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DISCUSSION PAPER SERIES

IZA DP No. 13839

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NOVEMBER 2020

ISSN: 2365-9793

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ABSTRACT

Female Employment and Childcare*

Childcare and women's employment decisions are intimately linked. I develop a dynamic model designed to analyse the effects of childcare subsidies on labour supply, fertility, marriage, and childcare decisions in a collective setting. In the model, children are a household good, produced by both parental time and time in childcare. Couples cannot commit to insure one another against the lower wages and lower consumption associated with spending time with a child. I estimate the model using the Panel Study of Income Dynamics in the United States to evaluate the impact of childcare subsidy programmes on various life-cycle outcomes of women and men. Offering a 10 percent childcare subsidy expands the labour supply of single women from lower-education backgrounds by 5.4 percent while married women, and higher-educated single women, respond much less. Finally, I show that there are large increases in childcare take-up associated with childcare subsidies, which improves the quality of children as a household good. This increases gains from marriage and results in an increase in the married fraction of the sample.

JEL Classification: J24, J22, J12, J13, D13

Keywords: female labour supply, childcare, collective household models

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* I would like to express my sincere gratitude to my advisor Ahu Gemici for her invaluable support through all stages of this project. Financial support from the British Academy is greatly appreciated. I thank the participants at University of Lausanne, Royal Holloway, UCL, RES 2017, EALE 2019, SEHO 2019, and the Econometric Society European Summer Meeting 2019 for helpful comments. I have benefited from discussions with Dan Anderberg, Orazio Attanasio, Jesper Bagger, Sekyu Choi, Eric French, Hamish Low, Rafael Lalive, Konrad Mierendorff, Suphanit Piyapromdee, Rob Sauer, Michela Tincani, Ija Trapeznikova, and Kenneth Wolpin.

1 Introduction

Over the past 50 years many countries, including the United States, have experienced large increases in women's participation in the labour force which in turn has reduced part of the gender pay gap (Blau and Kahn, 2017). In light of the increases in women's involvement in the labour market, the need for policies balancing the family-work life of mothers are becoming ever more relevant and the provision of affordable childcare could contribute to such a balance (Attanasio et al., 2008). Due to the relevance of such policies for women's employment, various countries have adopted childcare support programmes. However, the role of childcare policies on the labour supply of mothers is not well understood and the literature studying the impact of these policies provides mixed evidence on how they impact mothers' labour supply (See Blau and Currie (2006), and Morrissey (2017) for surveys).

The main objective of this paper is to provide empirical evidence on how subsidies towards childcare costs, such as childcare subsidy programmes in France, affect female employment in the US. There are various channels of policy impacts. First, subsidies could increase the labour supply of mothers by decreasing the reservation wage (substitution effect) but might also decrease labour supply by increasing net labour income (income effect). The second channel is through the production of the main public good produced in the household, i.e. children (Becker, 1973). Since childcare contributes to the production of this public good, subsidising its cost can alter the gains obtained from marriage. Childcare subsidies therefore might not only affect married and single individuals differently, but might also impact marital decisions.

To understand the issues related to female employment and childcare subsidy programmes, I develop a discrete choice dynamic programming model of employment and childcare decisions. In the model, wages, employment, childcare usage, fertility, and marital decisions are endogenously determined. Household decisions are modelled using a Nash bargaining framework, where outside options are specified as the values that spouses obtain from making decisions as single individuals in a collective framework.

There are three distinctive features in this framework which allow me to study the lifetime impacts of childcare subsidy programmes on the labour market outcomes and wages of single and married individuals: i) part-time and full-time work experiences are endogenously determined and affect wages differently to the extent that the decision of women not to work or to work part-time could have long-term consequences on their future income and their ability to purchase childcare in the future; ii) couples cannot commit to insure one another against the lower consumption associated with reducing their labour supply; iii) children are a private household good (or a public good when the parents are married), produced both with parents' time and with time in childcare. By modelling household good production, I intend to understand, first, whether the time spent by the parents in producing household goods and the time that a child spends in childcare are substitutable. Second, whether the contribution of subsidies in the production of the household good affects marital decisions.

I estimate the model using the Panel Study of Income Dynamics (PSID) in the United States. I find that the hourly returns to full-time and part-time experiences are not different, although there are large differences in wage levels. The estimated difference in wage levels implies that full-time and part-time wages differ in other dimensions such as occupation rather than in returns to human capital. I also find that parental time and the time that a child spends in childcare are close substitutes. This result indicates that households should be able to substitute childcare with housework hours and obtain an almost equivalent household good.

Based on these estimates, I evaluate the impact of childcare subsidy programmes on employment, wages and marital decisions. I conduct several policy experiments with varying levels of subsidies. The first result from these experiments is that childcare subsidies increase childcare take-up. A 10 percent decrease in the cost of childcare increases take-up by 8.7 percent. However, despite the close substitutability between childcare and housework hours, the labour supply of married women is hardly affected by the subsidies. On the other hand, single women and specifically those from lower-education backgrounds are considerably more responsive to these policies. A 10 percent decrease in the cost of childcare increases the labour supply of lower-educated single women by 5.4 percent and their overall life-time earnings by 4.4 percent. The reasons behind the different responses of married women compared to single women lies in the income and substitution effects arising from childcare subsidies. For married women the substitution effects of childcare subsidies are almost offset by their income effects. On the other hand, single women and specially those from lower-education backgrounds, have a smaller income effect and therefore childcare subsidy programmes increase their labour supply.

The second result from these policy experiments is that childcare programmes increase the fraction of married individuals provided that the subsidy is below 80 percent of childcare costs. A 10 percent decrease in the cost of childcare decreases the fraction of divorced and single individuals by -2.57 and -0.37 percent, respectively. This result is driven by an increase in gains from specialisation; i.e. households benefit from an increase in the husband's labour supply to purchase subsidised childcare while women spend time on household production. However, as childcare subsidies exceed 80 percent of childcare costs, a larger number of parents can purchase childcare as single individuals. As a result, there are fewer gains from specialisation within marriage, which in turn decreases the married fraction in the sample.

This paper is related to two strands of literature. The first strand of literature studies whether parental time with the child could be substituted with childcare services. These studies use children's cognitive and non-cognitive outcomes as well as their later life outcomes to evaluate whether childcare services could act as a substitute for parental time with the child. The evidence from this literature is mixed. For example, Bernal (2008), Baker et al. (2008), and Bernal and Keane (2011) find that higher female labour supply accompanied with more childcare in early years has a negative impact on children's cognitive and non-cognitive outcomes. On the other hand, Griffen (2018) finds that childcare programmes such as Head Start improve children's cognitive abilities. Similar results are found by Havnes and Mogstad (2011) on adult outcomes from the expansion of childcare programmes and on children's cognitive and non-cognitive outcomes (Felfe and Lalive, 2018). In this paper I abstract away from modelling how parental time with a child and the time that a child spends in childcare maps into child outcomes. Modelling cognitive and non-cognitive child development, which have both shown to be important for children's later life outcomes (see Heckman and Rubinstein (2001)), is beyond the scope of this paper. I take a different approach: following Del Boca et al. (2014) and Agostinelli and Sorrenti (2018), who found that both parental time and money inputs are important for children's cognitive development, I assume that both time in childcare and parental time are inputs into household good production. I then estimate the substitutability between these two inputs using data on childcare usage and parental housework hours.[1]

Second, this paper builds on the long history of female labour supply literature and specifically that which addresses the issues related to part-time and full-time human capital in a dynamic life-cycle framework (see for example Francesconi (2002), Keane and Wolpin (2010) and Blundell et al. (2016)).[2] The dynamic labour supply literature estimating the welfare and labour supply gains from childcare or tax reforms has mainly focused on single or married women.[3] For example, Blundell and Shephard (2012) and Ho and Pavoni (2020) study the optimal design of tax reforms and childcare reforms for single women while Bick

[1]Blundell et al. (2018) estimate a home production function in which the elasticity of substitution between parental childcare hours is estimated. They find that these two inputs are close substitutes. In this paper, I assume that parental housework hours are perfect substitutes but I estimate the elasticity of substitution between housework hours and time spent in childcare.

[2]For a survey on Discrete Choice Dynamic Programming literature, see Keane et al. (2011).

[3]Estimating labour supply responses to childcare programmes goes back to Heckman (1974). Ribar (1995), Apps et al. (2016), and Gong and Breunig (2017) are among the papers that study the choice of childcare and labour supply in a static framework. Del Boca (2002) and Haan and Wrohlich (2011) model fertility and labour supply decisions but they do not explicitly model human capital formation.

(2016) examines the implications of childcare reforms for married women. Domeij and Klein (2013) and Guner et al. (2020) focus on the labour supply responses to childcare programmes of both single and married women but these models are set in a unitary framework and the marital decisions of the parents are not explicitly modelled. The closest model to this paper is developed by Chan and Liu (2018) in which a dynamic model of female labour supply, fertility, and childcare decisions is estimated to analyse the labour supply responses to childcare programmes in Norway. The key distinguishing feature of the model developed here is that I model the labour supply decisions of both women and men in a collective framework with no commitment.

This paper contributes to the existing literature modelling household employment decisions in a dynamic collective framework such as Mazzocco et al. (2007), Gemici and Laufer (2011), Eckstein et al. (2016), Voena (2015), and Doepke and Kindermann (2019), first by adding the choice of childcare to the household decision-making process and, second, by treating children as the main household good produced by parental time and time in childcare. This set-up allows me to incorporate women's considerations regarding the consequences of specialisation in household production and not using childcare; i.e. lower work experience and therefore lower income upon divorce, in the household decision-making process. My results indicate that even though return to work experience is high and the lack of insurance through limited commitment cannot protect women against the child penalty associated with working less after having a child, childcare subsidy programmes do not increase the labour supply of married women. They do, however, expand childcare take-up which increases the value of the household good produced in the household resulting in an increase in the fraction of married individuals. Conversely, I find that childcare subsidies increase the labour supply of lower-educated single women.

The remainder of the paper is organised as follows. Section 2 describes the model. Section 3 explains the PSID data used in the estimation. Section 4 covers the estimation and discusses how the model fits the patterns observed in the data. The results and a discussion about identification are included in Section 5. In Section 6, I discuss the results of policy experiments and explain which features of the model contribute to obtaining these results. Section 7 concludes.

2 Model

In this section I develop a dynamic model of the labour supply, fertility, childcare, and marital decisions of women w and men m. I start by modelling the behaviour of below-college educated individuals and college graduates at age $a = 18$ and $a = 22$, respectively.

Individual j, $j \in \{w, m\}$, starts her/his finite life with no work experience and the decision horizon ends at age $A = 50$, an age after which there are no fertility decisions for most people.

In each period, labour supply, fertility, childcare, and marital decisions are endogenously determined as a result of the optimising behaviour of an individual or couple. Each individual j is endowed with a fixed amount of time T, which can be allocated to labour-market and housework hours. The time constraint in each period a is

$$l_a^j \; + \; h_a^j \; = \; T_a^j$$

l_a and h_a represent labour-market and housework hours, respectively.

Women can choose between three different states of employment denoted by $k \in \{f, p, o\}$, representing full-time (f) and part-time (p) employment, and not working (o). Men always work full-time. Both men and women can choose different hours within different states of employment. The working hours of men and women are $l_a^m \; = \; \{7, 9\}$, $l_a^w \; = \; \{0, 3, 5, 7, 9\}$ per day, respectively. 0 represents not working, 3 and 5 are part-time working hours and 7 and 9 are full-time working hours. At each age a, individuals decide on labour supply (l_a^j), fertility ($n_a^j \in \{0, 1\}$), as well as whether or not to marry. Mothers and fathers also choose how many hours of childcare to purchase ($H_{CC,a}^j$). Hours of childcare are $H_{CC,a}^j = \{12, 7, 0\}$. When married, husband and wife jointly decide on the above choices as well as whether or not to divorce.

2.1 The Individuals problem and the Couples Problem

In the model, single and married individuals face different choice sets, state spaces, and constraints. See Section 2.2.4 for the set of variables that enter the state space. I start by explaining the behaviour of single individuals in the terminal period A and then I move backwards to period $A - 1$. The model is explained from the terminal period since it does not have a closed-form solution and it is solved numerically using backward recursion.

2.1.1 Single individuals at age A

The individual's problem in the terminal period A is to maximise instantaneous utility subject to budget and time constraints, and is characterised as follows:

$$V_A^j(\Omega_A^j) = \max_{\{l_A^j, n_A^j, H_{CC,A}^j\}} U(c_A^j,\ Q_{1,A}^j,\ Q_{2,A}^j,\ \epsilon_{ch,A}^j)$$

$$\text{s.t.}\quad y_{f,A}^j\, l_A^j \times 1\{l_A^j = f\} \;+\; y_{p,A}^j\, l_A^j \times 1\{l_A^j = p\} \;=\; c_A^j \;+\; (\pi_{CC} \;+\; \epsilon_{CC,A}^j) H_{CC,A}^j \times N_A^j$$

$$Q_{1,A}^j = f(h_A^j) \qquad\qquad Q_{2,A}^j = f(h_A^j, H_{CC,A}^j) \times N_A^j \qquad\qquad l_A^j \;+\; h_A^j \;=\; T$$

l_A^j represents the labour-market hours of single individual j. n_A^j represents the choice of having a child and $H_{CC,A}^j$ is hours of childcare. In each period, individuals gain utility from consumption of a private good (c_A^j) and household goods. There are two different types of household goods: $Q_{1,A}^j$ and $Q_{2,A}^j$. $Q_{1,A}^j$ represents value of goods produced at home such as a meal or a clean house. $Q_{2,A}^j$ serves as the child's qualities as valued by the parent (e.g. cognitive skills as well as non-cognitive skills such as a child's kindness, honesty or self-discipline). N_A^j is equal to 1 if the individual has a child and zero otherwise. Parents enjoy $Q_{2,A}$ in addition to $Q_{1,A}$ while individuals without a child only gain utility from $Q_{1,A}^j$. h_A^j represents the housework hours of individual j, which is used in the production of Q_1^j; however, parents can use both childcare $H_{CC,A}^j$ and housework hours to produce child qualities. $y_{f,A}^j$ and $y_{p,A}^j$ are full-time and part-time hourly wages, respectively (See Section 2.2.3). π_{CC} represents the hourly cost of childcare and $\epsilon_{CC,A}^j$ is the shock to the cost of childcare. $\epsilon_{ch,A}^j$ is the shock to the utility of having a child. The transitory shocks to childcare cost, and the preference shock to the utility of having a child are distributed as follows:

$$\epsilon_{CC,A}^j \overset{i.i.d}{\sim} N(0, \sigma_{CC}^2) \qquad\qquad \epsilon_{ch,A}^j \overset{i.i.d}{\sim} N(0, \sigma_{ch}^2)$$

Ω_A^j comprises the values of the state variables of single individual j in period A. Finally, $V_A^j(\Omega_A^j)$ is the the value function for individual j at state Ω_A^j when j is single.

2.1.2 Couples at age A

The value of marriage is determined by solving a Nash bargaining problem in which the outside options are defined as the values that each partner obtains from remaining/becoming single. The outside option (threat point) is given by the utility of an agent in case negotiations break, i.e. the value of divorce or the value of remaining single.[4] The outcome of this Nash bargaining is characterised by the solution to the following maximisation problem:

[4] McElroy and Horney (1990) and Manser and Brown (1980) are the first papers to model the household decision-making process in a joint static framework. The bargaining problem in these papers is formulated

$$\max_{\{c_A^j, l_A^j, H_{CC,A}, n_A\}} \Big(U(c_A^m,\ Q_{1,A},\ Q_{2,A},\ \Sigma_A)\ -\ V_A^m(\Omega_A^m)\Big)^{\theta}\Big(U(c_A^w,\ Q_{1,A},\ Q_{2,A},\ \Sigma_A)\ -\ V_A^w(\Omega_A^w)\Big)^{(1-\theta)}$$

$$\text{s.t.} \sum_{j=m,w} y_{f,A}^j\, l_A^j \times 1\{l_A^j = f\} \ +\ \sum_{j=m,w} y_A^j\, l_A^j \times 1\{l_A^j = p\}$$
$$= \sum_{j=m,w} c_A^j \ +\ (\pi_{CC}\ +\ \epsilon_{CC,A})\, H_{CC,A} \times N_A$$

$$Q_{1,A} = f(G_A) \qquad\qquad Q_{2,A} = f(G_A,\ H_{CC,A}) \times N_A$$

$$G_A = f(h_A^m,\ h_A^w) \qquad\qquad l_A^j\ +\ h_A^j\ =\ T, \qquad j = m, w$$

In the Nash product, $V_A^j(\Omega_A^j)$ is the value of being single for individual j. θ determines the bargaining power of each spouse. G_A is a composite good produced at home with the housework hours of men h_A^m and women h_A^w. The composite good will be used in the production of household goods $Q_{1,A}$ and $Q_{2,A}$. Σ_A is a vector of preference shocks which includes the shock to utility of having a child $\epsilon_{ch,A}$ and the shock to utility of remaining married $\epsilon_{mar,A}$. Marriage shocks are distributed as follows:

$$\epsilon_{mar,A} \overset{i.i.d}{\sim} N(0, \sigma_{mar}^2)$$

The optimal necessary transfers through the allocation of private consumption c_A^j are determined by solving the above maximisation problem for each alternative in the choice set $\{l_A^m, l_A^w, H_{CC,A}, n_A\}$. The Nash bargaining solution implies that each spouse receives their outside option (expected present discounted lifetime utility of being single) plus a share of the total marriage surplus, determined by parameter θ. $W_A^j(\Omega_A)$, $j = m, w$, denotes the value functions for both partners corresponding to the couple's optimal choice obtained from Nash bargaining, which is the choice that provides the household with the highest marriage surplus.

2.1.3 Single individuals at age $a < A$

A single individual's problem at age $a < A$ is to maximise the instantaneous utility as well as the expected discounted value of life-time utility. Dynamics are introduced to the model

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as a Nash bargaining problem. The collective models developed in Chiappori (1988) and Chiappori (1992) rely on Pareto efficiency and allow for any type of efficient decision making. For models that use non-cooperative outcomes as a threat point see Lundberg and Pollak (1993), Chen and Woolley (2001), and Rasul (2008).

through the accumulation of work experiences (see Section 2.2.3 for a detailed explanation). The individual's problem in period a is characterised as follows:

$$V_a^j(\Omega_a^j) \;=\; \max_{\{l_a^j, n_a^j, H_{CC,a}^j\}} \; U(c_a^j,\; Q_{1,a}^j,\; Q_{2,a}^j,\; \epsilon_{ch,a}^j) \;+\; \delta \begin{cases} E[V_{a+1}^j(\Omega_{a+1}^j|\Omega_a^j)], & \text{if single} \\ E[W_{a+1}^j(\Omega_{a+1}|\Omega_a)], & \text{if married} \end{cases}$$

$$\text{s.t.} \qquad y_{f,a}^j\, l_a^j \times 1\{l_a^j = f\} \;+\; y_{p,a}^w\, l_a^w \times 1\{l_a^w = p\} \;=\; c_a^j \;+\; (\pi_{CC} \;+\; \epsilon_{CC,a}^j)\, H_{CC,a}^j \times N_a^j$$

$$Q_{1,a}^j = f(h_a^j) \qquad\qquad Q_{2,a}^j = f(h_a^j, H_{CC,a}^j) \times N_a^j \qquad\qquad l_a^j + h_a^j = T$$

δ is the discount factor. If individual j meets a potential partner, they can decide to marry, which affects their value functions at age $a+1$. The value functions of married individuals for $a+1 = A$, was explained in Section 2.1.2. For $a+1 < A$ the Nash bargaining problem is described in Section 2.1.4. For single individuals in period a the problem will involve calculations of the expected future values from marriage.[5] Therefore, expected future values of life-time utility for single individuals include the expected values from future possibilities of getting married as well as remaining single.

2.1.4 Couples at age $a < A$

As for $a = A$, the value of marriage in period a is determined by solving a Nash bargaining problem in which the outside options $V_a^j(\Omega_a^m)$ are defined as the values that each partner obtains from remaining/becoming single. The outside options in period $a < A$ also include the possibilities of possible future marriages (see Section 2.1.3). The outcome of this Nash bargaining is characterised by the solution to the following maximisation problem:

[5] The expectations are taken over the transitory shocks and are calculated using Monte Carlo Integration.

$$\max_{\{c_a^j, l_a^j, H_{CC,a}, n_a\}} \left(U(c_a^m, Q_{1,a},\ Q_{2,a},\ \Sigma_a) \ + \ \delta \begin{cases} E[V_{a+1}^m(\Omega_{a+1}^m|\Omega_a^m)], \text{ if single} \\ E[W_{a+1}^m(\Omega_{a+1}|\Omega_a)], \text{ if married} \end{cases} \Bigg\} - \ V_a^m(\Omega_a^m) \right)^{\theta}$$

$$\left(U(c_a^w,\ Q_{1,a},\ Q_{2,a},\ \Sigma_a) \ + \ \delta \begin{cases} E[V_{a+1}^w(\Omega_{a+1}^w|\Omega_a^w)], \text{ if single} \\ E[W_{a+1}^w(\Omega_{a+1}|\Omega_a)], \text{ if married} \end{cases} \Bigg\} - \ V_a^w(\Omega_a^w) \right)^{(1-\theta)}$$

s.t.

$$\sum_{j=m,w} y_{f,a}^j \, l_a^j \times 1\{l_a^j = f\} \ + \sum_{j=m,w} y_a^j \, l_a^j \times 1\{l_a^j = p\}$$

$$= \sum_{j=m,w} c_a^j \ + \ (\pi_{CC} \ + \ \epsilon_{CC,a}) \, H_{CC,a} \times N_a$$

$$Q_{1,a} = f(G_a) \qquad\qquad Q_{2,a} = f(G_a,\ H_{CC,a}) \times N_a$$

$$G_a \ = \ f(h_a^m,\ h_a^w) \qquad\qquad l_a^j \ + \ h_a^j \ = \ T, \qquad\qquad j = m, w$$

The solution to the above problem, entails all values of possible future marriages and future values of remaining single. The optimal transfers and optimal choice within marriage will be determined, in consideration of possibilities of future marriages and divorces. The marriage decision of individual j at age a affects the value functions at age $a+1$. If individual j decides to get divorced, his/her value function in period $a+1$ will be a single individual's value function and if she/he decides to stay married, his/her value function in period $a+1$ will be a married individual's value function. For period $a+1 = A$, the calculation of single value functions and married value functions were explained in Sections 2.1.1 and 2.1.2, respectively.

The optimal individual consumption (c_a^j) needs to be determined, to find the optimal choice within marriage for each alternative in the choice set $\{l_a^m, l_a^w, H_{CC,a}, n_a\}$. In a no commitment model individuals cannot commit to the allocation of future resources, which implies that the bargaining problem over consumption is static.[6] The solution to the Nash bargaining problem implies that each spouse receives their outside option; i.e. the expected life-time utility of being single as well as a share of the marriage surplus determined by θ. The bargaining parameter (θ, or sharing rule) remains fixed and does not change based on the decisions made in the household (See Gemici (2011), Tartari (2015), and Doepke and Kindermann (2019) for similar models). Although the sharing rule in each period is fixed, the consequences of choices in each period influence the optimal choice made in the current

[6] Mazzocco (2007) rejects intra-household commitment in a dynamic framework.

period through altering expected utility. For example, the decision of not working today decreases future wages by lowering work experiences and subsequently affects future outside options through lower consumption. Anticipation of lower consumption in the future affects per-period optimal choices made in the household.[7]

2.1.5 Marriage Market

In each period a, individual j meets a potential partner with probability ω. When a meeting occurs, the characteristics of the potential partner are determined by a random draw from the distribution of potential partners. These characteristics of the potential partners are discretely uniformly distributed. I assume that individuals always meet a potential partner of the same age. The characteristics of a potential spouse at the time of meeting consists of their education, current number of children, years of full-time experience and years of part-time experience.

2.2 Empirical Implementations

To make the model computationally feasible, I make four assumptions. First, men only work full-time but can choose to work different hours within full-time employment. This assumption is not very restrictive as the observed proportions of non-working and part-time employed men are low in the data. Secondly, I assume a static budget constraint which does not allow for consumption smoothing through savings over the life-cycle. Although a model with endogenous savings and human capital would be more realistic, I have made the choice of focusing on the endogenous part-time and full-time human capital accumulation of women. Adding another source of dynamics to the model increases the state space and adds considerable computational burden to the solution of the model. The third assumption is that the individual's total time endowment is spent on home production and labour-market work. This assumption is made to reduce the size of the choice sets. Fourthly, to avoid tracking number of children and to reduce the size of the state space, I assume that individuals can only have one child.

[7]This framework has the computational advantage that the sharing rule does not enter as a variable in the state space. However it has the shortcoming that the bargaining outcome changes instantly once the threat point - value of divorce - changes. Basu (2006) examines inter-temporal models in which the bargaining parameter is endogenously determined. Mazzocco et al. (2007), Gemici and Laufer (2011), and Voena (2015) are examples of papers that allow for gradual changes in the bargaining parameter depending on the decisions made in the household.

2.2.1 Preferences

The instantaneous utility function of a single individual j at age a is:

$$\begin{aligned} U_a^j \;&=\; \alpha_c\, c_a^j \;+\; \alpha_{q1}\, Q_{1,a}^j \;+\; \Big(\alpha_{q2}\, Q_{2,a}^j \;+\; \alpha_n \;+\; \epsilon_{ch,a}^j\Big) \times N_a^j \\ &+\; \alpha_f^w \times 1\{l_a^w = f\} \;+\; \alpha_p^w \times 1\{l_a^w = p\} \;+\; \alpha_{nw}^w \times 1\{l_a^w = o\} \end{aligned}$$

α_c is the marginal utility of consumption goods. α_{q1} and α_{q2} represent the marginal utility of household goods Q_1 and Q_2, which are private goods for single households. α_n is the direct utility from having a child and $\epsilon_{ch,a}^j$ is the per period shock to the utility of having a child. α_f^w, α_p^w, α_{nw}^w are the direct utility/disutility from working full-time, part-time and not working of women. I assume that marginal utility of consumption α_c, and household goods α_{q1} and α_{q2}, are the same for men and women. On the other hand, utilities from different working hours are female-specific.

The instantaneous utility function of married individual j at age a is:

$$\begin{aligned} U_a^j \;&=\; \alpha_c\, c_a^j \;+\; \alpha_{q1}\, Q_{1,a} \;+\; \Big(\alpha_{q2}\, Q_{2,a} \;+\; \alpha_n \;+\; \epsilon_{ch,a}\Big) \times N_a \;+\; \epsilon_{mar} \\ &+\; \alpha_f^w \times 1\{l_a^w = f\} \;+\; \alpha_p^w \times 1\{l_a^w = p\} \;+\; \alpha_{nw}^w \times 1\{l_a^w = o\} \end{aligned}$$

An important feature of the above specification is that the preferences of single and married individuals are the same. This is an identification restriction, which allows me to use the observed labour market and housework behaviour of single individuals to identify preference parameters. In terms of preferences, the only difference between a single and married person is the shock to the utility of marriage, ϵ_{mar}. A detailed discussion of the identification of preference parameters can be found in Section 5.

2.2.2 Household Production

The two household goods Q_1 and Q_2 are produced using housework hours and childcare. Households without a child produce only Q_1 while those with a child produce Q_1 and Q_2.

The production technology for household good Q_1 of single individual j is:

$$Q_{1,a}^j = \lambda h_a^j$$

h_a^j represents housework hours and λ represents its marginal productivity. If single individual j has children, she also produces household good Q_2:

$$Q_{2,a}^j = \lambda\Big((h_a^j)^\gamma + (H_{CC,a}^j)^\gamma\Big)^{\frac{1}{\gamma}}$$

I assume a Constant Elasticity of Substitution (CES) production technology in which a combination of housework hours h_a^j and formal childcare hours $H_{CC,a}^j$ is used to produce household good Q_2. The elasticity of substitution parameter γ is important in the model since it governs the ability of individuals and households to substitute childcare with housework hours. A detailed discussion of these mechanisms is included in Section 6.

For a married couple, the production technology for Q_1 is:

$$Q_{1,a} = \lambda G_a$$

G_a is a composite good which combines housework hours of the husband h_a^m and housework hours of the wife h_a^w:

$$G_a = \alpha h_a^m + (1 - \alpha) h_a^w$$

The housework hours of husband and wife are assumed to be perfect substitutes, but they have different marginal productivities, which are determined by parameter α.

Similar to the case of single individuals, households with children produce Q_2 in addition to Q_1 according to the following CES production technology:

$$Q_{2,a} = \lambda \Big(G_a^\gamma + (H_{CC_a})^\gamma \Big)^{\frac{1}{\gamma}}$$

Similar to the case of preferences, I restrict the parameters of home production technologies so that they are the same for both single and married households.

In the empirical implementation of the model, I do not take a stance on how Q_1 and Q_2 map into the data. Some examples of Q_1 are a clean house and meals. On the other hand, Q_2 could be viewed as any aspect of having children that provides utility to the parents, such as the child's cognitive skills as well as her/his non-cognitive skills such as empathy, sociability, honesty, etc. By not using a strict mapping between Q_2 and a measure of child outcomes from the data, I refrain from putting restrictions on which of the child's qualities give utility to the parents. There are advantages and disadvantages to this approach. One of the advantages is that it allows me to avoid measurement issues arising from using data on child outcomes. For purposes of tractability, the literature usually treats these child outcomes as one-dimensional and focuses only on either cognitive or non-cognitive measures. However, the importance of both skills has been highlighted in the literature (Heckman and Rubinstein, 2001; Heckman et al., 2006). Another implication of this modelling is that the identification of parameters in the production technologies of Q_1 and Q_2 relies on the functional forms specification of the household production technologies. Section 5 includes a detailed discussion of the identification of these parameters.

2.2.3 Human Capital and Wage Equations

The wage equations in this paper are similar to Francesconi (2002) and address issues related to wages which could be attributed to differences in part- and full-time human capital as well as differences in wage levels, which are unrelated to work experience. The part-time and full-time hourly wage equations for women are:

$$\begin{aligned} log(y^w_{k,a}) \; &= \; \beta^w_{0,k} \; + \; \beta^w_{1,k} \, X_{f,a-1} \; + \; \beta^w_{2,k} \, (X_{f,a-1})^2 \\ &+ \; + \, \beta_{3,k} \, X_{p,a-1} \; + \; \beta_{4,k} \, (X_{p,a-1})^2 \; + \; \beta^w_{5,k} \, S^w \; + \; \epsilon^w_{k,a} \end{aligned}$$

$y^w_{k,a}$ are women's hourly wages depending on age and employment status $k \in \{f, p\}$, where f represents full-time and p part-time employment. X_k are specific part-time and full-time experiences. $S^w \in \{0, 1\}$ is equal to 1 if the individual has some college education and is equal to 0 if she has a lower level of education. $\epsilon^w_{k,a}$ are per period shocks to full-time and part-time wage offers, reflecting any changes in earnings, independent from household decision-making process.

In the wage equations, hours of work are translated into part-time and full-time experience levels, which affect wages differently, and returns to full-time and part-time experiences vary by the current employment status. Allowing such differences in parameters could generate state dependence in part-time and full-time employment and enforce employment in a type of employment with higher accumulated human capital. Part-time and full-time wage offers also differ in terms of wage levels ($\beta_{0,k}$), which reflects wage differences that cannot be attributed to human capital but other factors that differentiate part-time and full-time employment, such as differences in job characteristics.

Since men only work full-time, their wages depend only on full-time experience:

$$log(y^m_{f,a}) \; = \; \beta^m_{0,f} \; + \; \beta^m_{1,f} \, X_{f,a-1} \; + \; \beta^m_{2,f} \, (X_{f,a-1})^2 + \beta^m_{3,f} \, S^m \; + \; \epsilon^m_{f,a}$$

$\epsilon^m_{f,a}$ is the shock to the full-time wage offers of men. The wage shocks are independently and identically normally distributed:

$$\epsilon^m_{f,a} \overset{i.i.d}{\sim} N(0, (\sigma^m_f)^2) \qquad \epsilon^w_{f,a} \overset{i.i.d}{\sim} N(0, (\sigma^w_f)^2) \qquad \epsilon^w_{p,a} \overset{i.i.d}{\sim} N(0, (\sigma^w_p)^2)$$

The dynamics are introduced to the model through accumulation of work experiences according to the following laws of motion:

$$X^j_{f,a} \; = \; X^j_{f,a-1} \; + \; 1 \times 1\{l^j_a = f\} \qquad X^w_{p,a} \; = \; X^w_{p,a-1} \; + \; 1 \times 1\{l^w_a = p\}$$

By working full-time or part time, part-time or full-time human capital accumulates by 1.

2.2.4 State Space

The state space of a single man (Ω_a^m) comprises education, full-time experience, stock of children (N_a^m), wage shocks, childcare cost shocks ($\epsilon_{CC,a}$), and shocks to the utility of having children ($\epsilon_{ch,a}$). I assume joint custody which implies that upon divorce parents become single mothers and fathers.

$$\Omega_a^m = \{S^m, X_{f,a-1}^m, N_a^m, \epsilon_{f,a}^m, \epsilon_{ch,a}^m, \epsilon_{CC,a}^m\}$$

State space for a single woman (Ω_a^f) contains all the above variables, as well as her part-time experience and shocks to her part-time wage.

$$\Omega_a^w = \{S^w, X_{f,a-1}^w, X_{p,a-1}^w, N_a^w, \epsilon_{f,a}^w, \epsilon_{p,a}^w, \epsilon_{ch,a}^w, \epsilon_{CC,a}^w\}$$

When married, the state of a couple (Ω_a) includes shocks to utility of marriage ($\epsilon_{mar,a}$), in addition to the union of the above state variables, . Each partner receives the same marriage and child preference shock. The number of children in the household at the time of marriage is equal to $N_a = max\{N_a^w, N_a^m\}$.

$$\Omega_a = \left\{S^m, S^w, X_{f,a-1}^m, X_{f,a-1}^w, X_{p,a-1}^w, N_a, \epsilon_{f,a}^m, \epsilon_{f,a}^w, \epsilon_{p,a}^w, \epsilon_{ch,a}, \epsilon_{mar,a}, \epsilon_{CC,a}\right\}$$

Individuals with a college degree enter the model at $a = 22$ and those without a college degree enter the model at age $a = 18$. Since education is exogenous, its value remains the same in the entire life-cycle. I assume that individuals have no previous labour-market experience at the age that they finish schooling, implying that initial part-time and full-time experiences are zero. The evolution of state variables over the life-cycle depends on fertility and employment decisions. The chosen hours of childcare and marital decisions also affect the state variables, but only through affecting employment and fertility decisions.

3 Data

The data used in this study are taken from 30 waves (1968 to 1997) of the Panel Study of Income Dynamics (PSID). PSID started collecting labour-market information on individuals for the previous year from 1969 onwards. Therefore, the effective years of data are 29 periods (1968 - 1996). Individuals have been interviewed biennially since 1997. Since in my model each period is defined as a year, I do not use the data collected from 1997 onwards.

3.1 Sample

PSID consists of a core sample, a sample of low income households known as SEO (Survey of Economic Opportunity sample), a Latino sample (first interviewed in 1990 or 1992), and an immigrant sample (first interviewed in 1997). The individuals in SEO, Latino, and immigrant samples are endogenously selected based on their income, ethnicity or immigration status. I drop these oversampled individuals to overcome any potential biases resulting from sample selection. The sample is further restricted to household residents who are either head or wife and were interviewed at least 3 times between 1968 and 1997. Since I model the behaviour of individuals aged 18 to 50, all the descriptive statistics and subsequent analyses are reported for a sample of 18- to 50- year-olds. The unit of observation, therefore, is 18- to 50- year-old men and women who were surveyed for at least 3 periods.

Table 1: Descriptive statistics of the sample

	Education		Marital status			Fertility	
	College	Below college	Single	Married	Divorced	Parents	Non-parents
Women							
%	44.50	55.50	7.047	68.91	24.04	78.18	21.82
No.	2,047	2,553	5,498	53,762	18,757	58,296	16,269
Men							
%	47.84	52.16	6.894	70.67	22.44	75.10	24.90
No.	2,056	2,242	5,036	51,626	16,389	51,608	17,110

College graduates are defined as individuals having more than 12 years of schooling and those having a lower level of education are classified as below-college educated. Data Source: PSID (waves 1968-1997).

Table 1 reports the descriptive statistics of the sample. The PSID's unbalanced sample consists of 4,298 men and 4,600 women with women representing 52 percent of the sample. Around 44 percent of women and 48 percent of men in the sample have schooling above 12 or more years of education and I classify them as college graduates. Around 70 percent of individuals in the sample are married, 7 percent are single and about 23 percent are divorced.[8] 75 and 78 percent of men and women in the sample are observed to have at least one child.

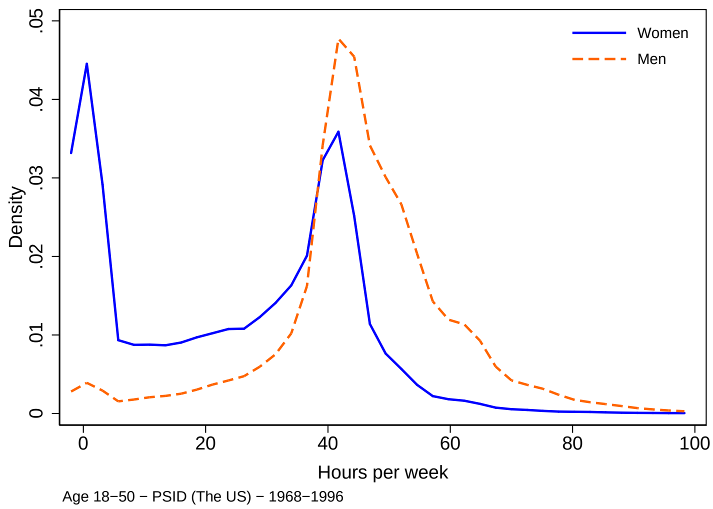
To obtain data on costs and hours of childcare, I use the PSID's Child Development Supplement (CDS). In 1997, PSID collected data on a sample of children born between

[8] I classify cohabiting individuals as married.

1984-1997. 2,394 families were surveyed about the childcare arrangements used for their 3,563 children. I match the CDS sample to my main sample from PSID using the Family Identification Mapping System (FIMS), which maps the parents of these children to PSID's core sample. I can match 1,079 children to their parents in my sample, providing information on hours and costs of childcare used by 1,029 mothers and 1,004 fathers.

3.2 Part-time Employment - definition and prevalence

Figure 1: Kernel density estimates of hours of work, men vs. women



The Kernel density of labour-market hours in Figure 1 shows that working hours are clustered around certain hours and women are more likely to work fewer hours and to stay out of the labour market. The left tail of the density of hours of work is thicker for women and many women tend to work between 10 and 35 hours. Based on this figure, I define part-time employment as those working 10 or more hours but below 35 hours per week.[9] Those working between 0 and 10 hours are categorised as out of the labour market. The remaining women work 35 hours or more and are classified as full-time employed. PSID data are collected annually, therefore the data on annual hours of work might not necessarily reflect part-time employment. This is because the beginning and end of a spell cannot be identified from the data. Therefore, those who do not work for half a year and are full-time employed in the second half of the year are considered part-time workers.[10]

[9] Francesconi (2002) and Blank (1994) also use the same definition for part-time employment.

[10] In labour supply models there is no distinction between not working and unemployed individuals. It is a common assumption in modelling labour supply that everyone who seeks a job finds one immediately.

Table 2 gives evidence on how family formation and parenthood are strongly linked to part-time employment in the data. We can see that the employment patterns of men and women are very similar when they do not have a child with full-time employment at around 70 percent and part-time employment at around 20 percent. When married, women reduce their labour supply along both the intensive and extensive margins of labour supply. Among married non-mothers only 58 percent work full-time, which is about 18 percent lower than for single non-mothers. The proportion of part-time employed married non-mothers is also about 10 percent larger than single non-mothers. In contrast, married non-fathers are more likely to work, with 84 percent of them being in full-time employment. Therefore, by the time women start to have children, there will already be large differences in their labour-supply behaviour compared to men.

Married women's labour supply decreases even more when they become mothers with 40 percent of married mothers not working and 47 percent of those who are employed working part-time. In contrast, married fathers work more and longer with only 2 percent of them being out of the labour market. The labour market behaviour of mothers and fathers is completely different when they are single (divorced or never married). The participation rate for single mothers is 28 percent higher than for married mothers, and they are less likely to work part-time. The labour supply behaviour of single fathers is also different from that of married fathers- they participate less in the labour market and also work fewer hours.

These differences between the labour supply of single and married women highlights the importance of marital status in the employment decisions of women. The model developed here addresses these issues by modelling marital, fertility, and labour-supply decisions simultaneously.

3.3 Part-time Employment and Wages

It is well-known in the literature that part-time employed individuals receive lower wages compared to those working full-time, which is known as the part-time pay penalty (see Hirsch (2005) in the US and Manning and Petrongolo (2008) in the UK). Figure 2 shows the difference between the median log hourly wages of part-time and full-time working women between 1968 and 1996.[11] We can see that the hourly wages of part-time employed individuals with below-college level of education were around 30 percent lower than those of full-time workers. The observed pay penalty is lower when I take into account college education, but educated workers still earn on average around 20 percent less than full-time

[11] I would like to thank Alan Manning and Barbara Petrongolo for sharing their Stata code to plot graphs similar to the Part-time Penalty graph in their paper.

Table 2: Employment by marital status - parents and non-parents

Marital status		Not working (1)	Part-time (2)	Full-time (3)	Total
Single non-mothers	% of row	4.826	24.00	71.18	
	No. of obs	218	1,084	3,215	4,517
Married non-mothers	% of row	14.44	27.52	58.04	
	No. of obs	1,169	2,227	4,697	8,093
Married mothers	% of row	40.18	28.04	31.78	
	No. of obs	16,328	11,394	12,917	40,639
Single mothers	% of row	22.78	22.81	54.41	
	No. of obs	1,654	1,656	3,951	7,261
Single non-fathers	% of row	3.677	18.34	77.98	
	No. of obs	183	913	3,881	4,977
Married non-fathers	% of row	2.051	13.04	84.91	
	No. of obs	148	941	6,126	7,215
Married fathers	% of row	1.982	8.114	89.90	
	No. of obs	750	3,070	34,016	37,836
Single fathers	% of row	7.568	14.08	78.36	
	No. of obs	257	478	2,661	3,396

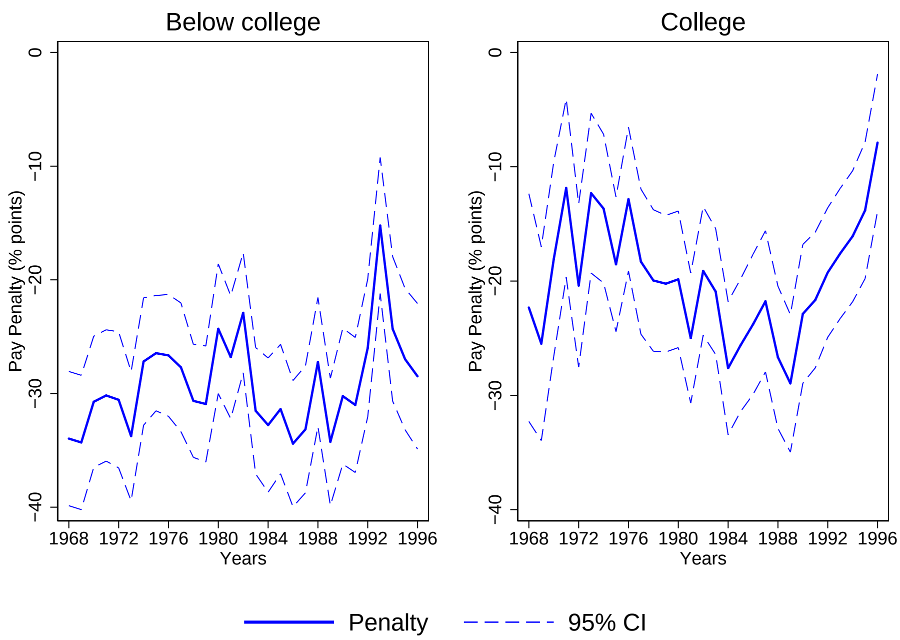
Part-time employment is defined as those working 10 hours or more but less than 35 hours. Full-time employment is defined as individuals working 35 hours or more. Not working individuals are those working below 10 hours. Single individuals could be either divorced, separated or never married. Data Source: PSID (waves 1968-1997).

workers. Such wage differences could be attributed to the different occupations of part- and full-time employed individuals (Manning and Petrongolo, 2008), differences in the process of human capital (Blundell et al., 2016; Francesconi, 2002) or discrimination against part-time workers. This paper tries to understand whether the skills and work experiences obtained from part-time work are similar to the those obtained from full-time work. I intend to do this to understand whether choosing to work part-time in order to spend more time at home and with children has long-term consequences on the future wages and employment of women.

3.4 Childcare and Parental Employment

The matched CDS and PSID sample is used to construct the childcare usage of mothers by employment status. PSID's Child Development Supplement reports 9 different childcare

Figure 2: Part-time pay penalty for women - by education



Part-time pay penalty is defined as the difference between the median hourly wages of full-time and part-time workers. Part-time employment is defined as working between 10 and 35 hours and full-time as working 35 hours or more. All wages are CPI adjusted to 1984 US dollars. Source: PSID (wave 1968-1997).

arrangements used by families since the birth of the child. Therefore, the childcare cost and hours are constructed using the first 4 types of arrangement. I use data on the childcare used for the first child because it is the behaviour of parents for the first child born into the household that is considered in the model. Furthermore, I only construct hours and cost of childcare from the birth of the child until the child turns 5 years old, since in many states children attend schools at the age of 5.[12] CDS reports various types of childcare used since the birth of the child. Since only a few mothers use more than four types of arrangement, childcare cost and hours are constructed using the first 4 types of arrangement.

These arrangements can be categorized into formal and informal types of childcare. Informal childcare is defined as care provided by a relative in the child's home or in the relatives' home. Care that is provided by non-relatives in or out of the child's home including the Head Start programmes, childcare centres, and before- or after- school program are classified as formal care. In this paper I consider formal childcare to be the only form of childcare that can be subsidised by the government. The implication of using only formal childcare in estimating the model is that only formal childcare enters the household production function implying that informal childcare does not have a role in the production

[12]The age that a child must be in kindergarten in the United States varies across states. In 1998, the obligatory entry age was between 5 to 8 years old. See Table 3 in (Datar, 2006).

of household good (child quality). Bick (2016) and Gong and Breunig (2017) are among the papers that model informal and formal care. Chan and Liu (2018) show that informal childcare, as opposed to formal childcare, has a negative effect on child outcomes.

Table 3: Hours of formal childcare by parental employment status

Employment status	Not working		Part-time		Full-time	
	mean	sd	mean	sd	mean	sd
			Mothers			
Hours in care per day	0.395	1.340	1.864	2.780	3.602	3.784
No.	1718		1552		1484	
			Fathers			
Hours in care per day	1.210	2.581	1.427	2.626	1.889	3.064
No.	98		415		4050	

Part-time employment is defined as those working 10 hours or more but less than 35 hours. Full-time employment is defined as individuals working 35 hours or more. Out of labour force are those working below 10 hours. Data Source: PSID (waves 1968-1997) and Child Development Supplement (wave 1997).

Table 3 reports the hours of formal childcare used by parents. We can see that the hours of childcare used vary depending on the employment status of mothers rather than fathers. Part-time employed mothers on average use fewer hours of childcare than full-time workers, and non-working mothers use even fewer hours. Table 4 reports the hourly cost of childcare in US dollars. The mean estimated hourly cost of childcare is 3.3 dollars per hour and there is a large variance in the cost of childcare.

Table 4: Cost of formal childcare

	Mean	sd	No.	Min	Max
Hourly cost (US dollars)	3.33	9.190	4,295	0	359.643

Data Source: PSID (waves 1968-1997) and Child Development Supplement (wave 1997).

Since the number of hours that the child spends in formal childcare is related to the mothers' employment, I categorize its usage into 3 different states which correspond to the mothers' employment status. I define full-time childcare usage as when more than 7 hours of formal daily childcare is used and part-time childcare is defined as when the child spends fewer than 7 hours per day in formal care. Lastly, no childcare is when no formal childcare is used. Table 5 reports how this constructed childcare usage variable corresponds to the mother's employment status. In general, only 12 percent of mothers use full-time formal childcare and among them around 73 percent are full-time employed mothers (see Column 1 in Table 5). Around 60 percent of mothers do not use formal childcare but only 21 percent of these mothers are full-time employed (see Column 3 in Table 5). These statistics indicate that although many mothers in the United States do not rely on formal childcare, they are more likely to use it when they are working and even more likely to use more hours of formal childcare when they are working full-time.

Table 5: Formal childcare usage by mother's employment status

		Formal childcare			
		Full-time	Part-time	No childcare	Total
Employment status		(1)	(2)	(3)	
Full-time	% of Col	73.30	34.29	21.13	31.22
	% of Row	29.78	28.98	41.24	
	No.	442	430	612	1484
Part-time	% of Col	21.89	44.26	29.86	32.65
	% of Row	8.51	35.76	55.73	
	No.	132	555	865	1552
Not working	% of Col	4.81	21.45	49.02	36.14
	% of Row	1.69	15.66	82.65	
	No.	29	269	1420	1718
Total	% of Row	12.68	26.38	60.94	100.00
	No.	603	1254	2897	4754

Part-time employment is defined as those working 10 hours or more but less than 35 hours. Full-time care is defined as individuals working 35 hours or more. Out of labour force are those working below 10 hours. Full-time care is defined as 7 or more hours of formal childcare per day and part-time care as between zero and 7 hours of formal care per day. Data Source: PSID (waves 1968-1997) and Child Development Supplement (wave 1997).

The patterns in the data suggest that the reduction in the labour supply of women along the intensive and extensive margins of labour supply is associated with marriage and to a larger degree with motherhood. One explanation for why married mothers work fewer hours is specialisation in household good production which becomes even more important when there is a child in the household. The high cost of childcare could deter mothers from working and gaining work experience to the extent that even the loss of current wages and lower expected future wages do not push women into employment. In the next section, I explain the estimation method and discuss how the model replicates the observed patterns in the data.

4 Estimation

McFadden (1989) proposes to use the Method of Simulated Moments in estimating models that require numerical integrations. I use the following method of moment estimator:

$$argmin \qquad g(\theta)'Wg(\theta)$$

The simulated method of moments searches for the values of θ (a vector that contains all the unknown parameters) that minimise the distance between the moments calculated from the simulated data and the moments calculated from the actual data. W are the weights, which are the inverse of the estimated variances obtained from the actual data, divided by the number of individuals that contribute to each moment. $g(\theta)$ is defined as:

$$g(\theta) = \frac{1}{N}\sum_{i=1}^{N} g_i(\theta) = [\bar{m}_1 - \mu_1(\theta), ..., \bar{m}_k - \mu_k(\theta)]$$

where $(\bar{m}_1, .., \bar{m}_k)$ corresponds to the data moments, and $(\mu_1(\theta), .., \mu_1(\theta))$ are the corresponding model moments. N denotes the number of individuals in the sample.

4.1 Model Fit

In this section I discuss how the model captures the patterns observed in the data (see Figures in Appendix A). I calculate moments at different ages, ranging from 18 to 50, which are conditioned on various outcomes such as fertility and marital status.

Employment and Wages: Figures 9a - 10c show how the model fits the employment patterns of single and married mothers compared to non-mothers. The model does a very good job in matching the life-cycle employment patterns of women. In general, single women are more likely to work compared to married women and they are also more likely to work full-time. Motherhood is associated with a reduction in labour supply and this observed decrease is larger for married mothers compared to single mothers. The change in labour supply due to motherhood is observed in both intensive and extensive margins of employment.

Figures 11a - 12c show the employment parents of below-college educated individuals and college graduates by marital status. The model captures the observation in the data that college-graduate women have higher extensive and intensive margins of labour supply and are unlikely to be out of the labour market. However, the model overstates the proportion of non-working women from lower education backgrounds. In terms of work experience, the model captures the data feature that as part-time and full-time experiences increase, employment in the same sector increases and women with higher work experience are less likely to be out of the labour market. Figures 13a - 14c show that the model can generate these patterns.

Figures 15a - 18b show that the the model does a good job in fitting the wages of both full-time and part-time employed women by age and marital status. The average wages with respect to part-time and full-time experiences also match the data well, but the return to part-time experience of below-college educated women is understated. The variance in full-time and part-time wages also exhibits the right patterns and is reported in Figures 19a to 20b. Figures 21a - 23b show that the model does a good job in replicating first and second moments for male wages but understates the wages of college-graduate men.

Fertility and Marital Status: The marriage and divorce patterns generated by the model also match the data well. However, the fraction of married individuals at the beginning and towards the end of the life-cycle are understated (Figures 24a to 25b). With respect to fertility, the model fits the fraction of single and married men with children but individuals start to have children earlier than the time observed in the data (Figure 26a).

Childcare Take-up and Cost: Table 8 reports the variation in childcare usage by female employment status. Full-time working single mothers use more hours of childcare compared to non-working mothers. However, for part-time working single mothers, very few use childcare when we compare these fractions with the data. For married mothers, we can see that they purchase more childcare when they are employed; however, here I again cannot match the patterns showing that married non-working mothers do not purchase formal childcare as observed in the data. Table 9 shows the model fit for the distribution of childcare costs. In general, the estimated mean and variance of childcare cost are higher than the moments observed in the data. One explanation for the observed low cost of childcare in the data is that the PSID childcare cost data are not very well reported and the problem with its values has been mentioned by Lee and Seshadri (2019).

5 Parameter Estimates

In this section I report the model's estimated parameters and also discuss which features of the data help in identifying those parameters. Since the model is estimated using the Simulated Method of Moments, a formal identification of its parameters is not possible; instead I discuss the most relevant features that can contribute to identifying a parameter.

When discussing the identification of the parameters it is important to mention that various features of the data help in identifying a single parameter.

Wages and Employment: Tables 6 and 7 report the estimated parameters. The estimated male wage equation shows that in the first year of the life-cycle, one year of full-time experience increases male hourly wages by 5%. The return to experience exhibits a concave form, such that the return to full-time experience reaches its peak at 20 years of experience and diminishes gradually afterwards. Male college graduates experience a 20% higher hourly wage compared to the below-college educated men.

The larger intercepts of the log hourly wages of men and full-time working women shows the difference in wages which cannot be explained by experience or education. The intercept for men's full-time wages is about 20 percentage points higher that that of women and, even when the college wage premium is taken into account, the gap remains at 14 percentage points. This difference in the intercepts can be attributed to factors which are not specifically modelled, such as selection of men into higher-paid occupations or gender discrimination in the labour market. The return to full-time experience is twice as large for men as it is for women and the estimated concavity degree of full-time experience is estimated to be larger for men than women. As a result, as women gain more full-time experience, the difference in return to full-time experience between men and women decreases.

The estimated part-time and full-time wage equations for women demonstrate two important results. First, there are differences between the intercepts of part-time and full-time log hourly wages of women, but my estimates do not suggest that the return to part-time and full-time human capital are significantly different. This difference in the intercepts can be interpreted as a part-time wage penalty, and is about 1.15 dollars per hour for a full-time employed woman with no experience and without a college degree and for a similar college-graduate woman is about 1 dollar per hour. The differences in intercepts for full-time and part-time wages are also estimated by Keane and Wolpin (2010) and Francesconi (2002) using The National Longitudinal Survey of Youth 1979 in the United States.

Second, the estimated return to full-time experience for part-time employed individuals, together with its concavity degree, indicate that when women have a few (less than 3) years of full-time experience, their return to full-time experience is almost equal to their return to part-time experience. Therefore, switching between part-time and full-time jobs for mothers with a few years of human capital is less costly. However, as they work full-time for a longer period, switching to a part-time job becomes more costly. Looking at the estimates in the full-time wage equation, we observe similar patterns suggesting that as

Table 6: Log Hourly Wage Parameters

Model parameters	Description	Estimated value	Standard errors
Wage parameters (full-time employment, male)			
$\beta^m_{0,full}$		1.5705	(0.0022)
$\beta^m_{1,full}$	Return to full-time experience	0.0497	(0.0001)
$\beta^m_{2,full}$	Dec/inc return to full-time experience	-0.0012	(0.0000)
$\beta^m_{3,full}$	Return to education	0.1986	(0.0017)
ϵ^m_f	Variance	0.8564	(0.0030)
Wage parameters (full-time employment, female)			
$\beta^w_{0,full}$		1.3840	(0.0020)
$\beta^w_{1,full}$	Return to full-time experience	0.0325	(0.0000)
$\beta^w_{2,full}$	Dec/inc return to full-time experience	-0.0002	(0.0000)
$\beta^w_{3,full}$	Return to part-time experience	0.0332	(0.0001)
$\beta^w_{4,full}$	Dec/inc return to part-time experience	-0.0008	(0.0000)
$\beta^w_{5,full}$	Return to college	0.2514	(0.0011)
ϵ^w_f	Variance	0.3148	(0.0012)
Wage parameters (part-time employment, female)			
$\beta^w_{0,part}$		1.2493	(0.0028)
$\beta^w_{1,part}$	Return to full-time experience	0.0396	(0.0002)
$\beta^w_{2,part}$	Dec/inc return to full-time experience	-0.0031	(0.0000)
$\beta^w_{3,part}$	Return to part-time experience	0.0334	(0.0002)
$\beta^w_{4,part}$	Dec/inc return to part-time experience	-0.0002	(0.0000)
$\beta^w_{5,part}$	Return to college	0.3692	(0.0023)
ϵ^w_p	Variance	0.3774	(0.0017)

women gain more experience in the part-time jobs, their return to employment in full-time jobs decreases. These estimates suggest that switching from full- to part-time employment is less costly when women have less work experience, but changing becomes more costly as they gain more experience in a specific type of employment.

It is worth mentioning that while Francesconi (2002) finds different returns to part-time and full-time experiences, my estimates do not point in that direction. One possible explanation for discrepancies in our estimated wage equations is the differences between our samples. He estimates the model using a sample of always-married women while the parameters here are estimated using a sample of single and married women who can marry/remarry and also divorce. Always-married women might have unobserved characteristics that are correlated with the women's decision to work part-time or full-time. The parameters estimated in this paper are corrected for such biases by modelling employment decisions together with marital decisions, and are consequently expected to be different.

Table 7: Parameters: preferences and household production

Model parameters	Description	Estimated values	Standard errors
Preference parameters			
α_c	Marginal utility of consumption	0.2024	(0.0028)
α_{q1}	Marginal utility of household good	0.2200	(0.0042)
α_{q2}	Marginal utility of child quality	0.5143	(0.0048)
α_n	Direct utility of having a child	0.0733	-
ϵ_{ch}	Variance in utility of having a child	0.3517	(0.0095)
α_f	Utility of working full-time (women)	2.4889	(0.0215)
α_p	Utility of working part-time (women)	-0.6912	(0.0074)
α_{nw}	Utility of not working (women)	-1.9046	(0.0109)
Household production			
α	Marginal productivity of housework hours of	0.3424	(0.0022)
	men relative to women	0.3424	(0.0022)
λ	Marginal productivity of housework hours	4.5829	(0.0036)
γ	Degree of substitutability between childcare and housework hours	0.7074	(0.0023)
Marriage			
ω	Probability of meeting a potential partner	0.2173	(0.0033)
ϵ_{mar}	Variance in utility of marriage	14.3340	(0.1160)
Childcare cost			
π_{CC}	Log hourly childcare cost	3.1412	(0.0095)
ϵ_{CC}	Variance of childcare cost	1.5253	(0.0081)
δ	Discount factor (not estimated)	0.954	-
θ	Bargaining weight in Nash product (not estimated)	0.5	-

The wage distribution parameters $(\beta^w_{0,k} - \beta^w_{5,k})$, $(\beta^m_{0,full} - \beta^m_{3,full})$ and $(\epsilon^j_f, \epsilon^w_p)$ are identified using the first and second moments of wages conditional on work experiences and education, together with employment choices conditional on life-cycle choices, such as fertility and marital decisions at different ages.

Production Function Parameters: Table 7 reports the estimated household production and preference parameters. The marginal productivity of housework hours of single individuals (λ) is 4.58 and the marginal productivity of housework hours of men relative to women (α) is 0.34, indicating that for men 1 hour of housework hours is less productive in terms of household production than for women, which results in women's specialisation in household production. Along with various other features in the data, the marginal productivity of housework hours of single individuals λ is identified by the proportion of individuals who work part-time or are out of the labour market. On the other hand, the relative marginal productivity of household production of men compared to women (α) is identified by the difference between the proportions of part-time and non-working single women and the proportions of part-time and not-working married women, together with the proportion of married individuals. Consider the case that women's housework hours are more productive than men's housework hours, i.e. we have a small (α). In this case we should observe in the data that upon marriage women start to work less because there are gains from their specialisation in household production, and because of these gains from marriage we also should observe in the data that a larger fraction of individuals are married.

Preference Parameters: The estimated marginal utility of consumption (α_c) and marginal utility of household goods (α_{q1}) are 0.2024 and 0.22, respectively. These estimated parameters are such that an additional unit of household goods gives about 10 percent larger utility than an additional utility of consumption. The marginal utility of child quality (α_{q2}) is 0.5143, which is about 2.5 times larger than the marginal utility of household goods. This shift in preferences upon having a child shows the shift in women's preferences towards staying at home and spending time with the child upon becoming mothers. The shock to utility of having a child is 0.35.

Various features of the data help in identifying the preference parameters, and among them are changes in proportions of part-time, full-time and non-working women across the life-cycle, conditional on fertility and marital decisions. Consider the case that marginal utility from household goods (α_{q1}) is larger than marginal utility from consumption (α_c). In this case we expect to observe in the data that, firstly, single non-mothers start to work fewer hours upon getting married, because, upon marriage, both members of the household benefit from the joint consumption of the public good, i.e. household good (Q_1), and secondly, that a larger proportion of individuals in the data get married to gain from specialisation in the household. On the other hand, if the marginal utility of consumption (α_c) is larger than (α_{q1}) we would still observe that people get married because of the joint consumption of the public good, but we should not observe a reduction in the labour supply of single non-mothers upon marriage, since consumption would have provided them with a higher marginal utility. In fact, in the data we observe that a large fraction of individuals get married and that women reduce their labour market hours upon marriage. These features of the data among various other features help in identifying the marginal utility of consumption from the marginal utility of household good production.

A similar argument holds for the identification of the marginal utility of child quality (α_{q2}). For example, consider the case that marginal utility of child quality is larger than marginal utility of household production and they are both larger than marginal utility from consumption ($\alpha_c < \alpha_{q1} < \alpha_{q2}$). In this case, we should observe in the data that a large fraction of married couples have children because children provide the household with an additional household good with a high marginal utility. Furthermore, we should observe that upon having children, married mothers start to work less because a larger time spent with the child provides the household with larger utility compared to the same time spent working in the labour market and obtaining higher consumption. In the data, I observe that a large fraction of married couples have children, and I also observe that in transition to motherhood, a large fraction of married women start to work less or drop out of the labour market. Therefore, the fraction of married couples with children and the proportions of mothers moving to part-time employment or dropping out of the labour market, among various other features of the data, help in identifying the marginal utility from child quality (α_{q2}).

The direct utility from working full-time, part-time, or not working is 2.48, -0.69, and -1.90, respectively. These parameters are identified by the proportion of individuals working full-time, part-time and those who are not working, together with the proportions of part-time and full-time working individuals who have a child and/or are married.

It is important to discuss how the marginal utility of household goods production (α_{q1}), the marginal utility of child quality (α_{q2}), the relative marginal productivity of men to women (α), and the marginal productivity of housework hours of single individuals (λ) are identified separately from each other. λ is a common parameter in the production of household goods and child quality of single and married men and women. Therefore, in general, the amount of time individuals spend out of the labour market identifies this parameter. The marginal productivity of men compared to women (α) is a common parameter for married individuals and therefore the change in housework hours of single individuals upon marriage together with the fraction of married individuals identifies this parameter. On the other hand, α_c and α_{q1} are identified by the extent to which housework hours change after marriage, conditional on not having a child, together with the proportion of married individuals, while α_{q1} and α_{q2} are separately identified by how much the labour supply of married women changes after having a child, together with the proportion of married individuals having a child.

The degree of substitutability between childcare and housework hours (γ) is estimated at 0.70, implying an elasticity of substitution of 3.3. This estimate indicates that housework hours and childcare hours are close substitutes. The high degree of substitutability implies that a relative decline in the cost of childcare, while keeping the opportunity cost of home production (wages) constant, should increase the use of childcare and decrease housework hours (or increase labour supply). The degree of substitutability between formal childcare and housework hours is identified using the estimated childcare cost and employment patterns of women, together with the choice of childcare. If childcare and housework hours are substitutable and childcare is expensive, we expect to observe the following patterns in the data: mothers work less than non-mothers because although childcare and housework hours are substitutable, mothers cannot easily substitute childcare with housework hours since childcare is expensive. In addition to differences in the labour supply of mothers, we expect to see that working mothers, who have higher incomes purchase more hours of childcare because they can afford to pay for its cost. To the contrary, those not working or working part-time should purchase less formal childcare. The variation in the use of childcare by employment status of the mother should be more salient when mothers are single because they do not have their partners' income to finance the cost of childcare.

Marriage Parameters and Shocks The probability of meeting a potential partner (ω) is 21 percent, implying that one in 5 meetings results in marriage. The variance in the utility of marriage (ϵ_{mar}) is estimated to be 14.3. This high variance in the utility of marriage increases the risk to marriage to the extent that negative marriage shocks have large effects on the utility of being married. However, marriage is still an attractive option because of the production of public goods and the gain from specialisation in such production. Many features of the data contribute to estimating the probability of meeting and the variance in the utility of marriage, such as employment patterns after marriage, flows to marriage and divorce, and fractions of married and divorced individuals at different ages.

Cost of Childcare: π_{CC} and ϵ_{CC} report the estimated mean and variance of the cost of childcare. One hour of childcare is estimated to cost 23 dollars on average, which is larger than an hour's return to both full-time and part-time employment for a woman without a college degree and no work experience. Therefore, women with lower work experience and education might prefer to stay home and take care of their children. Therefore, at this cost of childcare reducing labour hours and increasing housework hours can be expected, as long as the discounted expected future wages, due to lower work experience, do not deter women from spending more time in home production. childcare take-up and the first and second moments of cost of childcare at different employment states conditional on marital status, together with employment patterns, after having a child, help in identifying the mean and variance of childcare costs.

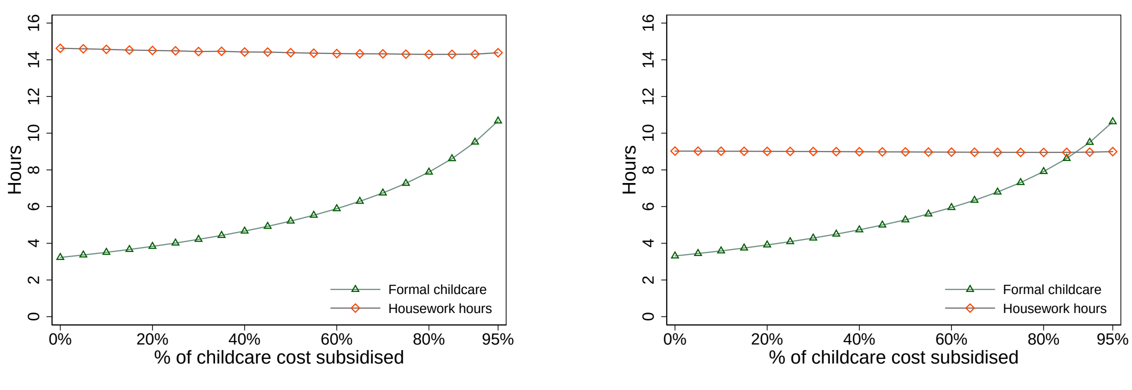
6 Policy Experiments: Childcare Cost Subsidies

In this section, I study how providing households with universal childcare subsidies, which range from 5 to 95 percent of the cost of childcare, affect take-up, employment, marital decisions, and wages. These policy experiments are universal and are independent of employment status or income. I evaluate the impact of these policies on single and married individuals separately. In doing so, I make use of the model's endogenous marital decisions' feature which makes the model a good fit for such an exercise. In each section, I explain several of the model's mechanisms which contribute to observing different behavioural responses. The reader should bear in mind that various aspects of the model simultaneously play a part in observing these results, and to explain one mechanism in isolation would be to simplify the each factor's contribution.

Childcare Take-up and Housework Hours: Figure 3 shows the simulated childcare take-up and housework hours of women and men in response to childcare subsidies. We can see that more generous childcare subsidies are positively associated with its take-up. A 10 percent decrease in the cost of childcare increases childcare take-up by women from an average of 3.23 hours to 3.51 hours per day (or by 8.7 percent) and we observe similar responses for men. However, the substitution between formal childcare and housework hours happens at a much slower rate than the increase in childcare take-up with a 10 percent subsidy, having almost no impact on housework hours.

The decision to substitute childcare with housework hours (or increasing labour supply) is governed by the trade-off between (i) working more, having a higher consumption and being able to purchase more childcare, and (ii) working less and having a higher household good production (Q1 and Q2 in the model). This trade-off depends on: (i) the return to

Figure 3: Effects of subsidies on childcare take-up and housework hours



(a) Women (b) Men

employment, i.e. current wages; (ii) future returns to participation in the labour market, i.e. return to investment in human capital; (iii) childcare costs; (iv) the degree of substitutability between childcare and housework hours; as well as (v) the marginal utility of consumption relative to household good production. In the following, I explain how these factors play a role in observing the patterns in the policy exercises.

First, let us focus on the income and substitution effects arising from childcare subsidies. In order to explain these two effects, let us for the moment assume that formal childcare and housework hours are perfect substitutes. In this case, by substituting formal childcare with housework hours, households obtain the same amount of child quality (Q2 in the model), a higher consumption, but a lower Q1 because this household good is produced by housework hours only. In this scenario, we expect to observe a decrease in housework hours (increase in labour supply) as long as the life-time utility from working is larger than the forgone household good production. This is the so called substitution effect. On the other hand, childcare subsidies increase household income by decreasing the cost of childcare to the extent that by working fewer hours households could obtain higher levels of consumption and/or household goods.

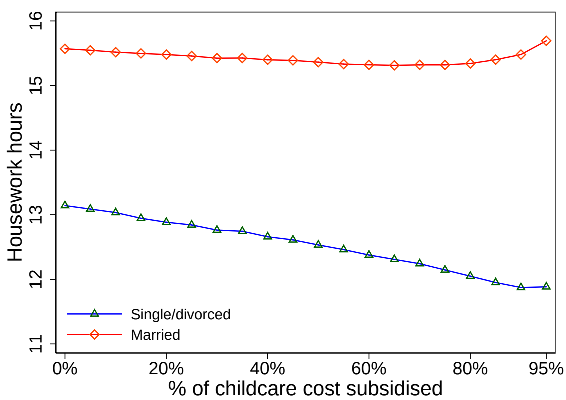
The fact that housework hours remain unchanged in response to policy exercises indicates that the substitution and income effects for housework hours offset each other. Decreasing housework hours leads to an increase in consumption (through increased labour market income) and a decrease in the production of both Q1 and Q2, keeping all else constant. The overall return from a change in housework hours then partly depends on the marginal utility of consumption and the marginal utility of Q1 and Q2. It can be seen in the parameter estimates (see Table 7) that the marginal utility of consumption and Q1 are both about 0.2. Consequently, the marginal gain from decreasing housework hours and increasing employment is essentially offset by the marginal loss from foregone household good production, i.e. Q1 and Q2. While housework hours can be substituted by childcare for the production of Q2, there are no such substitution possibilities for the production of Q1, which explain the fact that housework hours remain unchanged in response to childcare subsidies.

Figure 4a illustrates that single women are considerably more responsive to childcare subsidies compared to married women. For example, a 40 percent decrease in the cost of childcare reduces housework hours from 13.14 hours to 12.66 per day (or by 3.7%) for single women and from 15.57 to 15.4 per day (or by 1.1 percent) for married women.

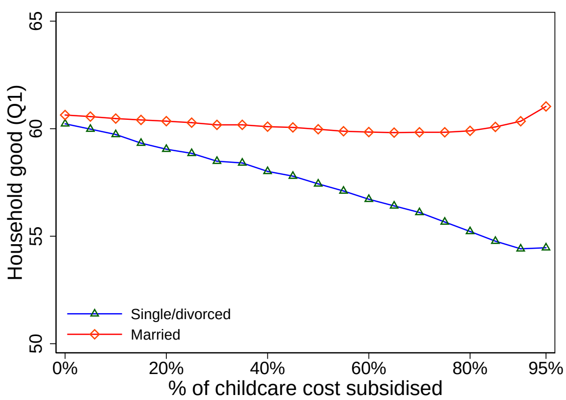
In general, the two opportunity costs arising from substituting housework hours with childcare, i.e. forgone household good production (Q1) and child quality (Q2), are larger for married women, mainly because these goods are used publicly within the household. In the estimated model, the opportunity cost of decreasing housework hours is smaller for men than for women, because men have relatively higher wages (see Table 6) and their housework hours are less productive in terms of household good production. More specifically, the parameter estimates show that the relative marginal productivity of housework hours of men is 34 percent of that of women (see Table 7). Given the estimates of the model, if the household is seeking funds to purchase childcare and if time restriction also allows, we expect to observe a decrease in the housework hours of men (or an increase in their hours of work) while women specialise in household good production, which is one explanation for why the increase in the housework hours of married women is less than for single women.

As a result of the reduction in the housework hours of single women, we would expect the production of household good (Q1) - which is produced with housework hours only - to decrease. For married women this fraction is expected to remain unchanged because the housework hours of both married men and women remain relatively unchanged. Indeed,

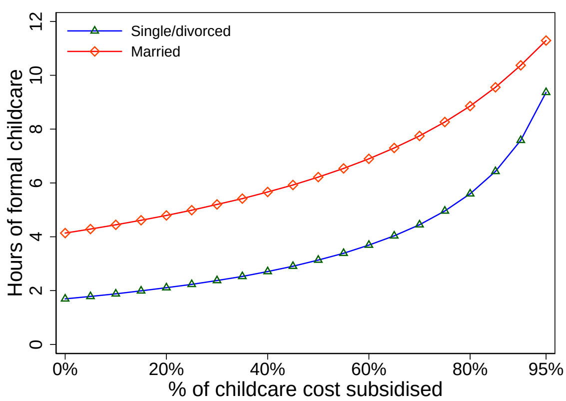
Figure 4: Effects of subsidies on home production of single and married women



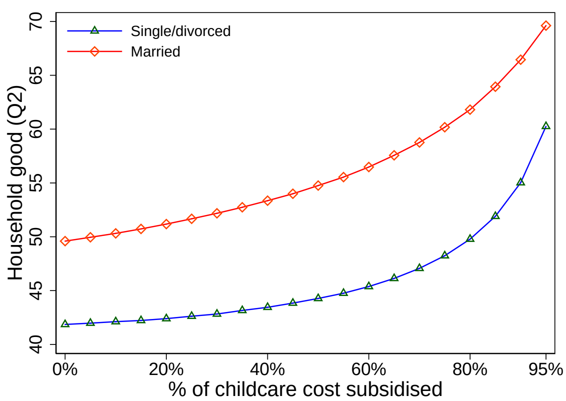
(a) Housework hours



(b) Household good (Q1)



(c) Childcare take-up



(d) Household good (Q2)

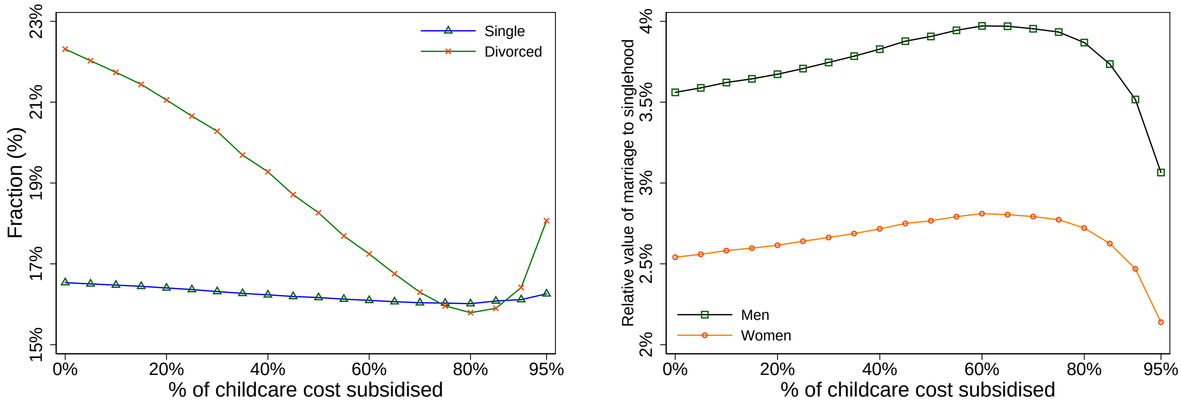
Figure 4b shows that this is the case, so that Q1 of single women falls while that of married women remains unchanged. On the other hand, as depicted in Figure 4c, there is an increase in childcare take-up for both single and married women. Hence, we expect to observe an increase in the child quality (Q2) of both single and married women but a relatively smaller increase in the child quality of single women relative to married women because Q2 is produced with both housework and childcare hours. These results have implications for gains from marriage which will be discussed further.

Another interesting feature in Figure 4a is that any subsidy above 80 percent increases the housework hours of married women and does not have any further impact on the housework hours of single women. To explain this, let us turn to the non-linearity aspect of the child quality production function. The estimated elasticity of substitution between childcare and housework hours is 3.3, implying that childcare and housework hours are close substitutes; nevertheless, there is some complementarity between the two inputs. This complementarity implies that, keeping the total amount of the two inputs constant, a more equal proportion of both inputs produces a higher child quality in contrast to a disproportionate amount. Therefore, at lower levels of childcare subsidies, when the proportion of formal childcare to housework hours is lower, we observe that households have higher incentives to reduce housework hours and work more to purchase childcare. On the other hand, when childcare subsidies are very generous, i.e. at 80 percent or above, households have incentives to purchase a large amount of childcare but simultaneously want to spend more time at home with the child due to the existing complementarity between the two inputs, implying a smaller impact of policies on housework hours.

Marriage and divorce: Figure 5a shows the impact of childcare subsidies on marital status. A policy which subsidizes 40 percent of childcare costs decreases the fraction of divorced individuals by 3.03 percentage points. As subsidies get more generous, the fraction of divorced individuals decreases further and at 80 percent reaches its minimum, which is 6.52 percentage points lower than the benchmark model. Similar patterns, albeit smaller, are observed in the fraction of single individuals. The second interesting observation from these exercises is that policies that subsidize more than 80 percent of the cost of childcare increase the fraction of divorced/single individuals. Figure 5b shows that indeed the value of life-time utility from marriage relative to life-time utility of being single starts to decrease significantly when childcare subsidies reach 80 percent.

In order to explain these patterns, recall from Figure 4a that childcare programmes below 80 percent increase the housework hours of single women but do not affect those of married women. The reduction in single women's housework hours decreases their produc-

Figure 5: Effects of childcare subsidies on marital decisions



(a) Marital status

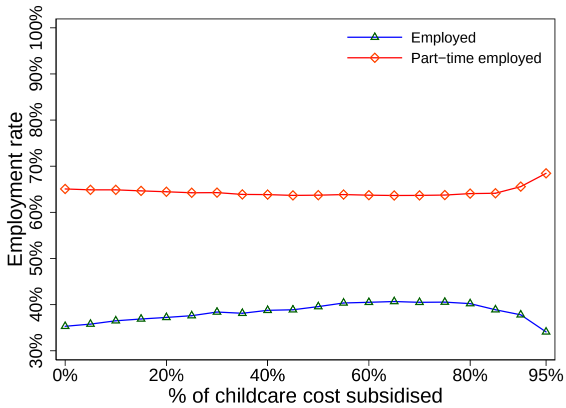
(b) Life-time utility, by marital status

tion of household goods (Q1 and Q2) of single women in comparison to married women (see Figures 4b and 4d). The larger increase in Q1 and Q2 within marriage, which also has a higher marginal utility compared to the marginal utility of private consumption, increases gains from marriage and as a result we see that the fraction of divorced/single individuals decreases. On the other hand, subsidies above 80 percent do not change the housework hours of single women any further but lead to a larger increase in childcare take-up by single women compared to married women (see Figure 4c). Hence, one would expect to observe a larger increase in child quality (Q2) for single women compared to married women. Figure 4d shows that this is the case, with childcare subsidised by 80 percent, the difference between Q2 for single and married women starts to decrease. This explains why we observe a larger increase in the fraction of divorced individuals as subsidies pass 80 percent.

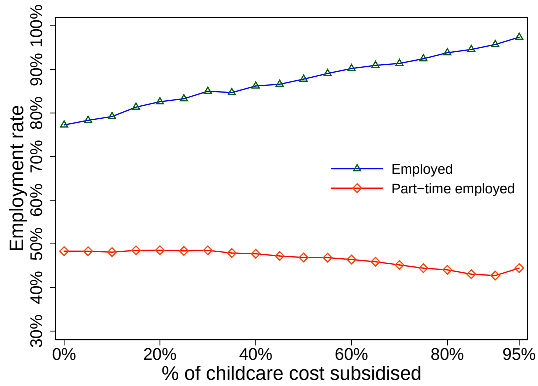
Employment and Wages: Figures 6a and 6b show how subsidies affect the intensive and extensive margins of female labour supply. Married women's labour supply remains relatively unchanged, while subsides have significant impacts on the labour supply of single women. A 90 percent decrease in the cost of childcare increases employment rates of single women by 18.44 percentage points and that of married women by 2.5 percentage points. More interestingly, the share of part-time employed women does not increase, implying that subsides increase full-time employment, which is associated with higher wages. Figures 6c and 6d depict the labour supply responses of single women by level of education and indicate that the increase in employment is observed among lower educated women with a 90 percent childcare subsidy, increasing their employment rate by 30 percentage points.

Figure 7 shows the growth in the life-time income and overall employment rate of lower and higher educated women and indicates that education plays an important role in how

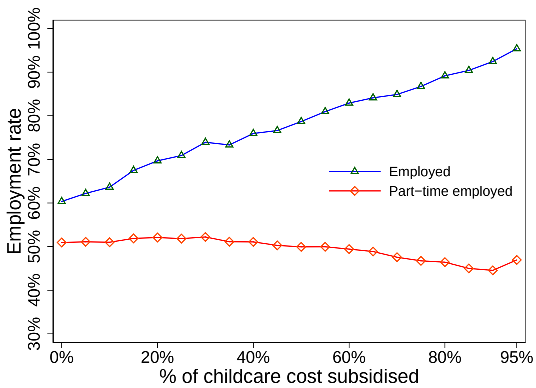
Figure 6: Childcare subsidies and female labour supply



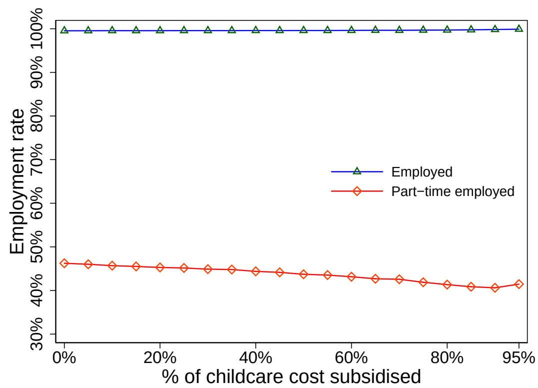
(a) Married



(b) Single



(c) Single: below-college educated



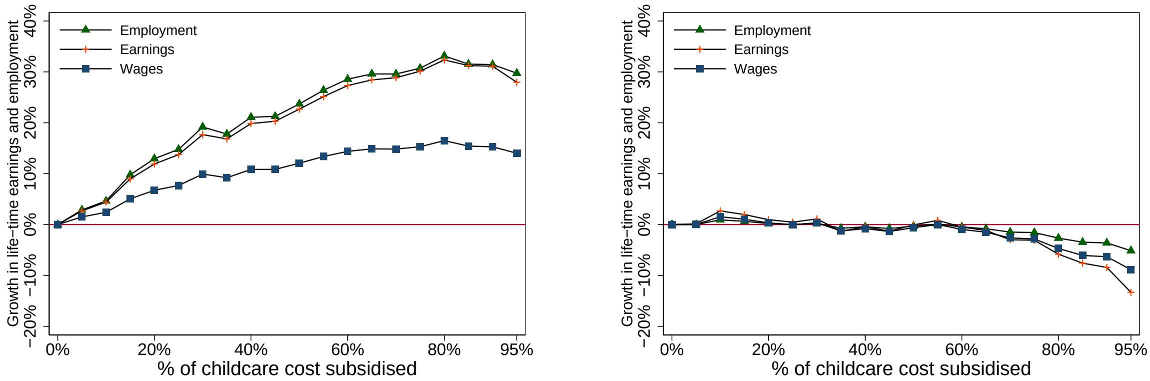
(d) Single: college-graduates

This figure shows the simulated intensive and extensive labour supply responses to childcare subsidy programmes. Single individuals include never-married and divorced individuals.

women respond to childcare subsidies. Any subsidy above 60 percent decreases the labour supply of higher-educated women which subsequently affects their life-time earnings and wages. For example, a 90 percent subsidy decreases the employment rate of higher-educated women by 3.1 pp and their life-time income by 8.4 percent (See Figure 7b). Conversely, such a subsidy increases the employment rate of lower educated women by 9.1 pp and their life-time income by 31.1 percent (See Figure 7a).

Welfare Implications Figure 8 depicts the implications of childcare subsidies for overall welfare where welfare is defined as the expected life-time utility at the beginning of the life-cycle. Recall from Figure 4d that childcare subsidies increase the value of household good (Q2) or child quality, and are therefore expected to increase welfare. Figures 8a and 8b show that the growth in welfare follows a similar pattern, with $Q2$ increasing. Furthermore, the increase in welfare is observed among both women and men from lower- and higher-

Figure 7: Childcare subsidies, employment, and life-time earnings

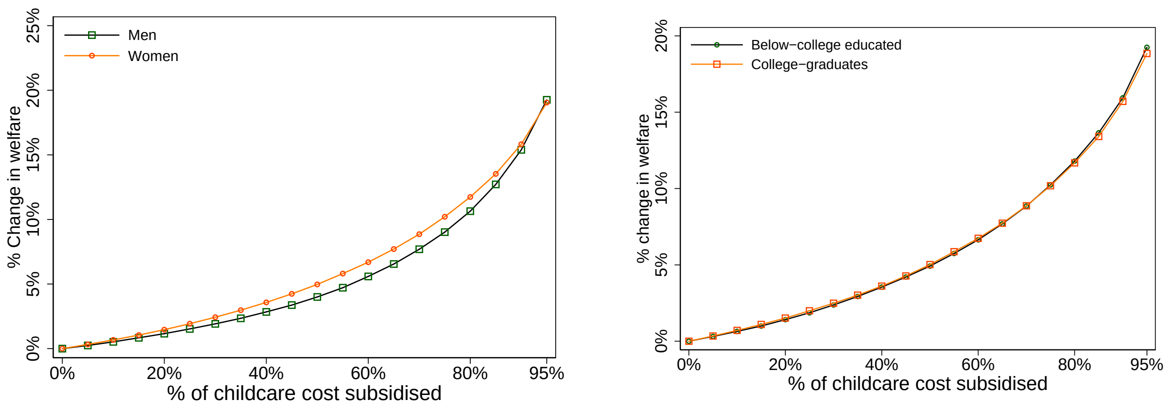


(a) Below-college educated (b) College-graduates

The growth in earnings and wage is calculated as the percentage change in the overall life-time wages and earnings relative to the benchmark model; i.e. 0% childcare subsidy.

education backgrounds. There are however slight differences on how welfare changes for these subgroups. The increase in welfare is larger for women in general and also when subsides are more generous, i.e. subsidies above 60 percent lead to a larger increase in the welfare of lower-educated individuals in particular.

Figure 8: Welfare implications of childcare subsidies



(a) Welfare - by gender (b) Welfare - by education

7 Conclusion

In this paper I develop and estimate a dynamic model of employment, fertility, marital, and childcare decisions in order to evaluate the impact of childcare subsidies on various life-time outcomes for men and women. In the model, labour supply, fertility, and marital decisions are endogenously determined. Household decisions are modelled in a Nash bargaining framework, where outside options are specified as the values spouses obtain from making decisions as single individuals. Household members cannot commit to insure against the child penalty associated with the lower labour supply of women. The model is estimated using the 1968-1996 waves of PSID, thereafter the estimated model is used for counter-factual analyses.

There are three important take-aways from these policy experiments: first, childcare subsidies increase its take-up but, despite the close substitutability between childcare and housework hours, the labour supply of married mother is hardly affected. However, single mothers and specifically those form lower-education backgrounds are considerably more responsive to these programmes. Secondly, I show that the increase in the labour supply of lower-educated women expands their life-time income substantially. Thirdly, I show that the increase in childcare take-up due to childcare subsidies affects the fraction of married individuals. Childcare as an input into production of household good improves the value of the household public good produced within marriage and increases the fraction of married individuals. The fourth take-away from these exercises is that childcare subsidies increase overall welfare by improving the value of the household good produced in the household.

To conclude, the model estimated in this paper studies the implications of childcare subsidies in a dynamic collective framework. However, due to computational limits, I abstract away from modelling child development and savings. Adding both cognitive and non-cognitive child development to the model is beyond the scope of this paper. Furthermore, I do not model savings and wealth formation which could have implications for household consumption smoothing behaviour. Lastly, my estimates represent 1968-1997 data in which wages and the proportion of female college graduates were different from those of present-day US. Therefore, the estimated parameters are expected to be different if recent US data are to be used.

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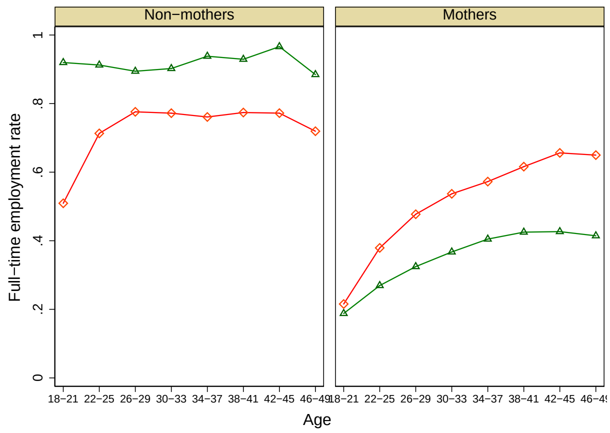
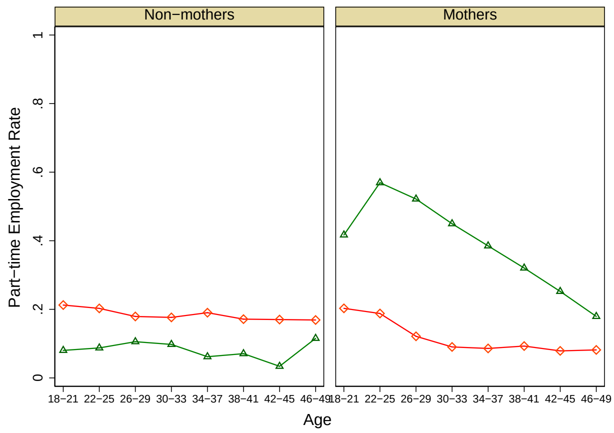
Appendix

A Appendix: Model Fit

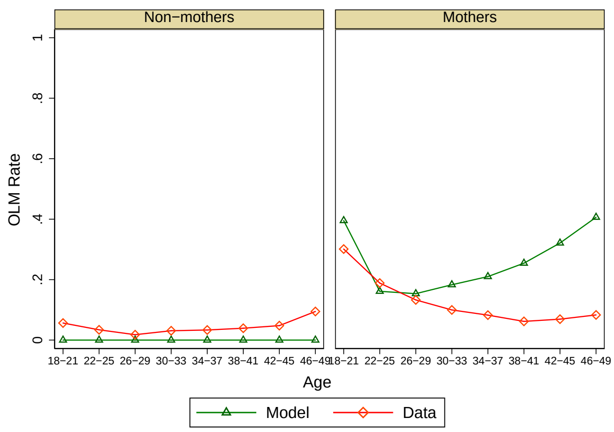
Figure 9: Employment of single mothers and non-mothers



(a) Full-time employment

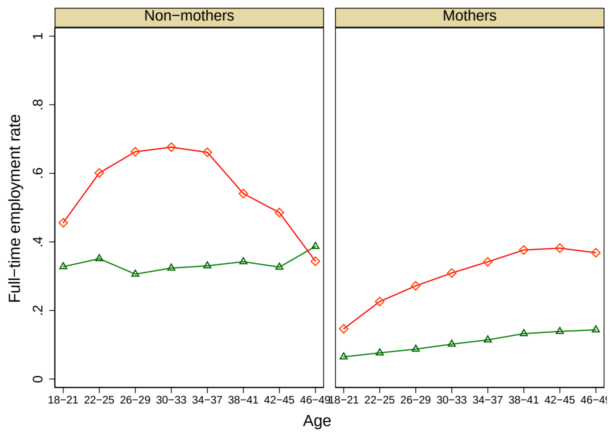


(b) Part-time employment

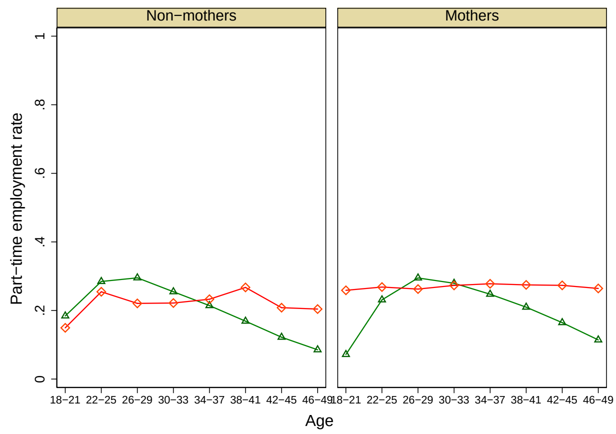


(c) Not working

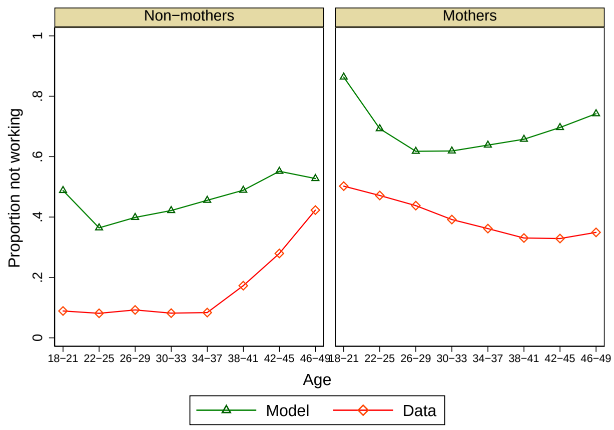
Figure 10: Employment of married mothers and non-mothers



(a) Full-time employment

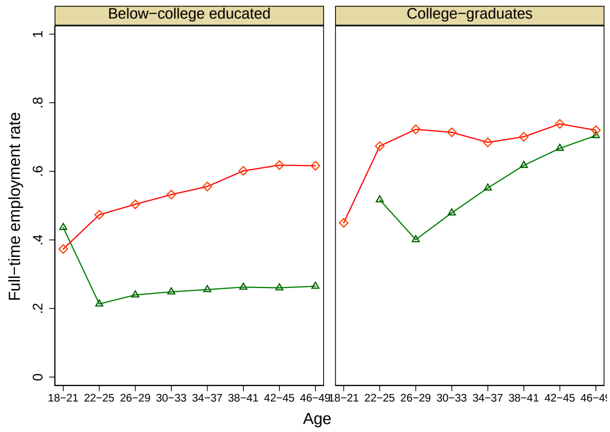


(b) Part-time employment

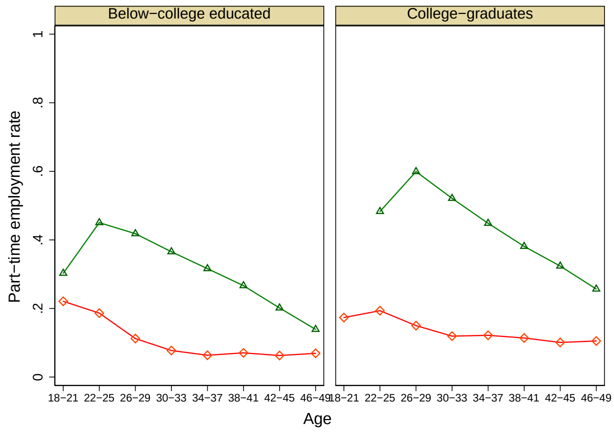


(c) Not working

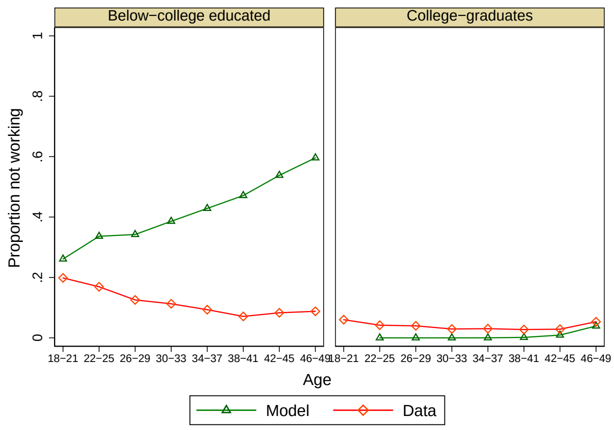
Figure 11: Employment of single women, by education



(a) Full-time employment

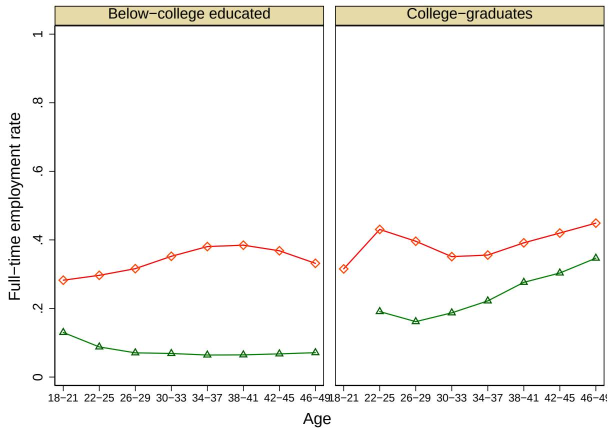


(b) Part-time employment

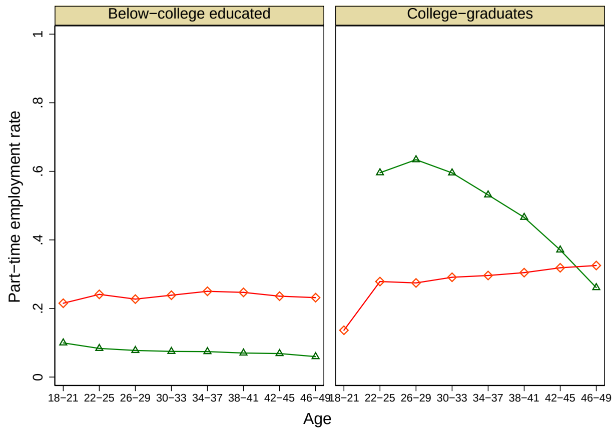


(c) Not working

Figure 12: Employment of married women, by education



(a) Full-time employment



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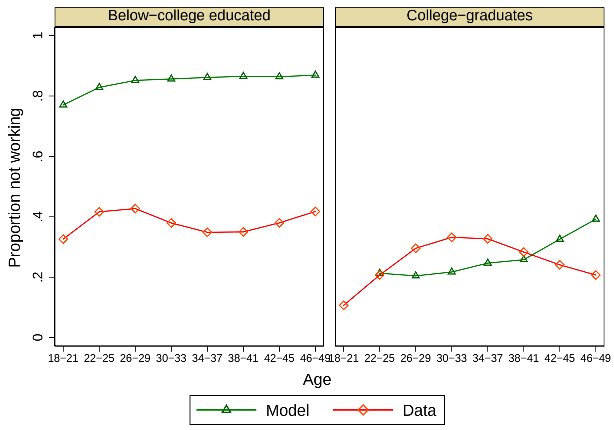

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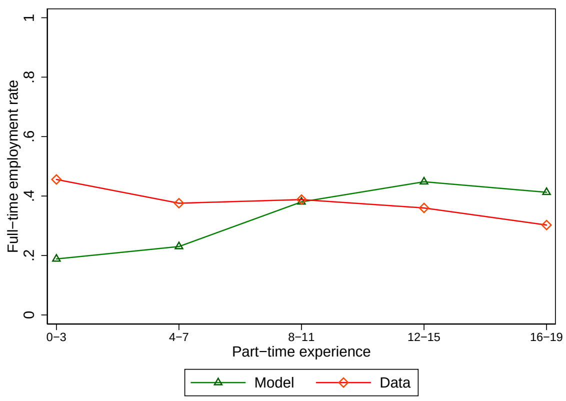
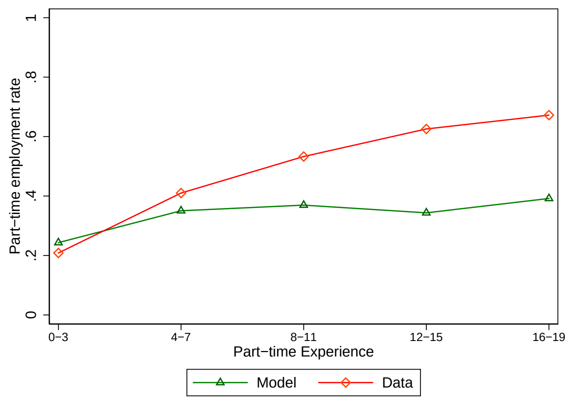
Figure 13: Employment of women, by part-time work experience



(a) Full-time employment



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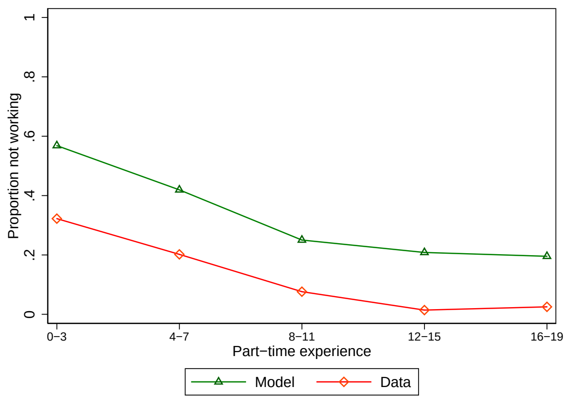
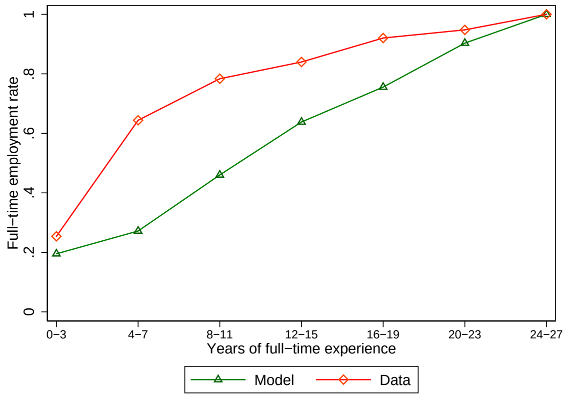
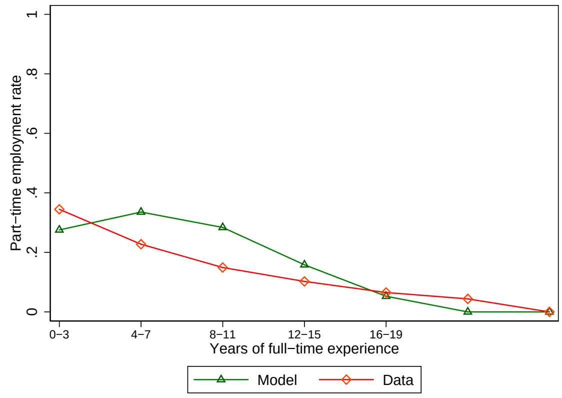


(c) Not working

Figure 14: Employment of women, by full-time work experience



(a) Full-time employment



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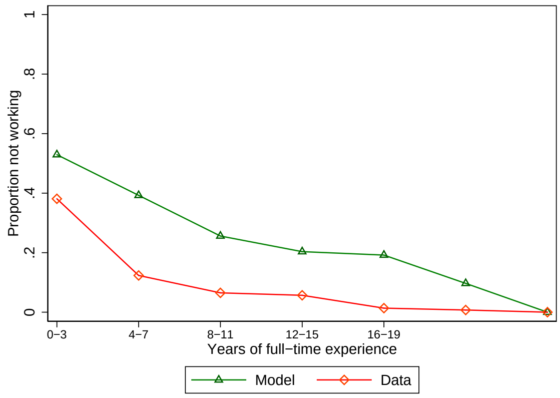
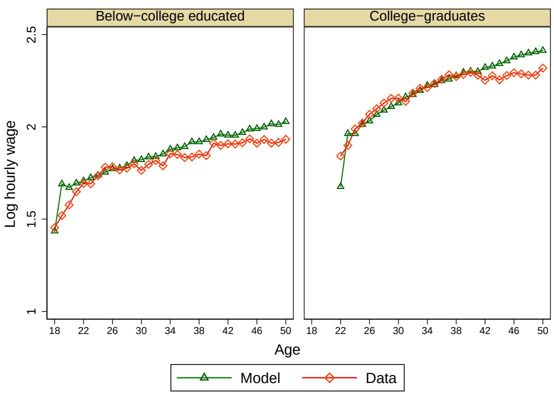
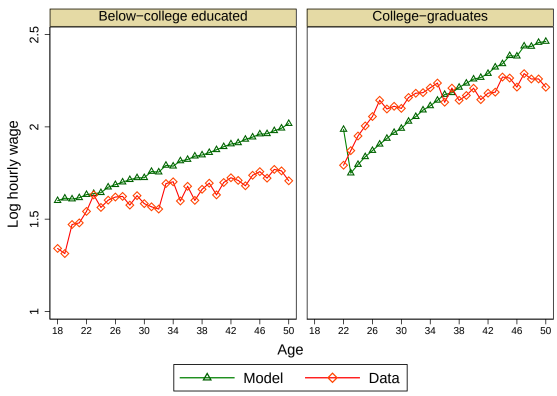


(c) Not working

Figure 15: Women log hourly wage, by education

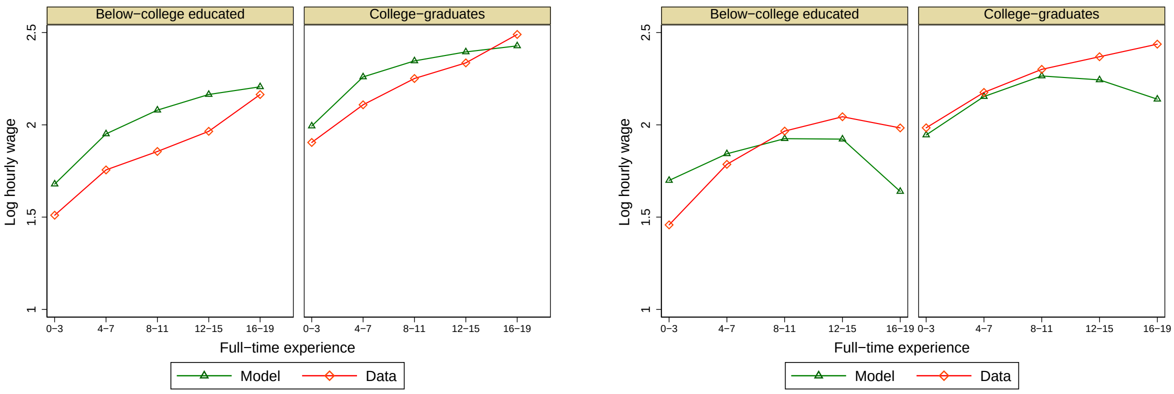


(a) Full-time employed



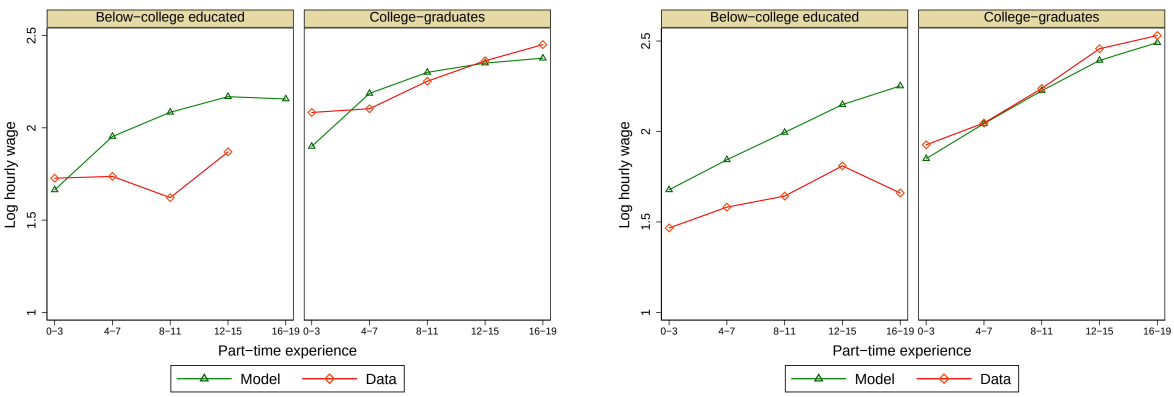
(b) Part-time employed

Figure 16: Growth in women log hourly wage by full-time experience



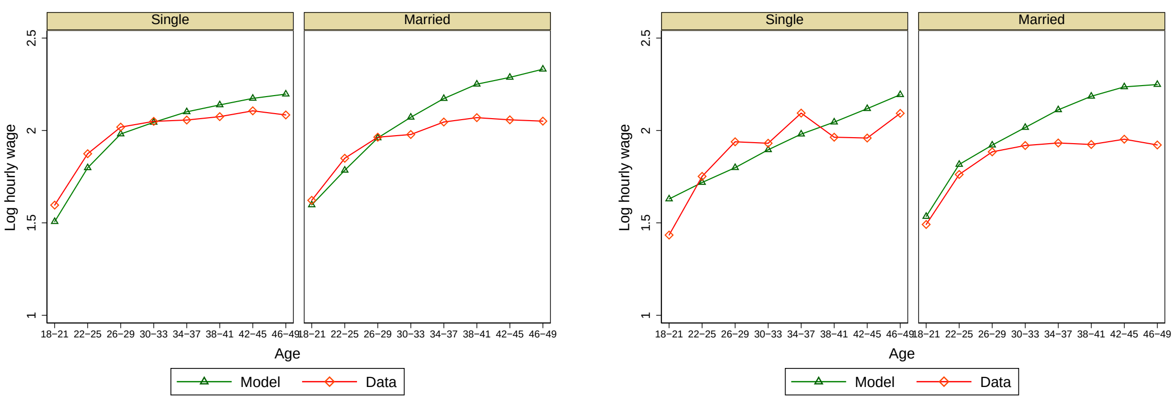
(a) Full-time employed (b) Part-time employed

Figure 17: Growth in women log hourly wage by part-time experience



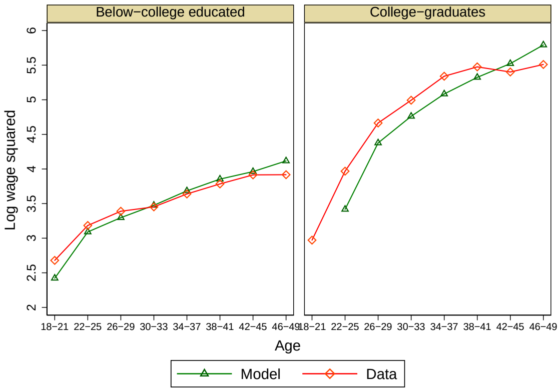
(a) Full-time employed (b) Part-time employed

Figure 18: Women log hourly wage, by marital status

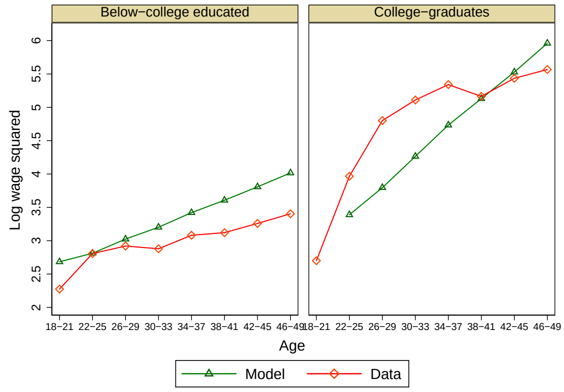


(a) Full-time employed (b) Part-time employed

Figure 19: Women log hourly wage squared, by education

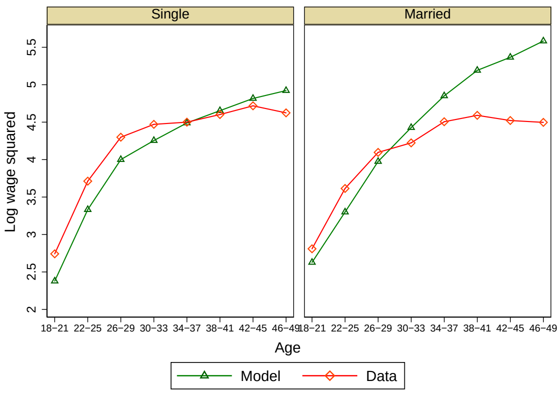


(a) Full-time employed

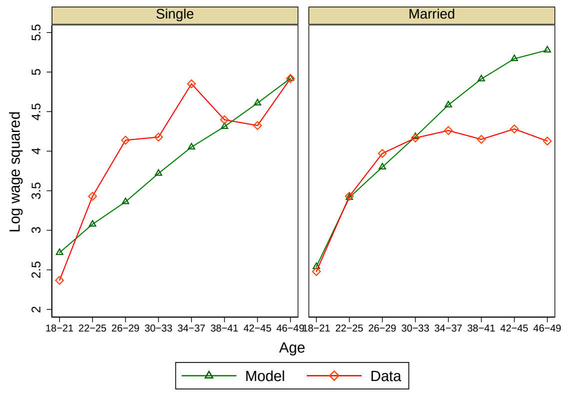


(b) Part-time employed

Figure 20: Women log hourly wage squared, by marital status

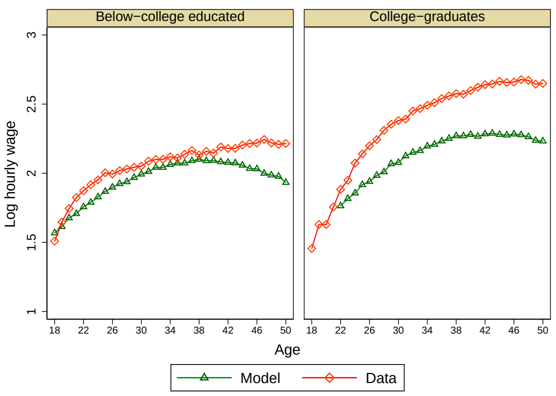


(a) Full-time employed

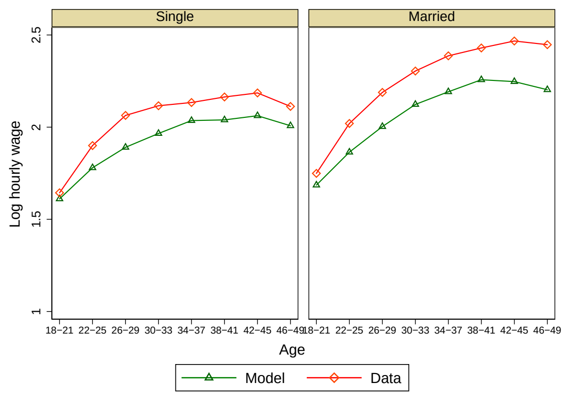


(b) Part-time employed

Figure 21: Men's full-time log hourly wages



(a) By education



(b) By marital status

Figure 22: Men's log hourly wage, by full-time experience

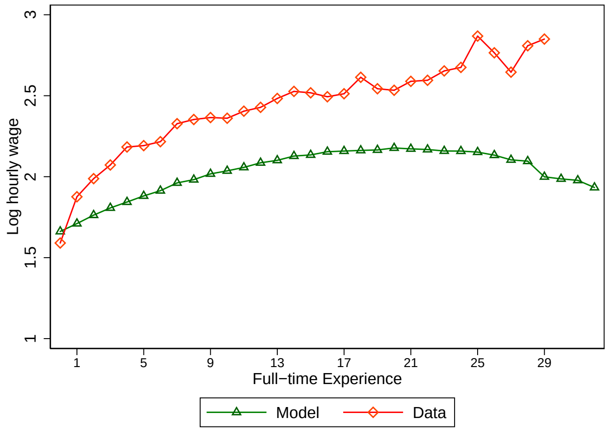
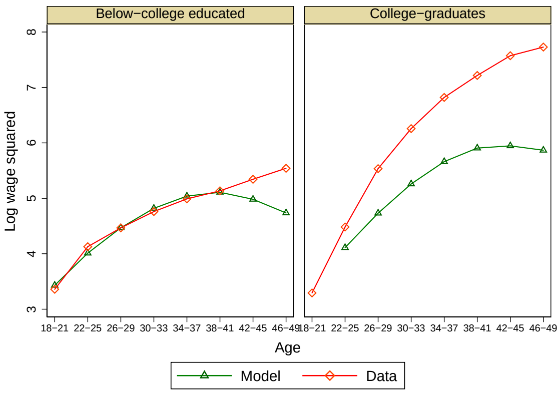
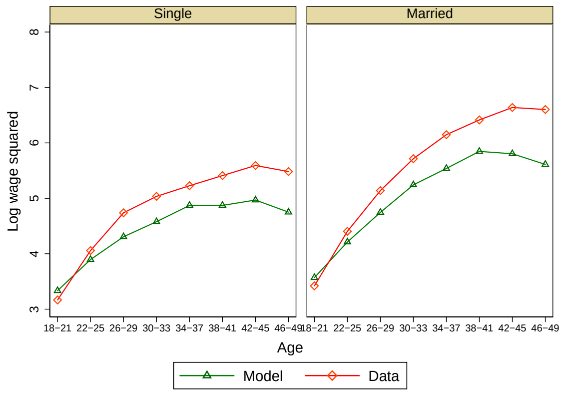


Figure 23: Men's full-time log hourly wage squared

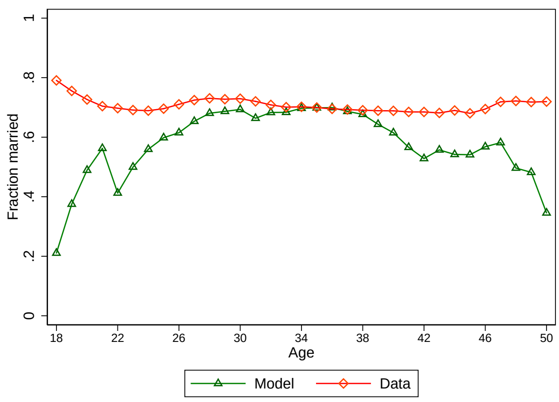


(a) By education

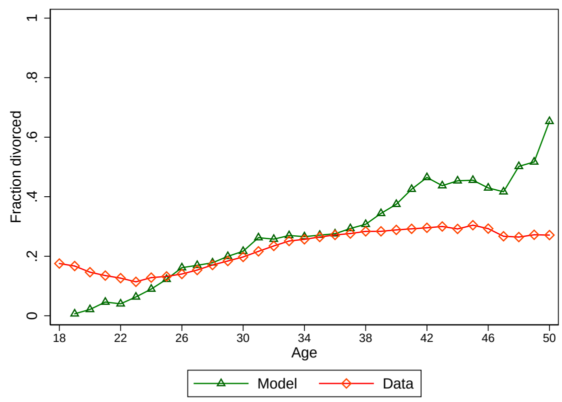


(b) By marital status

Figure 24: Marital status

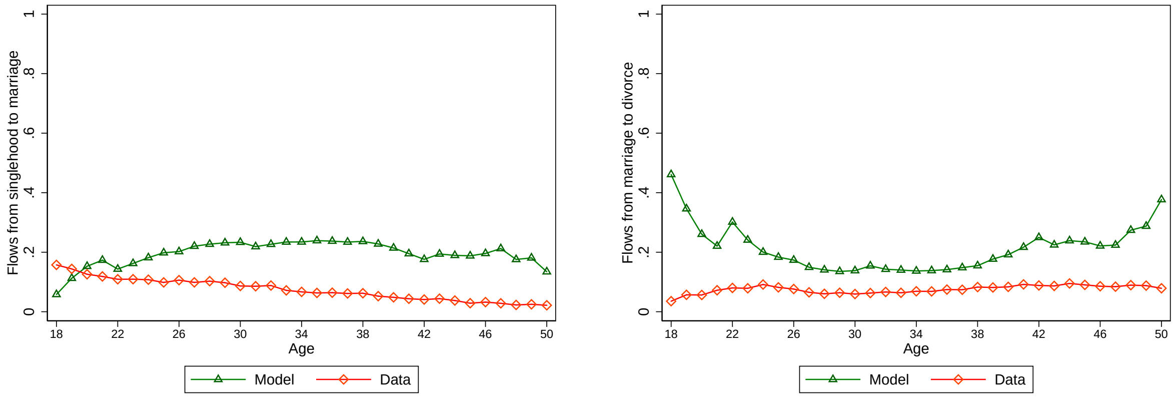


(a) Married



(b) Divorced

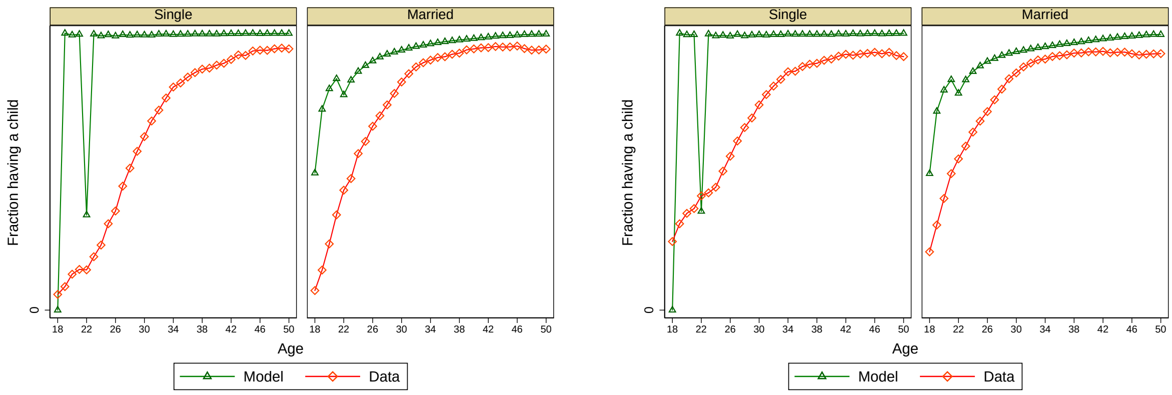
Figure 25: Flows to divorce and marriage by age



(a) Transition to marriage

(b) Transition to divorce

Figure 26: Fraction having children by marital status



(a) Men

(b) Women

Table 8: Hours of childcare used by men and women

Gender	Marital status	Employment status	Childcare hours	Model	Data
Women	Single	Full-time	No CCare	0.610	0.483
			Part-time	0.175	0.280
			Full-time	0.215	0.237
		Part-time	No CCare	0.909	0.548
			Part-time	0.030	0.339
			Full-time	0.061	0.113
		Not working	No CCare	1.000	0.907
			Part-time	0.000	0.079
			Full-time	0.000	0.019
Men	Single	Full-time	No CCare	0.816	0.682
			Part-time	0.071	0.227
			Full-time	0.113	0.091
Women	Married	Full-time	No CCare	0.265	0.407
			Part-time	0.338	0.290
			Full-time	0.397	0.303
		Part-time	No CCare	0.507	0.558
			Part-time	0.168	0.358
			Full-time	0.325	0.083
		Not working	No CCare	0.690	0.821
			Part-time	0.075	0.162
			Full-time	0.235	0.017

Table 9: Hourly cost of childcare, by gender and marital status

Gender	Marital status	Employment status	Mean		Variance	
			Model	Data	Model	Data
Women	Single	Full-time	1.197	0.640	1.857	1.553
		Part-time	0.523	0.571	1.027	0.939
		Not working	0.000	0.549	0.000	0.916
Men	Single	Full-time	1.150	0.756	1.938	0.984
Women	Married	Full-time	1.899	0.709	4.003	1.029
		Part-time	1.634	0.988	3.339	1.714
		Not working	1.474	1.035	3.056	1.980