wn}}.I_{2,\mathrm{wn}},F^{\mathrm{d}}_{2\mathrm{w}}\right\}X(x_k|x_i)Z(z_l|z_j) \tag{41}$$

4. If neither works in period 1

$$\mathrm{CV}_{\mathrm{nn}}=\sum_{k=1}^{K}\sum_{k=1}^{K}\max\left\{\sum_h\Gamma(\gamma_h)F^{\mathrm{m}}_{2,\mathrm{nn}}.I_{2,\mathrm{nn}},F^{\mathrm{d}}_{2\mathrm{n}}\right\}X(x_k|x_i)Z(z_l|z_j) \tag{42}$$

where $F^{\mathrm{m}}_{2,\mathrm{ww}}$, $F^{\mathrm{m}}_{2,\mathrm{nw}}$, $F^{\mathrm{m}}_{2,\mathrm{wn}}$, and $F^{\mathrm{m}}_{2,\mathrm{nn}}$ are defined by Eq. 31; $F^{\mathrm{d}}_{2\mathrm{w}}$ and $F^{\mathrm{d}}_{2\mathrm{n}}$ are defined by Eqs. 20 and 21 resulting from Eqs. 17 and 18 modified to include child-support payments of ex-husbands, $I_{2,\mathrm{ww}}$, $I_{2,\mathrm{nw}}$, $I_{2,\mathrm{wn}}$ and $I_{2,\mathrm{nn}}$ are defined by Eqs. 32–37; and $X(x_k|x_i)$ and $Z(z_l|z_j)$ are the transition functions according to which female and male productivity evolves from period 1 to period 2, respectively. Given the definitions of CV above, we can now define the following auxiliary functions that will, in turn, be used to construct the married young females continuation values:

$$\begin{aligned}F^{\mathrm{m}}_{1\mathrm{OO}}&=\max\left[\left(F^{\mathrm{m}}_{2a}+\beta\mathrm{CV}_{\mathrm{ww}}\right),\left(F^{\mathrm{m}}_{2b}+\beta\mathrm{CV}_{\mathrm{nw}}\right),\left(F^{\mathrm{m}}_{2c}+\beta\mathrm{CV}_{\mathrm{wn}}\right),\left(F^{\mathrm{m}}_{2d}+\beta\mathrm{CV}_{\mathrm{nn}}\right)\right]\\ F^{\mathrm{m}}_{1\mathrm{NO}}&=I[nm1\geq s]\left(F^{\mathrm{m}}_{2b}+\beta\mathrm{CV}_{\mathrm{nw}}\right)+I[nm1<s]\left(F^{\mathrm{m}}_{2d}+\beta\mathrm{CV}_{\mathrm{nn}}\right)\\ F^{\mathrm{m}}_{1\mathrm{ON}}&=\max\left[\left(F^{\mathrm{m}}_{2c}+\beta\mathrm{CV}_{\mathrm{wn}}\right),\left(F^{\mathrm{m}}_{2d}+\beta\mathrm{CV}_{\mathrm{nn}}\right)\right]\\ F^{\mathrm{m}}_{1\mathrm{NN}}&=F^{\mathrm{m}}_{2d}+\beta\mathrm{CV}_{\mathrm{nn}}\end{aligned} \tag{43}$$

[28]Lower case subscripts indicate the couples' working history. In particular, the first letter corresponds to the labor supply choice of the wife, whereas the second letter corresponds to the labor supply choice of the husband. For example, nw indicates that the wife did not work in period 1, whereas the husband did.

**Table 11** Definitions of maximum utility by type of agent

| Maximum utility | Description |
|---|---|
| $F^{\mathrm{s}}_{2,\mathrm{n}}(M^{\mathrm{s}}_{2,\mathrm{n}})$ | For single old woman (man) who did not work in period 1 |
| $F^{\mathrm{s}}_{2,\mathrm{w}}(M^{\mathrm{s}}_{2,\mathrm{w}})$ | For single old woman (man) who worked in period 1 |
| $F^{\mathrm{d}}_{2,\mathrm{n}}(M^{\mathrm{d}}_{2,\mathrm{n}})$ | For divorced old woman (man) who did not work in period 1 |
| $F^{\mathrm{d}}_{2,\mathrm{w}}(M^{\mathrm{d}}_{2,\mathrm{w}})$ | For divorced old woman (man) who worked in period 1 |
| $F^{\mathrm{s}}_{1,\mathrm{N}}(M^{\mathrm{s}}_{1,\mathrm{N}})$ | For single young woman (man) who did not receive a job offer in period 1 |
| $F^{\mathrm{s}}_{1,\mathrm{O}}(M^{\mathrm{s}}_{1,\mathrm{O}})$ | For single young woman (man) who received a job offer in period 1 |
| $F^{\mathrm{n}}_{2,\mathrm{ww}}(M^{\mathrm{m}}_{2,\mathrm{ww}})$ | For married old woman (man) who worked in period 1 and whose spouse also did |
| $F^{\mathrm{m}}_{2,\mathrm{nw}}(M^{\mathrm{m}}_{2,\mathrm{nw}})$ | For married old woman (man) who did not work in period 1 but spouse did |
| $F^{\mathrm{m}}_{2,\mathrm{wn}}(M^{\mathrm{m}}_{2,\mathrm{wn}})$ | For married old woman (man) who worked in period 1 but whose spouse did not |
| $F^{\mathrm{m}}_{2,\mathrm{nn}}(M^{\mathrm{m}}_{2,\mathrm{nn}})$ | For a married old woman (man) who did not work in period 1 and whose spouse did not work either |

$F^{\mathrm{m}}_{1\mathrm{OO}}$ corresponds to the maximum utility attained by a married young woman characterized by the fact that both she and her husband received an offer during the first period; $F^{\mathrm{m}}_{1\mathrm{NO}}$ is the maximum utility attained by a married young woman who did not receive an offer during the first period and is married to a man who received an offer; $F^{\mathrm{m}}_{1\mathrm{ON}}$ is the maximum utility attained by a married young woman who received an offer during the first period and is married to a men who did not receive one and $F^{\mathrm{m}}_{1\mathrm{NN}}$ corresponds to the maximum utility attained by a married young woman who received an offer during the first period and is married to a man who also received an offer. Finally, we can define the unconditional maximum utility level of married young women as:

$$F^{\mathrm{m}}_{1} = \lambda^2 F^{\mathrm{m}}_{1\mathrm{OO}} + \lambda(1-\lambda)\left[F^{\mathrm{m}}_{1\mathrm{NO}} + F^{\mathrm{m}}_{1\mathrm{ON}}\right] + (1-\lambda)^2 F^{\mathrm{m}}_{1\mathrm{NN}} \tag{44}$$

Analogously for men, in the Tables 11, 12 and 13 we summarize all definitions.

Steady State

In this section, we outline how the number of married, divorced, and single agents in each period is determined in equilibrium.

To find the number of two-period intact households of type $(x_i, z_j, x_k, z_j, \gamma_h)$, $Y^{m,m}$, we need the probability that a woman of type $i$ meets a man of type $j$, transition

**Table 12** Definitions of unconditional value functions

| Unconditional value function | Description |
|---|---|
| $F^{\mathrm{s}}_{1}(M^{\mathrm{s}}_{1})$ | For young single woman (man) |
| $F^{\mathrm{m}}_{1}(M^{\mathrm{m}}_{1})$ | For young married woman (man) |

**Table 13** Definitions of optimal choices by type of agent

| | Description |
|---|---|
| Optimal labor supply | |
| $L^{\rm s}_{i,2,\rm n}(L^{\rm d}_{i,2,\rm n})$ | For single (divorced) old agent $i = f, m$ (if agent did not work in period 1) |
| $L^{\rm s}_{i,2,\rm w}(L^{\rm d}_{i,2,\rm w})$ | For single (divorced) old agent $i = f, m$ (if agent worked in period 1) |
| $L_{i,2,\rm ww}$ | For married agent $i = f, m$ (if agent and spouse worked in period 1) |
| $L^{\rm s}_{i,1}$ | For single young agent $i = f, m$ |
| Optimal child care | |
| $T^{\rm s}_{f,2,\rm n}(T^{\rm d}_{f,2,\rm n})$ | For single (divorced) old mother (if she did not work in period 1) |
| $T^{\rm s}_{f,2,\rm w}(T^{\rm d}_{f,2,\rm w})$ | For single (divorced) old mother (if she worked in period 1) |
| $T^{\rm s}_{f,1}$ | For single young woman |

to type $k$, and decide to stay married in the second period. In addition, one needs to account for all possible labor market histories:

$$\begin{aligned} Y^{\rm m,m}\left(x_i, z_j, x_k, zl, \gamma_h\right) &= \Phi_1\left(x_i\right)\Phi_2\left(z_j\right)\Gamma(\gamma_h).I_1\left(x_i, z_j\right).J_1\left(x_i, z_j\right).X(x_k|x_i).Z(z_l|z_j). \\ &\Big[I[L^{\rm m}_{f,1} \geq s, L^{\rm m}_{m,1} \geq s]I_{2,\rm ww}\left(x_k, z_l\right).J_{2,\rm ww}\left(x_k, z_l\right) \\ &+ I[L^{\rm m}_{f,1} \geq s, L^{\rm m}_{m,1} < s]I_{2,\rm wn}\left(x_k, z_l\right).J_{2,\rm wn}\left(x_k, z_l\right) \\ &+ I[L^{\rm m}_{f,1} < s, L^{\rm m}_{m,1} \geq s]I_{2,\rm nw}\left(x_k, z_l\right).J_{2,\rm nw}\left(x_k, z_l\right) \\ &+ I[L^{\rm m}_{f,1} < s, L^{\rm m}_{m,1} < s]I_{2,\rm nn}\left(x_k, z_l\right).J_{2,\rm nn}\left(x_k, z_l\right)\Big] \end{aligned} \tag{45}$$

where $I[\bullet]$ is an indicator function that equals 1 if the argument $\bullet$ is true. For example, $I[L^{\rm m}_{f,1} \geq s, L^{\rm m}_{m,1} \geq s]$ equals 1 if both the optimal labor supplies of the wife and of the husband are above the minimum requirement $s$.

Similarly, for the number of households with two parents during the first period but only one parent during the second, $Y^{\rm m,d}$:

$$\begin{aligned} Y^{\rm m,d}\left(x_i, z_j, x_k, \gamma_h\right) = \Phi_1\left(x_i\right)\Phi_2\left(z_j\right)\Gamma(\gamma_h)I_1\left(x_i, z_j\right)J_1\left(x_i, z_j\right)X(x_k|x_i)\cdot \\ \Bigg\{ \begin{array}{c} I[L^{\rm m}_{f,1} \geq s, L^{\rm m}_{m,1} \geq s] \\ \left[1 - \sum_{l=1}^{K}\sum_{n=1}^{W}\Gamma(\gamma_n)I_{2,\rm ww}\left(x_k, z_l\right).J_{2,\rm ww}\left(x_k, z_l\right).Z\left(z_l|z_j\right)\right] + \\ I[L^{\rm m}_{f,1} \geq s, L^{\rm m}_{m,1} < s] \\ \left[1 - \sum_{l=1}^{K}\sum_{n=1}^{W}\Gamma(\gamma_n)I_{2,\rm wn}\left(x_k, z_l\right).J_{2,\rm wn}\left(x_k, z_l\right).Z\left(z_l|z_j\right)\right] + \\ I[L^{\rm m}_{f,1} < s, L^{\rm m}_{m,1} \geq s] \\ \left[1 - \sum_{l=1}^{K}\sum_{n=1}^{W}\Gamma(\gamma_n)I_{2,\rm nw}\left(x_k, z_l\right).J_{2,\rm nw}\left(x_k, z_l\right).Z\left(z_l|z_j\right)\right] + \\ I[L^{\rm m}_{f,1} < s, L^{\rm m}_{m,1} < s] \\ \left[1 - \sum_{l=1}^{K}\sum_{n=1}^{W}\Gamma(\gamma_n)I_{2,\rm nn}\left(x_k, z_l\right).J_{2,\rm nn}\left(x_k, z_l\right).Z\left(z_l|z_j\right)\right] \end{array} \Bigg\} \end{aligned} \tag{46}$$

And finally, the number of one-parent households during both periods, $Y^{s,s}$:

$$Y^{s,s}(x_i, x_k) = \Phi_1(x_i)\left[1 - \sum_{j=1}^{K}\sum_{n=1}^{W}\Gamma(\gamma_n)I_1\left(x_i, z_j\right).J_1\left(x_i, z_j\right)\right]\cdot X(x_k|x_i) \qquad (47)$$

In addition, the human capital investment will depend upon both parents' labor market decisions. Let $H^{m}_{t,ww}$ be the human capital accumulated in period $t$ for a child of a married couple in which both wife and husband worked in that period, analogously, for $H^{m}_{t,nw}$, $H^{m}_{t,wn}$, and $H^{m}_{t,nn}$. Then, human capital investment for a child who was raised in a two-parent household during period $t$ is given by:

$$\begin{aligned} H^{m}_{t}(x_i, z_j, \gamma_h) = {} & I[L^{m}_{f,t} \geq s,\, L^{m}_{m,t} \geq s]H^{m}_{t,ww}(x_i, z_j, \gamma_h) \\ & + I[L^{m}_{f,t} \geq s,\, L^{m}_{m,t} < s]H^{m}_{t,wn}(x_i, z_j, \gamma_h) \\ & + I[L^{m}_{f,t} < s,\, L^{m}_{m,t} \geq s]H^{m}_{t,nw}(x_i, z_j, \gamma_h) \\ & + I[L^{m}_{f,t} < s,\, L^{m}_{m,t} < s]H^{m}_{t,nn}(x_i, z_j, \gamma_h) \end{aligned} \qquad (48)$$

Analogously for children of single mothers:

$$H^{s}_{t}(x_i) = I[L^{s}_{f,t} \geq s]H^{s}_{t,w}(x_i) + I[L^{s}_{f,t} < s]H^{s}_{t,n}(x_i) \qquad (49)$$

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