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## The effect of children on the level of labor market involvement of married women: what is the role of education?

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Market Involvement of Married Women:  
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March 2009

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## **ABSTRACT**

### **The Effect of Children on the Level of Labor Market Involvement of Married Women: What is the Role of Education?**

We analyze the way women's education influences the effect of children on their level of labor market involvement. We propose an econometric model that accounts for the endogeneity of labor market and fertility decisions, for the heterogeneity of the effects of children and their correlation with the fertility decisions, and for the correlation of sequential labor market decisions. We estimate the model using panel data from NLSY79. Our results show that women with higher education work more before the birth of the first child, but children have larger negative effects on their level of labor market involvement. Differences across education levels are more pronounced with respect to full time employment than with respect to participation. Other things equal, higher wages reduce the effect of children on labor supply. Controlling for wages, women with higher education face larger negative effects of children on labor supply, which suggest they are characterized by a combination of higher marginal product of time spent in the production of child quality and higher marginal product of time relative to the marginal product of other inputs into the production of child quality.

JEL Classification: C11, C15, J13, J22

Keywords: female labor supply, education, endogenous fertility decisions, heterogeneous children effects, multinomial probit model, Gibbs sampler

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# 1 Introduction

Theoretical household models of time allocation (Mincer, 1962, Becker, 1965, Willis, 1973, Michael, 1973, Leibowitz, 1974, Gronau, 1977, Angrist and Evans, 1996, 1998) suggest that children may have a larger negative effect on the labor supply of women with higher education. In these models, families maximize inter-temporal utility functions defined over a set of commodities, which include the number and the quality of children (the utility-generating characteristic of a given child). The utility-generating commodities are produced at home with combinations of goods and services purchased on the market and the time inputs of the household members. Utility is maximized subject to the wealth constraint, which equates life-time income with expenditure on utility-generating commodities, which are evaluated at their respective opportunity costs.<sup>1</sup> The solution to the optimization problem entails, on the one hand, the demand functions for the utility-generating commodities, and, on the other hand, the optimal allocation of household members' time among leisure, market work, and home production.<sup>2</sup> The derived demand for children is the underpinning element of economic models of fertility. On the supply side, the optimal allocation of time allows predictions about the effects of changes in wage offers, in non-labor income, in productivity of time spent in home production, and in the number of children on the supply of time to the market, on leisure, and on time spent in home production.

Women's education enters these models through three channels: preferences, home production functions, and wage offers. There is little theoretical guidance on how preferences or marginal product of time spent in home production vary across levels of education. On the other hand, women with higher education have higher wages. Other things equal, higher wages have both an income and a substitution effect. The increase in income shifts the production possibility frontier outwards, which increases consumption of all utility-generating commodities and reduces the time spent working in the market. An income-compensated increase in earnings has two effects. First, it induces a shift in consumption away from utility-generating commodities that are time-intensive and towards commodities that are intensive in market goods and services. Second, it induces substitution of market goods and services for time in the production of utility-generating commodities.

In this framework, the relative price of child quality is higher for more educated women, who have higher wages. Other things equal, they will demand less and will produce it with more market goods and services and less own time. As a result, children will have smaller effects on the labor supply of women with higher education. Other things are not equal, however, and therefore children could have a larger negative effect on the labor supply of women with higher education under several circumstances: first, if more educated women have stronger preferences for child quality and if the production of child quality is intensive in women's time, with very little possibility of substituting market goods and services for women's time; second, if more educated women are more efficient at producing child quality; third, if the increase in education increases the marginal product of woman's time more than the marginal products of the other inputs into the production of child quality, women with higher education will tend to devote more time per child to the production of child quality and will produce children who are more quality intensive.

Previous studies of the way in which women's education shapes the effects of children on their labor supply have generated mixed results. Early empirical evidence suggests children have stronger

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<sup>1</sup>The opportunity costs of the utility generating commodities include the prices of the inputs purchased on the market and the shadow value of the time spent in home-producing inputs and consuming the commodity.

<sup>2</sup>The distinction between leisure and time spent in home production (discussed by Mincer, 1962, and Gronau, 1977) as inputs into the production of utility-generating commodities is that leisure is an input with no market substitutes, whereas market substitutes are easily available for time spent in home production.

effects on the labor supply of more educated women. Gronau (1973) finds that children have a positive effect on the shadow value of women's time and this effect increases with education; Hill and Stafford (1980) and Leibowitz (1974) find that time inputs in child care increase with mother's education and, as a result, labor supply of more educated women is more sensitive to the presence of children; Mincer and Polacheck (1974, 1978) find that the rate of depreciation of human capital due to market-work interruptions is larger for more educated women and, therefore, birth related interruptions have a stronger adverse effect on the labor supply of more educated women. Two more recent studies, Angrist and Evans (1996, 1998) and Hyslop (1999), found, however, that the effect of children on labor force participation declines with mother's education.

This discrepancy could have been, in part, generated by methodological differences. Angrist and Evans (1996, 1998) and Hyslop (1999) focus on the effect of children on participation. If one of the primary effects of children on women's labor supply is through the number of hours worked, studies of participation dynamics will underestimate the effect of children and, potentially, the role of education. On the other hand, both these studies pay special attention to the endogeneity of fertility decisions: Angrist and Evans (1996, 1998) used exogenous variation in the probability of the third birth to measure the causal effect of children, and Hyslop (1999) estimated a dynamic model of labor force participation, specifically modelling individual-level heterogeneity.

This possibility notwithstanding, whether the effect of children on women's labor supply increases or decreases with education and what is the source of the variation across levels of education are important questions from a policy perspective. Economic and social developments that have taken place over the past few decades led to a rise in the private costs of children incurred by parents, especially by mothers, while increasingly making children a public good. Better job opportunities and higher wages for women raised the opportunity cost of children; the growth of transfer payments, like social security or public health systems, and taxation of future generations through reliance on public debt have raised the public benefits of children.<sup>3</sup> Moreover, recent economic and developmental psychology literature suggested that longer periods of maternal care improve child cognitive and behavioral outcomes.<sup>4</sup> The existence of positive externalities from raising children and from longer periods of maternal care as well as from mothers' investments in their own education and training creates the scope for new or improved public policy aimed at reducing the implicit cost of children. The efficient design of these policies depends on the accurate description of the magnitude and the structure of the effect of children on women's level of labor market involvement.

The goal of this paper is to analyze the way in which the effect of children on the level of labor market involvement of married women varies with education. We use an econometric model that explicitly accounts for the endogeneity of labor market and fertility decisions, for the heterogeneity of the effect of children on labor supply, for the correlation between the effect of children and fertility decisions, and for the correlation of sequential labor market decisions. Sequential labor market decisions, represented by a four-state multi-period multinomial probit, and fertility decisions, represented by a dynamic probit model, are jointly modeled in a mixed-effects simultaneous equation framework. Correlated individual-specific random coefficients included in the labor market and fertility equations capture the variation in labor market and fertility behavior, the heterogeneity of the effects of children on the level of labor market involvement, as well as the correlation between the effects of children on labor supply and fertility behavior.

In this framework, women's education affects their labor market and fertility decisions through two channels. First, expected wages included in the participation equations both by themselves

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<sup>3</sup>Folbre, 1994.

<sup>4</sup>Waldfoegel et al. (2002), Broogs-Gunn et al. (2002), Ruhm (2004)

and in interaction with the variables describing the number and age distribution of children are a function of education. Second, a set of education-specific random coefficients captures the variation of the labor supply, of the demand for children, and of the effects of children on labor supply across levels of education, controlling for own wage and other family-related relevant variables. We estimate the model using Markov chain Monte Carlo (MCMC) methods and panel data from 1979 National Longitudinal Survey of Youth (NLSY79). The 25-year (1979-2003) unbalanced panel we constructed<sup>5</sup> follows women from their entry into the labor force and captures almost complete fertility histories. We use simulations based on the estimation results to compute the effect of children on women’s level of labor market involvement. We compare this effect across levels of education, and we study the extent to which these differences are generated by differences in wage offers or by differences in factors like preferences and productivity in household work, captured by the random coefficients.

Our analysis shows that women with higher education have fewer children and work more before the birth of the first child, but children have larger negative effects on their level of labor market involvement. Differences across education levels are significantly more pronounced with respect to full time employment than with respect to participation; in response to the birth of a child, women with higher education are relatively more likely to move from full time work to part time work, whereas women with lower education are relatively more likely to stop working. Other things equal, higher wage offers reduce the effect of children on the level of labor market involvement. The larger effect of children on the level of labor market involvement of women with higher education is generated by differences in the productivity of time spent in home production of child quality, which are captured by the random coefficients: women with higher education are characterized by a combination of higher marginal product of time spent in home production of child quality and higher marginal product of time relative to the marginal product of other inputs into the production of child quality.

The policy significance of our results is twofold. First, since higher wage offers reduce the effect of children on women’s level of labor market involvement, public policies offering higher parental benefits will have the opposite effect – a larger reduction in the level of labor market involvement following the birth of a child. Second, public policy that increases availability of high quality child care and child care subsidies for working mothers could efficiently reduce the implicit cost of children. Provision of high quality child care increases the productivity of market inputs into the production of child quality; other things equal, higher productivity of market inputs reduces the effect of children on women’s labor supply.

The remainder of the paper is structured as follows. In the next section, we describe the construction of the panel data set used in the estimation and provide a preliminary, non-parametric analysis of the way in which the relationship between fertility and labor market decisions varies across levels of education. In section 3 we present the econometric model and the estimation procedure. In section 4 we present the estimation and simulation results. In section 5 we summarize and discuss the main results.

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<sup>5</sup>The panel is considerably longer than those previously used in the literature. For example Hyslop (1999) uses a 7-year panel of continuously married or women, with husbands continuously working, to estimate a two state model of labor force participation, Carrasco (2001) uses a 3-year panel of married or cohabitating women to estimate jointly two-state labor force participation decisions and fertility decisions.

## 2 Data

We study the effect of children on the level of labor market involvement of married women using panel data from the 1979 National Longitudinal Survey of Youth (NLSY79). The NLSY79 contains a representative sample of individuals with ages between 14 and 21 years in 1979, who are surveyed every year between 1979 and 1994, and every other year thereafter. For the purpose of our study, NLSY79 has two important features. First, it contains detailed information on respondents' labor supply history. Second, it contains information on the birth dates of respondents' children and on the beginning and end dates of respondents' marriages. Using this information, we constructed complete labor market, marital status, and fertility histories for each individual.

We use data from the nonmilitary sample of the 1979-2004 surveys and we exclude women who live on a farm larger than 100 acres at any point in the period. Since we focus on the labor supply of married women, we restrict the sample to women who are not married and are childless in 1979, get married after 1979, and remain married until 2004, only have children while married, and only have biological children in the household over the period of our data (this latter criteria eliminates women who adopt children or who marry men who have children who live with them). Imposing these strict selection criteria (especially the continuous marriage requirement) over a long period of time reduces the sample size, circumscribes the scope of our research to a narrower set of experiences and, potentially, leads to non-random selection of individuals with respect to unobserved traits that are relevant to their labor market and fertility behaviors. The focus on married women, however, is very common in the literature that studies the relationship between fertility and labor market decisions of women (Carrasco, 2001, Hyslop, 1999, Angrist and Evans, 1998, Heckman and Willis, 1977, etc). The motivation for this focus is twofold. On the one hand, married women, specially married women with children, have driven the dramatic change in the labor supply behavior among women that took place over the past few decades (Blau, 1998, Blau, Ferber, and Winkler, 1998, Leibowitz and Klerman, 1995). On the other hand, underlying theoretical models (Mincer, 1962, Becker, 1965, Leibowitz, 1972, Willis, 1973, Michael, 1973, Gronau, 1977, Angrist and Evans, 1996, 1998) are household production models. Our sample is in a way more informative than those used in previous studies using panel data (e.g. Hyslop, 1999 and Carrasco, 2001) which contain women who are continuously married or cohabitating for the entire duration of the sample. Our panel is significantly longer and, since we begin following these individuals when they enter the labor market, we observe their level of labor market involvement both before and during marriage.<sup>6</sup>

In order to abstract from the trade-off between schooling and working, we only consider a woman at risk to work or to have a child once she has been out of school for at least 18 months continuously (once a women leaves school we consider her still at risk even if she returns to school). Finally, we require at least five years of data for each woman. It is important to note that all women are childless and have no labor market history in their first period in the sample, which implies that initial conditions are identical across individuals in the sample.<sup>7</sup>

Table 1 provides an overview of the variables used in the analysis. Panel A presents summary statistics, by year, for the time-varying personal characteristics used in the analysis. Column 2, which presents the number of women considered at risk in a given year, shows the unbalanced nature

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<sup>6</sup>To test the robustness of our results to sample selection, however, we estimated our model with a sample that did not impose the marriage-related restrictions. While the average level of labor market involvement is lower in this larger sample, the qualitative results regarding the effect of children on the level of labor market involvement hold.

<sup>7</sup>The sample construction is designed to capture complete labor market and fertility histories. Identical initial conditions imply that participation and the number of children at the entry in the panel do not have to be explicitly modeled.



of the data. In 1979 only 116 women are considered at risk, by 1997 all 645 women are considered at risk. Column 3 shows the proportion of women at risk that are married. Husband's income and income from other sources (columns 4 and 5 show averages per woman at risk) have been deflated using the CPI-U and are in 1979 dollars. Since after 1994 NLSY79 was conducted every other year, we imputed observations for the post-1994 missing years and several missing observations from the available years; our exact imputation procedure is described in the data appendix. Column 6 shows the yearly birth rates and columns 7 to 9 show the average number of children by age category, for women at risk. No women had any children prior to 1981. In the last years of the panel, birth rates are very low, which indicates that our data capture complete fertility histories for most women in the sample. In 2003, the average number of children was 1.8, and the average numbers of children for each age category were 0.05 for ages 0 to 1, 0.14 for ages 2 to 4, and 1.61 for 5 years older.

We represent the labor market decisions using a model with four states – full time, full time part year, part time, and nonwork. This model provides a more accurate description of the level of labor market involvement than the two- or three-state models previously used in the literature. As we will show, a majority of women work full time before the birth of the first child. Longer or shorter birth-related interruptions are followed by a return to full-time work, a switch to part-time work, or a longer period of market inactivity. Many birth-related interruptions, specially the shorter ones, are the result of women using accumulated vacation time, sick leave, formal maternity leave, and unpaid leave before returning to work, which helps women avoid the loss of job-search costs, firm specific human capital, and match-specific information.<sup>8</sup> In a two-state model (work, nonwork) in which labor market states are defined using hours worked in a given year, as is the case in this paper and in most of the previous literature, women who return to full time work after short birth-related interruptions will be classified as working during the year. Therefore, the two-state model does not capture the variation in the number of hours, which may represent a significant share of the effect of children. A three-state model (full-time, part-time and nonwork) inaccurately classifies many of the years in which birth-related interruptions occur as part time when, in fact, they are combinations of full-time work and inactivity (paid and unpaid leave), giving rise to a large number of birth-related, spurious transitions to and from part time and, thus, artificially reducing the persistence of the part-time state.

The empirical probability distribution of the labor market states of women at risk is showed in columns 10 to 13. To be considered working a woman must have both positive hours worked and positive income. Women who worked more than 1750 hours in a year are classified as full time. Women who work between zero and 1750 hours, but who work on average more than 35 hours a week, are considered full time part year. Women who work between zero and 1750 hours, but who work on average less than 35 hours a week, are considered part time (we imputed missing observations on the number of hours worked for several individuals; the imputation procedure is described in the data appendix). Women who work zero hours or who have zero income are considered not working. The percentages of women working full time and working full time part year decline over time while the percentages of women working part time and not working rise.

Panel B presents summary statistics for the time-invariant personal characteristics and family background variables that are used in the analysis: education, race, labor market status of respondent's mother, and parents' education. We construct three educational categories: 12 years of education or less, 13-15 years of education, and 16 years of education or more. Thirty-six percent of

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<sup>8</sup>These women are technically employed not at work. Klerman and Leibowitz (1994) use CPS data to show that the sharp increase in the labor force participation of mothers with very young children (3 months old and younger) during the 70s and 80s is mostly due to increase in paid and unpaid leave rather than work.

the women in the sample have 12 years of education or less, 27 percent have between 13 and 15 years of education, while 37 percent have 16 years of education or more. Seventy percent of our sample is white, with the remainder evenly split between Hispanic and black. About 1/3 of respondents' mothers work full time and 1/3 do not work at all. For a large majority of the sample, 75 percent, none of the parents has college education, for 16 percent one parent has college education, and for 9 percent both parents have college education.

Table 2 presents a summary of several important fertility and labor market outcomes by level of education. Panel A, which compares the average and the distribution of the number of children, shows that women with higher levels of education have fewer children. The average number of children is 1.966 for women with 12 years of education or less, compared with 1.703 for women who have between 13 and 15 years of education, and 1.731 for women with 16 years of education or more. The difference between the averages is generated by larger probability of not having children for women with higher education. The probability of not having any children is 0.145 for women with 12 years of education or less, 0.174 for women with 13-15 years of education, and 0.223 for women with 16 years of education or more. Panel B shows that the timing of marriage, measured as the average number of years from entry into the sample (that is, from finishing full-time education) is very similar across levels of education. Panel C, which compares the average number of years between marriage and first birth, indicates that women with lower levels of education have their first birth sooner after marriage.

Panels D, E, and F present an analysis of the way in which the relationship between fertility and the level of labor market involvement differs across individuals with different levels of education. Panel D compares the level of labor market involvement before the birth of the first child by level of education, for women who have at least one child between 1979 and 2003, panel E compares across levels of education the level of labor market involvement after the birth of the first child, for women who have exactly one child between 1979 and 2003, and panel F compares across levels of education the level of labor market involvement after the birth of the second child, for women who have exactly two children between 1979 and 2003. Panel D shows that differences in participation before the first birth are small across levels of education (96.2 for women with 12 years of education or less, 97.2 for women with 13-15 years of education, and 98.1 percent for women with 16 years of education or more), but women with higher levels of education are more likely to work full time (the probability of working full time is 0.704 for women with 12 years of education or less, 0.751 for women with 13-15 years of education, and 0.805 for women with 16 years of education or more). The comparison of panels D and E, shows that the decline in participation and in the level of labor market involvement of those that continue to participate is smaller for women with higher education. Participation declines by 0.149 for women with 12 years of education or less, by 0.090 for women with 13-15 years of education, and by 0.037 for women with 16 years of education or more. The probability of working full time declines by 0.155 for women with 12 years of education or less, by 0.144 for women with 13-15 years of education, and by only 0.056 for women with 16 years of education or more. A comparison of results in panels E and F shows that the effects of the second child on both participation and the level of labor market involvement of the participants are larger for women with higher education. Participation increases by 0.016 for women with 12 years of education or less, and decreases by 0.129 for women with 13-15 years of education and by 0.124 for women with 16 years of education or more.

These results may be generated in part by differences in observable personal characteristics we do not control for and by selection bias. The patterns observed in the data – more educated women have fewer children, have the first birth later in life, have higher levels of labor market involvement

before the birth of the first child, and face significantly stronger effects of the second child on the level of labor market involvement – suggest, however, a data-generating mechanism consistent with the predictions of the theoretical household models of time allocation.

### 3 Econometric model

Several problems arise in the estimation of the effects of children on women’s labor supply.<sup>9</sup> First, labor market and fertility decisions are endogenous, as the number and timing of children are variables that are controlled, at least in part, by women.<sup>10</sup> Second, the effects of children on labor supply are heterogeneous and are correlated with the fertility decisions. Heterogeneous preferences for market work and children influence pre-market and early career investments in human capital, which, in turn, affect the opportunity cost of children. Together, heterogeneous preferences and correlated, heterogeneous opportunity costs of children jointly determine women’s fertility and labor market decisions. Third, sequential labor market decisions are correlated and, therefore, maternity-related work interruptions or reductions in the level of labor market involvement affect labor supply in subsequent periods. The goal of the econometric model we propose is to capture the variation in labor market and fertility behavior, as well as in the effects of children on the level of labor market involvement, across levels of education in a framework that simultaneously addresses the three key issues in the estimation of the effects of children on labor supply: the endogeneity of labor market and fertility decisions, the heterogeneity of the effects of children on labor supply and their correlation with fertility decisions, and correlation of sequential labor market decisions.

Sequential labor market decisions are represented by a multinomial probit model with auto-correlated error terms while fertility decisions are represented by a probit model with state-dependence and auto-correlated error terms. Labor market decisions and fertility decisions are driven by a sequential optimization process. At the beginning of each period an individual chooses the level of labor market involvement for the current period and makes a fertility decision. The level of labor market involvement is selected from the set of four alternatives, full-time work (FT), full-time part-year work (FP), part-time work (PT), and non work (NW), by comparing their associated value functions denoted by  $U_{it}^{FT}$ ,  $U_{it}^{FP}$ ,  $U_{it}^{PT}$ , and  $U_{it}^{NW}$ , where the subscript  $i$  indicates individuals,  $i = 1, \dots, N$  and subscript  $t$  indicates time periods,  $t = 1, \dots, T_i$ . Fertility choices are driven by the comparison of the value functions corresponding to having and not having a child whose differences are denoted by  $U_{it}^F$ . Since the choice of a level of labor market involvement depends only on differences of value functions, we transform the model by considering only values relative to the nonwork state.

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<sup>9</sup>Browning (1992) and Nakamura and Nakamura (1992) provide reviews of the history of this literature.

<sup>10</sup>Browning (1992), Rosenzweig and Wolpin (1980), Angrist and Evans (1998), Carrasco (2001).

$$\begin{aligned}
U_{it}^1 &= U_{it}^{FT} - U_{it}^{NW} = K_{it}\alpha^1 + X_{it}^{LM}\beta^1 + Z_{it}^1\gamma + (K_{it} * Z_{it}^1)\delta + \sum_m K_{it}\theta_{ml(i,m)}^1 + u_{it}^1 \\
U_{it}^2 &= U_{it}^{FP} - U_{it}^{NW} = K_{it}\alpha^2 + X_{it}^{LM}\beta^2 + Z_{it}^2\gamma + (K_{it} * Z_{it}^2)\delta + \sum_m K_{it}\theta_{ml(i,m)}^2 + u_{it}^2 \\
U_{it}^3 &= U_{it}^{PT} - U_{it}^{NW} = K_{it}\alpha^3 + X_{it}^{LM}\beta^3 + Z_{it}^3\gamma + (K_{it} * Z_{it}^3)\delta + \sum_m K_{it}\theta_{ml(i,m)}^3 + u_{it}^3 \\
U_{it}^F &= K_{it}\alpha^F + X_{it}^F\beta^F + \sum_m K_{it}^F\theta_{ml(i,m)}^F + u_{it}^F
\end{aligned}$$

The transformed latent variables define the discrete labor market and fertility decisions the following way:

$$\begin{aligned}
y_{it}^{FT} &= 1 \text{ if } U_{it}^1 > U_{it}^2 \text{ and } U_{it}^1 > U_{it}^3 \text{ and } U_{it}^1 > 0; 0 \text{ otherwise} \\
y_{it}^{FP} &= 1 \text{ if } U_{it}^2 > U_{it}^1 \text{ and } U_{it}^2 > U_{it}^3 \text{ and } U_{it}^2 > 0; 0 \text{ otherwise} \\
y_{it}^{PT} &= 1 \text{ if } U_{it}^3 > U_{it}^1 \text{ and } U_{it}^3 > U_{it}^2 \text{ and } U_{it}^3 > 0; 0 \text{ otherwise} \\
y_{it}^{NW} &= 1 \text{ if } U_{it}^1 \leq 0 \text{ and } U_{it}^2 \leq 0 \text{ and } U_{it}^3 \leq 0; 0 \text{ otherwise} \\
y_{it}^F &= 1 \text{ if } U_{it}^F > 0; 0 \text{ otherwise}
\end{aligned}$$

The fertility decision is represented by a binary variable which takes value 1 if a child is conceived in a given year. We construct the fertility variable from data on children's birth dates and we do not consider pregnancies that end in miscarriage, stillbirth, or abortion.<sup>11</sup> This specification is a departure from previous literature which mostly used the occurrence of a birth to describe fertility decisions. Our specification rests on the premise that time-varying personal characteristics and variables describing a woman's relevant socioeconomic environment affect the fertility process through the conception decision, rather than through the birth of the child.

The vector  $K_{it}$  contains a constant term and three variables describing the number of children in three age categories (0-1, 2-4, 5 and older), where age is measured at the last birthday. The variables describing the number of children and their age distribution are included in the participation equation where they capture the effect of children on the level of labor market involvement. These variables which describe the entire history of fertility decisions – how many children have been born and how far in the past – are also included in the fertility equation, thus rendering current fertility decisions dependent on the entire fertility history.

$X_{it}^{LM}$  is a vector of personal characteristics relevant to labor market decisions that includes marital status, spouse's wage, other income, the region of residence (North East, North Central, South, and West), and whether the respondent resides in an urban or rural area.  $X_{it}^F$  is a vector of personal characteristics relevant to fertility decisions that includes other income, the region of residence, whether the respondent resides in an urban or rural area, and the number of siblings with children.

The number of siblings with children provides a description of the fertility behavior of a person's siblings. Our use of this variable rests on significant evidence from demographic literature that siblings' fertility behavior affects fertility decisions through social interaction occurring in the context

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<sup>11</sup>NLSY 79 contains information on the number of pregnancies ending in miscarriage, stillbirth, or abortion but not on the date those pregnancies begin. In addition, the likelihood of termination could be correlated with labor supply decisions.

of interpersonal networks.<sup>12</sup> The number of siblings with children is excluded from the equations of labor market decisions.<sup>13</sup> In a panel data setting, identification comes from changes in the number of siblings with children. The temporal structure of the decision process we assume in this paper makes it unlikely that changes in the number of siblings with children are correlated with the error terms in the participation equations. While respondent’s fertility variable captures the conception of a child during the current year, the number of siblings with children refers to the situation at the beginning of the same calendar year (children born to siblings during the past calendar year) and, therefore, reflects past fertility decisions made by the siblings. Even if contemporaneous shocks to labor supply are correlated across siblings, the number of siblings with children is predetermined. In Appendix table 1, we analyze the relationship between fertility and the change in the number of siblings with children. The table presents the estimation results of three OLS regressions that have the number of children born between 1979 and 2003 as dependent variable and the change in the number of siblings with children during the same period and a set of controls (number of siblings, respondent’s education and race, respondent’s parents’ education) as independent variables. The coefficient for the change in the number of siblings with children is significant in all specifications. In the specification that includes all controls, the coefficient for the change in the number of siblings with children is 0.1.<sup>14</sup>

Marital status or spouse’s wage are not included in the fertility equation because, as we focus on the effects of children on the labor supply of married women, the sample includes only women who have children while married. We do not include respondent’s age in the specification of the labor market and fertility decisions. Since we account for the dependence of sequential labor market and fertility decisions by specifying AR(1) structures for the error terms of the four equations, the effect of age measured as the age of individual  $i$  at time  $t$  cannot be identified. It is also unlikely our results will be affected by significant cohort effects since the age range in our sample is only seven years.

Education affects labor market and fertility decisions through two channels. First, education enters the model through the expected wages which are a function of the number of years of education. Expected wages for each of the alternative labor market states,  $Z_{it}^1, Z_{it}^2, Z_{it}^3$ , are included

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<sup>12</sup>Montgomery and Casterline (1996) provide a theoretical framework in which siblings’ fertility affect fertility decisions through social interaction. Numerous papers provide empirical evidence that siblings’ behavior influences a wide range of indices of fertility behavior. Hogan and Kitagawa (1985) found a significant effect of siblings’ behavior and teenage motherhood. Powers and Hsueh (1997) found that older sister’s out-of-wedlock childbearing affects younger sister’s age at premarital birth. Rowe et al. (1989), Rodgers and Rowe (1988) and Haurin and Mott (1990) examined the influence of older siblings on the adolescent sexual behavior of younger siblings and found that younger siblings tend to mimic sexual behavior of their older siblings. Axinn, Clarkberg, and Thornton (1994) find that siblings’ fertility behavior exerts an important influence on family size preferences even when other factors common to all family factors are held constant.

<sup>13</sup>Finding an instrument for identifying the effect of children on labor supply is notoriously challenging. The instruments used so far in the literature are based on natural experiments - gender composition of the first two children (Carrasco, 2001; Angrist and Evans, 1998) and the birth of twins at the first birth (Rosenzweig and Wolpin 1980). These instruments capture exogenous variation in the probability of the second or third birth. If the cost of having children declines with the number of children this may lead to underestimating the effect of children on labor supply. In a dynamic setting the challenge of finding an appropriate instrument is even greater because the variable has to change with individual and time period.

<sup>14</sup>By comparison, Rosenzweig and Wolpin (1980), who use twins at the first birth as instrument for fertility, find that among women who have the first birth between 15 and 24, completed fertility, as measured 20 years later, was 0.15 greater for those women who had twins than for those women without twins; Angrist and Evans (1998) who use the gender of the first two children as instrument for the birth of the third child find that among parents with 2 or more children, the proportion that have the 3 child is 0.06 greater if the first two children were of the same sex than if they were of opposite sex.

in the participation equations by themselves to capture the way in which they affect the level of labor market involvement, and in interaction with the variables describing the number and age distribution of children,  $(K_{it} * Z_{it}^1)$ ,  $(K_{it} * Z_{it}^2)$ ,  $(K_{it} * Z_{it}^3)$ , to describe the way in which the effect of children varies with the wage. We use the observed hourly wage for the current labor market state and impute the hourly wage for the alternative states. The imputation is based on a standard wage regression that includes second degree polynomials of years of education and experience, a full set of interactions between the terms of these polynomials and the labor market states, and the urban and region dummy variables.<sup>15</sup> It is important to note that expected wages and the interaction terms between expected wages and the children variables vary over  $i$ ,  $t$ , and labor market state, and their coefficients are constrained to be the same across states. Geweke, et al. (1997) point out that the inclusion of variables whose values differ across alternative choices and whose coefficient is constrained to be the same across states is important in the identification of multinomial probit models such as this, which would otherwise be difficult due to flat spots in the likelihood function.

Second, controlling for wages, education affects labor supply, demand for children, and the effects of children on labor supply through differences in preferences and in the productivity of time spent in the home production of utility-generating commodities. We capture these differences using a set of education-specific random coefficients.

The mixed-effect structure, which combines fixed and random coefficients, allows us to study how the relationship between fertility and labor market behavior varies across education levels and other time-invariant personal characteristics like race, and family background characteristics, and, controlling for these variables, to assess the role of individual-level heterogeneity.  $\alpha's, \beta's, \gamma$  and  $\delta's$  are vectors of global (fixed effect) parameters which are common across individuals in the sample. We use five,  $m = 1, \dots, 5$ , independent sources of heterogeneity affecting individuals' decisions: individuals' time invariant personal characteristics (education and race), family background variables related to tastes for work and family (the labor market status of respondent's mother and the education levels of respondent's parents), and individual-level heterogeneity. Each source of heterogeneity has  $l_m$  levels. The number of levels is three for education (12 years or less, 13-15 years, 16 years or more), three for race (white, black, and Hispanic), two for respondent's mother's labor market status (full time and other), three for parents' education (none of the parents, one, or both parents have college education), and is equal to the number of individuals in the sample for individual-level heterogeneity. Each individual in the data is assigned a level for each source of heterogeneity  $l(i, m)$  (individual  $i$ 's level of education, race, mother's labor market status, parents' education, her individual-specific level of heterogeneity). To level  $l$  of heterogeneity source  $m$  corresponds the vector of random coefficients  $\theta_{ml} = [\theta_{ml}^1 | \theta_{ml}^2 | \theta_{ml}^3 | \theta_{ml}^{F'}]$ . The four components of  $\theta_{ml}$ ,  $\theta_{ml}^1, \theta_{ml}^2, \theta_{ml}^3$ , and  $\theta_{ml}^{F'}$ , correspond to the four equations of the model. Each component includes

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<sup>15</sup>We acknowledge that including expected wages in the specification of the value functions raises the question of their endogeneity. The main potential source of endogeneity is the possibility that parameters of the wage offer distributions are correlated with time-invariant individual-specific components of the error terms in the participation equations. We account for this possibility by incorporating individual heterogeneity in the participation equations. Even after accounting for individual heterogeneity, there is still the possibility that shocks to the wage offer distribution may be correlated with shocks to the unobserved determinants of the level of labor market involvement. In a different setting (two-state model of labor force participation, which does not account for endogeneity of fertility and for individual heterogeneity) Geweke and Keane (2000) have showed how wages can be modeled endogenously. The extension of their model to our setting faces daunting challenges both technical (sharp increase in the number of dependent variables of the model) and substantive (the lack of appropriate instruments). Therefore, we do not pursue this avenue of research in this paper, choosing instead to focus on the endogeneity of fertility and the accurate definition of the level of labor market involvement.

four elements, one random effect and three random coefficients, corresponding to the four variables in the vector  $K_{it}$ . We assume  $\theta_{ml}$  are normally distributed, independent across the  $l_m$  levels of heterogeneity of source  $m$ ,  $\theta_{ml} \sim MVN(0, D_m)$ , independent across sources of heterogeneity, and uncorrelated with the regressors  $X_{it}^{LM}, X_{it}^F, Z_{it}$  and the error terms  $u_{it}$ .

The random coefficients corresponding to education, race, and family background variables capture the effects of these time-invariant personal characteristics on labor market and fertility decisions, while the individual-specific random coefficients describe the individual-level heterogeneity in labor market and fertility behavior. The random coefficients corresponding to the constant terms in the four equations capture the variation in propensities for market work and children. The random coefficients corresponding to the children variables in the participation equations describe the heterogeneity of the effects of children on the level of labor market involvement. The random coefficients corresponding to the children variables in the fertility equation capture individual variation in the timing and spacing of births (for example, a relatively small individual-specific coefficient for the variables describing the presence of young children and a relatively large individual-specific coefficient for the variable describing the presence of older children indicates the occurrence of births at larger intervals). Finally, the general correlation structure of the random coefficients – for each source of heterogeneity, random coefficients are assumed to be correlated both within and between equations – captures the correlation between preferences for market work and children, the effects of children on labor supply, and fertility behavior (timing and spacing of births).

We assume error terms are jointly normally distributed.

$$u_{it} = [u_{it}^1 | u_{it}^2 | u_{it}^3 | u_{it}^F]' \sim N(0, \Sigma).$$

Over time, error terms follow a AR(1) stationary process,  $u_{it} = Ru_{it-1} + \varepsilon_{it}$ , where  $\varepsilon_{it} = [\varepsilon_{it}^1 | \varepsilon_{it}^2 | \varepsilon_{it}^3 | \varepsilon_{it}^F]'$  is distributed  $IIDN(0, \Psi)$ ,  $\Psi = I_4$ , and it is uncorrelated with the random coefficients  $\theta_{sk}$  and variables  $X_{it}^{LM}, X_{it}^F, Z_{it}$ ,

$$R = \begin{bmatrix} \rho_1 & 0 & 0 & 0 \\ 0 & \rho_2 & 0 & 0 \\ 0 & 0 & \rho_3 & 0 \\ 0 & 0 & 0 & \rho_F \end{bmatrix}$$

Work experience, while not explicitly included in the specification of labor market decisions, enters our model in two ways. First, since we explicitly model dependence of sequential labor market decisions, the level of labor market involvement in the previous periods directly affects current decisions. Second, current labor market decisions depend on potential wages in each labor market state, which, in turn, depend on labor market experience – the realization of past labor market decisions.

In addition to exclusion restrictions mentioned earlier, two other sources contribute to identification in this model. First, we assume that the vectors of random coefficients corresponding to each source of heterogeneity have a joint normal distribution. Second, children variables entering the participation equations are non-linear transformations of the lagged dependent variables in the fertility equation. Non-linearity is generated by the construction of the children variables (number of children in certain age categories) as well as by the use of conception as the fertility variable (the decision to conceive a child in a given year could result in the birth of a child in the same calendar year or in the following calendar year, as well as in the birth of twins).

The dynamic nature of both participation and fertility decisions requires assumptions regarding initial conditions. Given our specification, we need to know the distributions of children variables

in the initial period and the distribution of the error terms. The selection of the sample ensures that initial conditions are identical across individuals – we choose the first year out of school as the first period in the sample and we include only women who marry and have children only after entering our sample.

To estimate the model, we employ Markov chain Monte Carlo techniques (MCMC). MCMC methods avoid one of the major difficulties inherent in the alternative maximum likelihood or simulated maximum likelihood estimation methods – the evaluation at each step of the maximization process of multiple integrals, whose dimensions increase very quickly with the number of equations to be estimated. The estimation algorithm we propose in this paper builds on several sources in the literature: Geweke et al. (1997) who propose a Gibbs sampler algorithm for estimating a panel multinomial probit model where errors follow an AR(1) process, McCulloch and Rossi (1994) who estimate a multi-period multinomial probit model with random effects, and Gilks et al. (1993) who propose an algorithm for the estimation of a single-equation, panel-data model with random coefficients. For the parameters of interest we choose proper but noninformative prior distributions. The estimation algorithm and the exact form of our assumptions concerning the prior distributions are presented in Appendix 1.

## 4 Estimation Results

Although coefficient estimates are difficult to interpret because of the non-linearity of the model, the estimation results presented in tables 3, 4, and 5 provide essential insight into the effect of children on women’s labor supply. Table 3 shows the posterior means and the posterior standard deviations (PSTD) for the global parameters of the model. The coefficients of the three children variables are negative in all participation equations; their absolute values are largest for full-time work (column 1) and weakest for part-time work (column 5). The coefficient for children with ages between 0 and 1 year is -1.429 in the equation of full time relative to nonwork, -0.975 in the equation of full time part year relative to nonwork, and -0.128 in the equation of part time relative to nonwork. This suggests that children lower women’s level of labor market involvement by reducing the attractiveness of work relative to nonwork and the attractiveness of full time and full time part year work relative to part time. The coefficients for older children are smaller in absolute value, indicating that the effect declines with the age of the child. For example, in the equation of full time relative to nonwork the coefficients are -1.429 for a child age 0-1, -1.058 for a child age 2-4, and -0.530 for a child with age 5 years or more.

The coefficients for marital status are negative, large in absolute value, and significant in all equations, which indicates that marriage has a strong negative effect on the level of labor market involvement. Higher spouse’s wage and non-labor income are associated as well with lower levels of labor market involvement. Women leaving in urban areas are more likely to hold full-time jobs.

The coefficient for wage, 0.702, indicates that, for women without children, higher wage offers associated with a certain labor market state increase the likelihood of occupying that state. The coefficients for the interaction terms between wage offers and the children variables, -0.015 for the interaction between wage and the number of children with ages between 0 and 1, -0.046 for the interaction between wage and the number of children with ages between 2 and 4, and -0.097 for the interaction between wage and the number of children with ages age 5 years or more, suggest that although higher wages will increase the probability of returning to work after birth, their effect declines with the age of the child.



The estimates of the AR(1) coefficients,  $\rho$ , are 0.701 for the equation of full time relative to nonwork, 0.017 for full time part year relative to nonwork, and 0.724 for part time relative to nonwork. Given the definitions of the four labor market states in which full time part year describes relatively short work interruptions, whereas full time, part time, and nonwork describe longer spells with constant level of labor market involvement, the small coefficient for full time part year, 0.017, suggests that short birth-related interruptions will have a small effect on subsequent labor supply. On the other hand, the large coefficients in both full time and part time equations suggest that full time, part time, and nonwork are persistent states and, therefore, longer periods of nonparticipation or reduced labor market involvement will have strong negative effects on future labor supply.

The random coefficients capture the variation in the labor market and fertility behavior across levels of education, races, family background characteristics, and, controlling for these characteristics, across individuals. Table 4 shows the posterior means of the random coefficients corresponding to the personal and family background characteristics. Education is the strongest determinant of women's labor supply and of the effects of children on labor supply. Its effect is largest in the full-time equation. The coefficients corresponding to the constant term (column 1) are -0.330 for women with less than 12 years of education, 0.142 for women with 13-15 years of education, and 0.188 for women with 16 or more years of education, suggesting that women with higher education are relatively more likely to work full time. The coefficients corresponding to the children variables (columns 2-4) show that the negative effects of children on the probability of working full time are stronger for women with higher education. The coefficients corresponding to the number of children with ages between 0 and 1 (column 2) are 0.229 for women with 12 years of education or less, -0.042 for women with 13-15 years of education, and -0.187 for women with 16 or more years of education.<sup>16</sup> These values imply that the presence of a child with age between 0 and 1 reduces the propensity to work full time (the latent variable corresponding the full time work) by 1.200 for women with 12 years of education or less, compared with 1.471 for women with 13-15 years of education and with 1.615 for women with 16 years of education or more. Similarly, the effects of older children on the propensity to work full time are stronger for more educated women. The coefficients corresponding to the constant term in the fertility equations, 0.046 for women with 12 years of education or less, -0.014 for women with 13-15 years of education, and -0.032 for women with 16 or more years of education, indicate that propensity to have children declines with the level of education.

White women are more likely to work full time compared to black and Hispanic women: the coefficients corresponding to the constant term are 0.125 for white women, 0.009 for black women, and -0.115 for Hispanic women. The negative effects of children on the probability of working full time are stronger for white women relative to black and Hispanic women. The coefficients corresponding to the constant term in the fertility equations indicate that Hispanic women have a higher propensity to have children than both white and black women. The effects of family background variables are also concentrated in the full time equation: respondents whose mothers worked full time are more likely to work full time, while those whose parents were both college

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<sup>16</sup>The interpretation of these coefficients is analogous to that of the coefficients of a complete interaction between the children variables and each of the four variables in a classical regression setting. For example, to compute the effect of having one child with age between 2 and 4 on the propensity of working full time by education level, we add the coefficient for children with ages between 2 and 4 in the full time equation from table 2 with the coefficients for children with ages 2 to 4 in the full time equation from table 3. Thus, having one child between ages 2 and 4 reduces the propensity of working full time by  $-0.977+0.238=-0.739$  for someone with less than 12 years of education, by  $-0.977-0.085 = -1.062$  for someone with 13-15 years of education, and by  $-0.977-0.153 = -1.130$ , for someone with 16 or more years of education.

educated are less likely to work full time.

Table 5 shows the correlation matrix of the individual-specific random coefficients. The correlations between the random coefficients corresponding to the constant terms in the participation equations and the random coefficient corresponding to the constant term in the fertility equation vary from very low, 0.051, for full time and fertility, to 0.422 for full time part year and fertility, to 0.240 for part time and fertility. This indicates that, controlling for personal and family background characteristics, women with stronger propensities for lower levels of labor market involvement have stronger propensity to have children. The random coefficients corresponding to the children variables in the full time and full time part year equations are positively correlated with the random coefficients corresponding to the constant term in the fertility equation. The positive correlations indicate that strong negative effects of children on the level of labor market involvement are associated with lower propensities to have children.

These results underscore the importance of modelling fertility decisions endogenously and the strength of the mixed-effects framework in dealing with this problem. We showed that the effects of children on labor supply are correlated with the propensity to have children both across education levels and, controlling for individual characteristics, across individuals. These correlations imply that women who face higher implicit costs of children will have fewer children. As a result, without accounting for the endogeneity of fertility decisions, estimates of the effects of children would be upward biased (smaller in absolute value). In addition, if the effect of children is larger for women with higher education, estimated educational differences will be downward biased.

## 5 Simulation Results

### 5.1 Simulation Design

We use simulations based on the estimation results to measure the effects of children on the probability distribution of the four labor market states. We measure the variation of these effects across levels of education, and we assess the extent to which these differences are generated by differences in wage offers or by factors like preferences and productivity in household work, which are captured by the random coefficients.

While we recognize that both the number of births and their timing may affect women's labor market behavior, the large number of possible labor market and fertility histories forces us to focus exclusively on the number of births. We confine our analysis to three fertility histories: no birth, one birth, and two births. Table 6 describes the timing of the relevant events. In all three fertility histories marriage takes place in the second year. The conception of the first child takes place during the second period, and the first birth takes place at the beginning of the third period. The conception of the second child takes place during the eighth period, and the second birth takes place at the beginning of the ninth period. The timing of marriage and the timing of the first birth that we use in the simulation scenario are those with the highest frequency in our data: 15.3 percent of all marriages take place one year after entry into the labor market, 23 percent of the first conceptions take place in the year of marriage. The largest share of the second conceptions (32 percent) take place two years after the first conception, but we chose this particular timing for the second birth to avoid spurious results generated by the discrete changes in the ages of children. A child born at the beginning of year 3 moves into age category 2-4 in period 5 and into age category 5 years and older in period 8. The discrete changes in the age of the first child, specially the move in age category 5 years and older, generate large changes in the level of labor market involvement

and, because of the non-linearity of the multivariate normal cumulative distribution function, will have an impact on the effects of subsequent children.

We construct three basic individual profiles: white woman with 12 years of education, white woman with 14 years of education, and white woman with 16 years of education. For all three profiles, personal characteristics are set at the values with the highest frequencies in our sample. We assume that none of the respondent's parents has college education and that the respondent's mother did not work full time. We set other family income at zero, the region of residence to North-East, and the type of residence to urban. We set spouse's wage at 15530, the median level. For each individual profile, we set the random coefficients corresponding to the individual heterogeneity to zero, the average value. For every period along each possible labor market history, we compute the wages corresponding to the three working labor market states – full time, full time part year, and part time – using the coefficient estimates from the wage equation, the characteristics associated with the relevant individual profile (number of years of education, urban location, region), and the labor market experience accumulated until that point in time.

For each of the three individual profiles we compute the joint probability distribution of all possible labor market and fertility histories. The probability of a complete history is the cumulative distribution function of a multivariate normal distribution; to calculate the multivariate normal CDFs, we use the GHK smooth recursive simulator of Geweke (1989), Hajivassiliou (1990), and Keane (1994). Let  $S$  denote the set of four possible labor market states in a period, full time ( $ft$ ), full time part year ( $fp$ ), part time ( $pt$ ) and non work ( $nw$ ),  $s_t$  denote the labor market state in period  $t$ ,  $t = 1, \dots, 15$ , and  $h_j$  denote the fertility history, where  $j = 0, 1, 2$ , represents the number of births taking place in the respective fertility history. Further, let  $f(s_1, s_2, \dots, s_{15}, h_j)$  denote the joint probability distribution of all possible labor market histories and fertility histories. This probability distribution is conditional on a vector of observed characteristics and a level of individual-specific unobserved heterogeneity, but we omit this conditioning to simplify notation. Given these joint probabilities, for each observation, we compute the probability of having no children  $f(h_0)$ , one child in year three  $f(h_1)$  and two children in years three and nine  $f(h_2)$ , along with the probability of all possible labor market histories conditional on the specific fertility history  $f(s_1, s_2, \dots, s_{15}|h_j)$ , which to simplify notation we denote by  $f_j(s_1, s_2, \dots, s_{15})$ . Finally, we compute the probability distribution of the labor market states in every time period conditional on a given fertility history, which is denoted by  $f_j(s_t)$ .

We measure the effects of the two children on the level of labor market involvement by comparing the probability distributions of the labor market states  $f_j(s_t)$ , for all time periods, across the three fertility histories. The effect of the first birth, which takes place at the beginning of year 3, is computed by comparing the probability distributions for the fertility histories with zero and one birth, in the years following the birth:

$$TE_t^1 = f_1(s_t) - f_0(s_t), t \geq 3$$

The effect of the second birth, which takes place at the beginning of year 9, is computed by comparing the probability distributions for the fertility histories with one and two births, in the years following the second birth:

$$TE_t^2 = f_2(s_t) - f_1(s_t), t \geq 9$$

We assess the way education influences the effect of children on women's labor supply by comparing the total effects of the two children for women with 14 and 16 years of education with the total effect for the baseline case, women with 12 years of education.

To assess the extent to which the differences across levels of education are generated by differences in the random coefficients or by differences in the mean of wage offers, we construct two counterfactual profiles. For the first counterfactual profile, we set the level of education relevant for the computation of the mean wage at 12 years and the level of education relevant for the determination of the random coefficients at 14 years. For the second counterfactual profile, we set the level of education relevant for the computation of the mean wage at 12 years and the level of education relevant for the determination of the random coefficients at 16 years.

Levels of education relevant for the determination of random coefficients and wages					
	Basic profile 1	Cnterfct. profile 1	Basic profile 2	Cnterfct. profile 2	Basic profile 3
Rnd. Coeff.	12 years	14 years	14 years	16 years	16 years
Wage	12 years	12 years	14 years	12 years	16 years

For each level of education (14 or 16 years), the component corresponding to the random coefficients is constructed by comparing the corresponding counterfactual profiles with the baseline profile, women with 12 years of education. The component corresponding to the differences in the mean wage offer is computed by comparing the basic profiles 2 and 3 with their respective counterfactual profiles.<sup>17</sup>

## 5.2 Level of Labor Market Involvement before the First Birth

Table 7a shows the levels of labor market involvement before the first birth, by level of education. Women with higher education work more before the birth of the first child. The difference is not as much in the participation rates as in the level of labor market involvement of those who participate. Participation rates are 0.914 for women with 12 years of education, 0.966 for women with 14 years of education, and 0.978 for women with 16 years of education. The probability of working full time is 0.565 for women with 12 years of education (61.8 percent of those who participate), 0.708 for women with 14 years of education (73.3 percent of participants), and 0.744 for women with 16 years of education (76.1 of participants). The probabilities of working full time part year and part time are higher for women with lower levels of education: the probability of working full time part year is 0.205 for women with 12 years of education compared with 0.165 for women with 14 years of education and 0.156 for women with 16 years of education; the probability of working part time is 0.144 for women with 12 years of education compared with 0.093 for women with 14 years of education and 0.078 for women with 16 years of education.

The differences across education levels are in great part captured by the random coefficients. Table 7b shows the decomposition of the differences between the pre-birth levels of labor market involvement of women with different levels of education. Columns 1 and 2 show the decomposition of the difference between women with 12 years of education and those with 14 years of education, and columns 3 and 4 show the decomposition of the difference between women with 12 years of education and those with 16 years of education. Other things equal, higher wages increase participation and the probability of working full time, but their effect is much smaller than that

<sup>17</sup>Since model is non-linear, the order of the decomposition could be important. To check the robustness of our results, we performed the alternative decomposition in which the counterfactual profiles were constructed by changing the level of education relevant to the determination of wages and keeping the level of education relevant to the determination of the random coefficients the same as in the baseline profile. The results for this alternative decomposition are very similar.

captured by the random coefficients. For example, the participation probability of women with 16 years of education is 6.4 percentage points larger than that of women with 12 years of education; the component corresponding to the random coefficients is 3.7 percentage points, while the component corresponding to wages is 2.8 percentage points. The probability of working full time of women with 16 years of education is 17.9 percentage points larger than that of women with 12 years of education; the component corresponding to the random coefficients is 15.5 percentage points, while the component corresponding to wages is 2.4 percentage points.

To interpret these results, we use Gronau’s (1977) time-allocation model as reference. In this model, before the birth of the first child, women derive utility from the consumption of commodities unrelated to children, which are produced with a combination of goods and services purchased on the market and time. Women allocate their time between leisure, market work, and home production. Higher wages affect the time allocated to market work through three channels. First higher wages induce women to shift time from home production to market work (they substitute market goods and services for own time in the production of utility generating commodities) until the marginal productivity at home is equal to the wage. Second, higher wages induce women to substitute goods-intensive commodities for time-intensive commodities, thus reducing leisure and increasing the time allocated to market work (the substitution effect). Third, higher wages induce women to consume more of each commodity, thus increasing leisure at the expense of market work (the income effect).

Our results indicate that other things equal, the higher wages of more educated women increase the level of labor market involvement. This is possible under two circumstances. First, if the substitution effect dominates the income effect, then time allocated to market work increases at the expense of both home production time and leisure. Second, if the income effect dominates the substitution effect, but the transfer of time from home production to market work exceeds the transfer of time from market work to leisure, the time allocated to market work and leisure will grow at the expense of home production time. Much of the difference in the level of labor market involvement is captured, however, by the random coefficients. This implies that more educated women have either stronger preferences for utility-generating commodities that are goods-intensive, lower productivity in the home production of utility-generating commodities – which, holding the wage constant, induces them to spend less time in home production – or lower productivity of time relative to other inputs into the production of utility-generating commodities.

### 5.3 The Effect of Children on the Level of Labor Market Involvement.

The total effect of the first child and the results of the decomposition are presented in figures 1, 2, and 3. Figure 1 compares the total effect of the first child on the level of labor market involvement across levels of education. Figure 2 shows the decomposition of the difference between the effect of the first child for women with 14 years of education and the effect of the first child for women with 12 years of education. Figure 3 shows the decomposition of the difference between the effect of the first child for women with 16 years of education and the effect of the first child for women with 12 years of education. Each figure contains four panels depicting the effect of the child and the results of the decomposition separately for participation and for the probabilities of the three working labor market states, full time, full time part year, and part time.

Figure 1 shows that the birth of the first child reduces participation and the probabilities of working full time and full time part year, and increases the probability of working part time, for all levels of education. The effect of the child is largest immediately after birth and declines with

the age of the child.<sup>18</sup> The participation profile for women with 12 years of education is the lowest, while the profile for women with 16 years of education is the highest, which indicates that the effect of the first child on participation decreases with education. The opposite is true for the probability of working full time. The profile for women with 12 years of education is the highest, while the profile for women with 16 years of education is the lowest, indicating that the effect of the first child on the probability of working full time increases with education. The birth of the first child reduces the probability of working full time part year and increases the probability of working part time. For both full time part year and part time, the effects of the first child are stronger for more educated women. The discrepancy between the effect of education on participation and the effect on the probability of working part time is explained by the fact that, following the birth of the first child, more educated women are more likely to start working part time rather than to stop working.

Figures 2 and 3 show the results of the decomposition. In both figures, for both participation and full time, the component corresponding to the wage differences is positive, which means that the higher wage offers of the more educated women reduce the effects of children on participation and on the probability of working full time. The components corresponding to the random coefficients, which capture differences in preferences and productivity in home production, are negative for both participation and full time. For full time part year and part time, the components corresponding to both wages and the random coefficients are positive.

Figures 4, 5, and 6 show the total education effects and the results of the decomposition for the second child. The most notable difference between the results for the first child and those for the second child is the fact that the negative effect of the second child on participation is stronger for more educated women. Otherwise, the results for the second child are similar to a large extent to those for the first child. Following the birth of the second child, participation and the probabilities of working full time and full time part year decline, while the probability of working part time increases; the effects decline with the age of the child. The negative effect of the second child on the probability of working full time and the positive effect on the probability of working part time are stronger for more educated women. The reduction in the probability of working full time part year is stronger for women with lower education. For both participation and full time, the component corresponding to the wage differences is positive, suggesting that higher wages reduce the effect of the second child on participation and full time; the component corresponding to the random coefficients is negative. For full time part year and part time, the both components are positive.

For an interpretation of these results, we return to the theoretical framework provided by Gronau's (1977) model. When the first child is born, women who have been working start reallocating leisure and market time to the production of child-related, utility-generating commodities (number and quality). The transfer continues until the marginal product of time spent in the home production of child care is equal to the wage. If the market time is exhausted before the equality is reached, women will start transferring time spent in the home production of commodities unrelated to children to child care. This transfer will continue until the marginal product of time spent in home production of child care is equal to the marginal product of time spent in the home production of the utility-generating commodities unrelated to children. Women who have not been working in the market will reallocate leisure and time spent in home production of the utility-generating commodities unrelated to children to child care activities. Other things equal (productivity of home

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<sup>18</sup>The discrete changes in the direct effect of children are generated by the definition of the variables that describe the age of the children. In reality, the age of the child and the direct effect change continuously. An interpolation of our results would probably capture more accurately the dynamics of the direct and indirect effects and would mitigate the patterns that occur at discontinuity points.

production of child care, preferences) higher wages imply that, following the birth of the child, the transfer of time from market work to home production of child care will be smaller. Since the transfer takes place until marginal product in home production of child care equals wage, decreasing marginal product and higher wage mean that less time will have to be transferred to equate the two. Hence, other things equal, higher wages should be associated with smaller effects of children on labor supply. Our finding that higher wages reduce the effect of children is consistent with this prediction.

There is no theoretical guidance as to how preferences and productivity at home are related to education. In this theoretical framework, controlling for wage, higher marginal product schedule for the home production of child quality means that more time has to be transferred to child care before the marginal product is equal to the wage. Hence, controlling for wages, women with higher productivity in home production of child quality will spend more time per child in home production of child quality. Also important is the relationship between the marginal product of own time and the marginal product of market inputs into the production of child quality. It is possible that, as more time is allocated to child care, its marginal product becomes smaller than the marginal product of market inputs. Beyond this point, increases in child quality can be achieved only by increasing the quantity of market inputs, which implies an increase in the time allocated to market work. As a result, if productivity of time in the home production of child quality is high relative to the productivity of market inputs, then, other things equal, the effect of the child on labor supply will be larger.<sup>19</sup> Finally, stronger preferences for child quality imply higher demand for child quality and, other things equal, stronger effect of children on labor supply. Our results – the negative sign of the component captured by the random coefficients – suggest that women with higher education are characterized by a combination of stronger preferences for time-intensive child quality, higher marginal product of time spent in the production of child quality, and higher marginal product of time relative to the marginal product of other inputs into the production of child quality.

#### 5.4 Preferences vs. Productivity of Time Spent in Home Production of Child Quality

From a policy perspective, it is important to further examine the component captured by the random coefficients and disentangle the role of preferences from the role of the marginal product of time spent in the home production of child care. If differences across levels of education were mainly generated by differences in preferences, there would be little public policy can accomplish in terms of reducing the implicit cost of children. If, on the other hand, the productivity of time in home production of child quality played the dominant role, availability of high quality child care and child care subsidies for working mothers could efficiently reduce the implicit cost of children.

The mixed-effects framework allows us to further refine our analysis in this direction. The binding constraint is the lack of variables that accurately describe either preferences for child quality or productivity of own time in the home production of child quality. It is possible, however, to shed some light on the relative importance of these two factors, using information from NLSY79. Eight questions included in the 1979 and the 1982 surveys elicit information on individuals' attitudes towards the role of women in the household.<sup>20</sup> We use the answers to the questions from the 1982

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<sup>19</sup>For example, if market supplied child care is of low quality, women will prefer producing child quality using own time as input, regardless of how high their wages are.

<sup>20</sup>Surveyed individuals were asked their opinions on the following eighth statements: a) a woman's place is in the home not in the office of shop; b) a wife who carries out her full family responsibilities doesn't have time for outside

survey to construct an index of women’s attitudes.<sup>21</sup> The index has three categories and ranks women from those who strongly disagreed with the statements implying that the place of a woman is in the household (the first category) to those that strongly agreed with these statements (the third category). Although we recognize that our index is an imperfect description of an individual’s preferences over child quality and utility-generating commodities unrelated to children, we think it is correlated with these preferences. Women in the first category are likely to have relatively stronger preferences for utility-generating commodities unrelated to children, whereas women in the third category are likely to have relatively stronger preferences for child quality.

We re-estimated the model including this index among the observed sources of heterogeneity, together with education, race, and family background variables. We compute the effect of children on the level labor market involvement, we examine separately the role of preferences, and we decompose the educational differences in the component corresponding to wages and the component corresponding to the random coefficients, now controlling for preferences.<sup>22</sup>

Before turning to the main results, it is important to note that attitudes are correlated with education: women with higher education are more likely to disagree with the statements implying that the place of a woman is in the household. Among women with 16 years of education or more, 44 percent are in the first category of our index – strongly disagree – and 20 percent are in the third category – strongly agree; among women with 12 years of education or less, only 21 percent are in the first category, but 49 percent are in the third category. Insofar our index describes preferences, this implies women with higher education have relatively stronger preferences for utility-generating commodities unrelated to children.

In table 8 we compare the level of labor market involvement before the birth of the first child for women in categories 1 and 3 of the index. Women in category 1 – those with stronger preferences for utility generating commodities unrelated to children – have higher participation rates. Among those who participate, they have higher levels of labor market involvement: the share of participants working full time is larger for women in category 1 while the shares of participants working full time part year and part time are, larger among women in category 3.

In figure 7 we compare the effect of the first child on the level of labor market involvement for women in categories 1 and 3. The negative effects of the first child on participation, on the probability of working full time, and on the probability of working full time part year are smaller for women in category 1. The positive effect of the first child on the probability of working part time is larger for women in category 3. These results imply that children have smaller effects on the level of labor market involvement of women with stronger preferences for utility-generating commodities unrelated to children.

Finally in figure 8 we compare the component corresponding to the random coefficients from

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employment; c) a working wife feels more useful than one who doesn’t hold a job; d) employment of wives leads to juvenile delinquency; e) employment of both parents is necessary to keep up with the high cost of living; f) it is much better for everyone concerned if the man is the achiever outside the home and the women takes care of the home and family; g) men should share work around the house with women, such as doing dishes, cleaning, etc; h) women are much happier if they stay at home and take care of their children.

<sup>21</sup>We apply principal component analysis. The first principal component captures a large share of the variation in attitudes across individuals. It ranks women from those who strongly disagree with the statements implying that a woman’s place is in the household to those that strongly agree with them. We use the first principal component to construct a discrete index (with three categories) of women’s attitudes.

<sup>22</sup>For the sake of brevity, we present only the results pertaining to white women with 12 years of education and to the effect of the first child. The results for the second child and those for women with 14 and 16 years of education are very similar.



the main specification with that constructed using results from the specification that includes the indicator for preferences. The components corresponding to the random coefficients are larger in absolute value when we control for preferences, but differences across specifications are small. This result is not surprising. Women with higher education are more likely to have stronger preferences for utility-generating commodities unrelated to children. Since women with stronger preferences for utility-generating commodities unrelated to children face smaller effects of children, controlling for preferences increases the educational differences in the effect of children on labor supply.

Reiterating the caveat that the index of women's attitudes is an imperfect description of preferences, our results have three main implications. First, women with stronger preferences for utility-generating commodities unrelated to children work more before the birth of the first child and children have smaller effects on their level of labor market involvement. Second, women with higher education have relatively stronger preferences for utility-generating commodities unrelated to children. Third, controlling for preferences has a small effect on the magnitude of the component captured by the random coefficients, which means productivity of time spent in the home production of child quality is the main determinant of the stronger effect of children on the labor supply of more educated women. Women with higher education are more productive than women with lower education in the home production of child quality and have higher productivity of their own time relative to market inputs in the production of child quality.

## 6 Conclusion

We analyze the way in which the effect of children on the level of labor market involvement of married women varies with education. The econometric framework we propose explicitly accounts for the endogeneity of labor market and fertility decisions, for the heterogeneity of the effect of children on labor supply, for the correlation between the effect of children and subsequent fertility decisions, and for the correlation of sequential labor market decisions. We use a model with four labor market states which provides an accurate description of the level of labor market involvement. We estimate our model using a 25-year panel, which follows women from their entry into the labor force and captures almost complete fertility histories. We model the effect of women's education on their labor market and fertility decisions through two channels: first, we include expected wages and interaction terms between expected wages and the variables describing the number and age distribution of children in the participation equations; second, education-specific random coefficients capture the variation of the labor supply, of the demand for children, and of the effects of children on labor supply across levels of education.

We find that women with higher education have fewer children. Before the birth of the first child, women with higher education have higher rates of participation and among participants they have higher levels of labor market involvement. Differences in participation and in the level of labor market involvement of participants are generated by both wage differences and differences in preferences and productivity in home production, which are captured by the education-specific random coefficients. The birth of the first child reduces participation and the level of labor market involvement of those who continue to participate. The reduction in participation is larger for women with lower levels of education, but the reduction in the probability of working full time is larger for women with higher education. Women with higher education are relatively more likely to respond to the birth of the first child by lowering their level of labor market involvement rather than by dropping out of the market. The effect of the second child on both participation and the probability of working full time is larger for women with higher education.

We decompose the differences across levels of education in two components: a component generated by differences in wage offers across levels of education and a component generated by differences in preferences and differences in the productivity of time spent in home production of child care. We capture the first component by including wage offers and interaction terms between wage offers and the variables describing the number and the age distribution of children in the specification of the participation equations. The second component is captured by a set of education-specific random coefficients. For both participation and full time, the wage component is positive, which indicates that, other things equal, higher wage offers reduce the effect of children on the level of labor market involvement. For both participation and full time, the component captured by the random coefficients is negative and larger in absolute value than the wage component, which indicates that differences in preferences and productivity of time spent in home production of child quality are responsible for the larger effect of children on the labor supply of more educated women.

We further examine the component captured by the random coefficients. We use an index of women's attitudes as proxy for preferences to disentangle the role of preferences from that of productivity of time spent in home production of child quality. We find that productivity of time spent in the home production of child quality is the main determinant of the stronger effect of children on the labor supply of more educated women. Women with higher education are more productive than women with lower education in the home production of child quality and have higher productivity of their own time relative to market inputs in the production of child quality.

Our main finding that women's labor supply responsiveness to children increases with education is consistent with the results of Gronau (1973), Hill and Stafford (1980), Leibowitz (1974), Mincer and Polacheck (1974, 1978). Our results suggest that one of the primary effects of children on women's labor supply is through the number of hours worked and that women with higher education are relatively more likely to respond to the birth of a child by reducing the number of hours. This implies that studies that focus the effects of children on labor market participation will underestimate the effect of children on women's labor supply, as well as the differences in the effect of children across levels of education.

The policy significance of our results is twofold. First, since higher wage offers reduce the effect of children on women's level of labor market involvement, public policies offering higher parental benefits will have the opposite effect – a larger reduction in the level of labor market involvement following the birth of a child. Second, public policy that increases availability of high quality child care and child care subsidies for working mothers could efficiently reduce the implicit cost of children. Provision of high quality child care increases the productivity of market inputs into the production of child quality; other things equal, higher productivity of market inputs reduces the effect of children on women's labor supply.

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## 7 Appendix.

### 7.1 Estimation algorithm

To estimate the model, we employ Markov chain Monte Carlo techniques. Our approach combines elements from several sources in the literature. Geweke et al. (1997) propose a Gibbs sampler algorithm for estimating a panel MNP model where errors follow an AR(1) process. McCulloch and Rossi (1994) also use a Gibbs sampler to estimate a multiperiod multinomial probit model with random effects. The general random effects framework has been used for a long time in Bayesian hierarchical modeling of longitudinal data. In this paper we use the same approach as in Gilks et al. (1993). Also related, albeit in a continuous setting, is the paper by Chib and Greenberg (1995) on hierarchical SUR models with correlated errors. Finally, MCMC techniques for estimating multivariate probit models have been introduced by Chib and Greenberg (1998). We extend existing work by combining two discrete choice processes and jointly estimating the parameters of interest in both models.

The data set is an unbalanced panel, with  $N$  individuals  $i = 1, \dots, N$ , each individual  $i$  is observed for  $T_i$  periods. The total number of observations is  $df = \sum_{i=1}^N T_i$ . Let  $W_{it}^{LM} = [K_{it}|X_{it}^{LM}]$ ,  $W_{it}^F = [K_{it}|X_{it}^F]$ , and define the block diagonal matrices

$$\tilde{W}_{it} = \begin{bmatrix} W_{it}^{LM} & 0 & 0 & 0 \\ 0 & W_{it}^{LM} & 0 & 0 \\ 0 & 0 & W_{it}^{LM} & 0 \\ 0 & 0 & 0 & W_{it}^F \end{bmatrix}, \tilde{K}_{it} = \begin{bmatrix} K_{it} & 0 & 0 & 0 \\ 0 & K_{it} & 0 & 0 \\ 0 & 0 & K_{it} & 0 \\ 0 & 0 & 0 & K_{it} \end{bmatrix}$$

The conforming matrix of parameters is  $\tilde{\beta} = [\alpha^{1'}|\beta^{1'}|\alpha^{2'}|\beta^{2'}|\alpha^{3'}|\beta^{3'}|\alpha^{F'}|\beta^{F'}]'$ . Define  $U_{it} = [U_{it}^1|U_{it}^2|U_{it}^3|U_{it}^F]'$ ,  $\tilde{Z}_{it} = [(Z_{it}^1|(K_{it} * Z_{it}^1))' | (Z_{it}^2|(K_{it} * Z_{it}^2))' | (Z_{it}^3|(K_{it} * Z_{it}^3))' | 0]'$ . Let  $\tilde{\gamma} = [\gamma|\delta']'$ . Using this notation the model becomes

$$U_{it} = \tilde{W}_{it}\tilde{\beta} + \tilde{Z}_{it}\tilde{\gamma} + \sum_m \tilde{K}_{it}\theta_{ml(i,m)} + u_{it}$$

Define  $U_{i0} = u_{i0}$ ,  $\tilde{K}_{i0} = [0]$ ,  $\tilde{W}_{i0} = [0]$ ,  $\tilde{Z}_{i0} = [0]$ . Finally, let  $\dot{U}_{it} = U_{it} - RU_{it-1}$ ;  $\dot{\tilde{W}}_{it} = \tilde{W}_{it} - R\tilde{W}_{it-1}$ ;  $\dot{\tilde{K}}_{it} = \tilde{K}_{it} - R\tilde{K}_{it-1}$ ;  $\dot{\tilde{Z}}_{it} = \tilde{Z}_{it} - R\tilde{Z}_{it-1}$ .

To describe the sequence of labor market and fertility decisions, define  $d_{it}^{LM} = [d_{it}^1, d_{it}^2, d_{it}^3, d_{it}^0] = [y_{it}^{FT}, y_{it}^{FP}, y_{it}^{PT}, y_{it}^{NW}]$ ,  $d_{it}^F = y_{it}^F$ ,  $d_{it} = [d_{it}^{LM}, d_{it}^F]$ ,  $d_i = [d_{i1}, \dots, d_{iT}]$ .

The posterior kernel is given by the product of a multivariate normal kernel, the kernel of the unconditional distribution of the pre-sample error terms, the prior distributions of the parameters, and an indicator function controlling the ordering and the signs of the latent variables.

- The kernel of the joint normal distribution is:

$$|\Psi|^{-\frac{df}{2}} \exp \left\{ -\frac{1}{2} \sum_{i=1}^N \sum_{t=1}^{T_i} (u_{it} - Ru_{i,t-1})' \Psi^{-1} (u_{it} - Ru_{i,t-1}) \right\}$$

where  $u_{it} = U_{it} - \tilde{W}_{it}\tilde{\beta} - \tilde{Z}_{it}\tilde{\gamma} - \sum_m \tilde{K}_{it}\theta_{mi}$

- The kernel of the unconditional distribution of the pre-sample error:

$$|V_0(R, \Psi)|^{-\frac{N}{2}} \exp \left\{ -\frac{1}{2} \sum_{i=1}^N u'_{i0} [V_0(R, \Psi)]^{-1} u_{i0} \right\}$$

where  $[V_0(R, \Psi)]_{jk} = \frac{\psi_{jk}}{\rho_j \rho_k}$

- The indicator function for consistency and signs of U's:

$$\prod_{i=1}^N \prod_{t=1}^{T_i} H(U_{it}, d_{it})$$

- Prior distributions

- $\beta_j \sim N(\beta_{j0}, B_{j0}), j \in (1, 2, 3, F)$
- $\gamma \sim N(\gamma^0, \Gamma_0)$
- $\rho_j \sim TN(\rho_j^0, \sigma_{\rho_j^0}), j \in (1, 2, 3, F)$
- $D_m^{-1} \sim W(b_m, B_m)$

The prior distribution for  $\tilde{\beta}$  is multivariate normal with mean 0 and a variance matrix of 100 times the identity matrix, the prior distribution for  $\tilde{\gamma}$  is univariate normal with mean 0 and variance 100, the prior distribution for  $\rho$  is truncated normal with mean 0.5 and variance 0.25, the prior distribution for the precision matrix  $D_m^{-1}$  is Wishart with parameters  $b_m = 3, B_m = 0.01 * I$ , where  $I$  is an identity matrix with appropriate dimension.

A seven-step Gibbs sampling algorithm is employed to construct draws from the posterior distribution.

- Step 1. Draw  $U_{it}$  ( $i = 1, \dots, N, t = 1, \dots, T_i$ )

$$\left[ U_{it} | \tilde{\beta}, \tilde{\gamma}, \theta_{sk(i,s)}, D_s, R, u_{i0} \right] \text{ is a truncated multivariate normal distribution with mean } \begin{bmatrix} \mu_{i1} + Ru_{i0} \\ \dots \\ \mu_{iT} + R^T u_{i0} \end{bmatrix}$$

and variance  $G(I_T \otimes \Psi)G'$  where  $\mu_{it} = \tilde{W}_{it}\tilde{\beta} + \tilde{Z}_{it}\tilde{\gamma} + \sum_s \tilde{K}_{it}\theta_{sk(i,s)}$  and

$$G = \begin{bmatrix} I_4 & 0 & 0 & \dots & 0 & 0 \\ R & I_4 & 0 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ R^{T-1} & R^{T-2} & R^{T-3} & \dots & R & I_4 \end{bmatrix}$$

To draw from a truncated normal distribution, we used the method proposed by Geweke (1991).

- Step 2. Draw  $u_{i0}$  ( $i = 1, \dots, N$ ).

The conditional distribution  $\left[ u_{i0} | U_{it}, \tilde{\beta}, \tilde{\gamma}, \theta_{sk(i,s)}, D_s, R \right]$  is only a function of  $u_{i1}, R$ , and  $\Psi$ .

$$u_{i0} \sim N[Cu_{i1}, V_0(R, \Psi) - CV_0(R, \Psi)C']$$

where  $C = [V_0(R, \Psi)]R[V_0(R, \Psi)]^{-1}$

- Step 3. Draw  $\rho$ . The conditional distribution  $[\rho|U_{it}, \tilde{\beta}, \tilde{\gamma}, \theta_{sk(i,s)}, D_s, u_{i0}]$  is

$$N \left[ H_\rho (\nu_\rho + V_\rho^{-1} \rho^0), (H_\rho + V_\rho^{-1})^{-1} \right]$$

truncated to the hypercube dictated by stationarity, where

$$H_\rho = \begin{bmatrix} \psi^{11} \sum_{i=1}^N \sum_{t=1}^{T_i} (u_{it-1}^1)^2 & \dots & \psi^{13} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^1 u_{it-1}^3 & \psi^{1F} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^1 u_{it-1}^F \\ \dots & \dots & \dots & \dots \\ \psi^{13} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^1 u_{it-1}^3 & \dots & \psi^{33} \sum_{i=1}^N \sum_{t=1}^{T_i} (u_{it-1}^3)^2 & \psi^{3F} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^3 u_{it-1}^F \\ \dots & \dots & \dots & \dots \\ \psi^{F1} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^F u_{it-1}^1 & \dots & \psi^{F3} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^F u_{it-1}^3 & \psi^{FF} \sum_{i=1}^N \sum_{t=1}^{T_i} (u_{it-1}^F)^2 \end{bmatrix}$$

$$\nu_\rho = \begin{bmatrix} \sum_j \psi^{1j} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^1 u_{it}^j \\ \dots \\ \sum_j \psi^{3j} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^3 u_{it}^j \\ \dots \\ \sum_j \psi^{Fj} \sum_{i=1}^N \sum_{t=1}^{T_i} u_{it-1}^F u_{it}^j \end{bmatrix}, V_\rho = \text{diag} \left( \sigma_{\rho_1^0}, \sigma_{\rho_1^0}, \sigma_{\rho_3^0}, \sigma_{\rho_3^0}, \sigma_{\rho_F^0}, \sigma_{\rho_F^0} \right)$$

Due to the truncation, an acceptance step is necessary. Draws are rejected if  $|\rho_j| \geq 1$  for any  $j$ , then accepted with probability

$$|V_0(R, \Psi)|^{-\frac{N}{2}} \exp \left\{ -\frac{1}{2} \text{tr} S_{u_0} V_0(R, \Psi)^{-1} \right\} \div \left| \frac{1}{N} S_{u_0} \right|^{-\frac{N}{2}} \exp \left( -\frac{NL}{2} \right)$$

where  $S_{u_0} = \sum_{i=1}^N u_{i0} u_{i0}'$

- Step 4. Draw  $\tilde{\beta}_j, j = 1, 2, 3, F$ . Conditional distribution  $[\tilde{\beta}_j|U_{it}, \tilde{\gamma}, \theta_{sk(i,s)}, D_s, R, u_{i0}]$  is a multivariate normal  $\tilde{\beta}_j \sim N[b_j, B_j]$

$$B_j = \left[ B_{j0}^{-1} + \psi^{jj} \sum_{i=1}^N \sum_{t=1}^{T_i} \widetilde{W}_{it}^j \widetilde{W}_{it}^{j'} \right]^{-1}$$

and mean

$$b_j = B_j \left( B_{j0}^{-1} \beta_{j0} + \sum_l \psi^{jl} \sum_{i=1}^N \sum_{t=1}^{T_i} \widetilde{W}_{it}^j \widetilde{W}_{it}^{l(j)'} \right)$$

where  $w_{it}^{l(j)} = U_{it}^l - \tilde{W}_{it}^l \tilde{\beta}_l - \tilde{Z}_{it}^l \tilde{\gamma} - \sum_m \tilde{K}_{it} \delta_{ml(i,m)}$ , for  $l \neq j$  and  $w_{it}^{j(j)} = U_{it}^j - \tilde{Z}_{it}^j \tilde{\gamma} - \sum_m \tilde{K}_{it} \theta_{ml(i,m)}$

- Step 5. Draw  $\tilde{\gamma}$ . Conditional distribution  $[\tilde{\gamma} | U_{it}, \tilde{\beta}, \theta_{sk(i,s)}, D_s, R, u_{i0}]$  is normal  $\gamma \sim N[g, \Gamma]$

where the variance is

$$\Gamma = \left[ \Gamma_0^{-1} + \sum_{i=1}^N \sum_{t=1}^{T_i} \sum_l \sum_j \psi^{jl} \tilde{Z}_{it}^j \tilde{Z}_{it}^{l'} \right]^{-1}$$

and the mean is

$$g = \Gamma \left( \Gamma_0^{-1} \tilde{\gamma}_0 + \sum_{i=1}^N \sum_{t=1}^{T_i} \sum_l \sum_j \psi^{jl} \tilde{Z}_{it}^j \left( U_{it}^l - \tilde{W}_{it}^l \tilde{\beta}_l - \sum_m K_{it} \theta_{ml}^l(i,m) \right) \right)$$

where  $j, l = 1, 2, 3, F$ .

- Step 6. Draw  $\theta_{ml}$  for each source of heterogeneity. Conditional distributions  $[\theta_{ml} | U_{it}, \tilde{\beta}, \tilde{\gamma}, D_s, R, u_{i0}]$  are multivariate normal

$$[\theta_{ml} | \cdot] = N \left( D_m \sum_{i:l(i,m)=k} \sum_{t=1}^T \tilde{K}_{it} \Psi^{-1} e_{mit}, D_m \right)$$

where

$$D_m = \left[ \Omega_m^{-1} + \sum_{i:l(i,m)=k} \sum_{t=1}^T \tilde{K}_{it} \Psi^{-1} \tilde{K}_{it}' \right]^{-1}$$

and

$e_{mit} = U_{it} - \tilde{W}_{it} \tilde{\beta} - \tilde{Z}_{it} \tilde{\gamma} - \sum_{g:g \neq m} \tilde{K}_{it} \theta_{gl(i,g)}$ . Here,  $\sum_{i:l(i,m)=k}$  means sum for all individuals observations  $i$  for whom factor  $m$  is at level  $k$  and  $\sum_{g:g \neq m}$  means sum for all factors except  $m$ .

- Step 7. Draw  $D_m^{-1}$  for each source of heterogeneity. Conditional distributions  $[D_m^{-1} | U_{it}, \tilde{\beta}, \tilde{\gamma}, \theta_{ml}, R, u_{i0}]$  are Wishart.

$$D_m^{-1} \sim W \left( b_m + k_m, B_m + \sum_{l=1}^{l_m} \theta_{ml} \theta_{ml}' \right)$$

Convergence is assessed using the method proposed by Gelman and Rubin (1992) with the modified correction factor proposed by Brooks and Gelman (1998). One preliminary run of 14000 iterations, with OLS coefficients as starting values, was used to construct starting values for four independent chains. The starting values were extreme values chosen from the posterior distribution of the coefficients. The four independent chains, each with 20000 iterations were used to compute the scale reduction factor.

## 7.2 Data Appendix

Due to problems with the data we needed to impute some of the data values. The three main problems we faced were, top-coding of income, missing values for wages and income, and missing values for hours worked. Here we will briefly outline how we address each problem

### 7.2.1 Top-Coding of Spouse's Wage, Income from Business and Other Income

The top-coding of income data in the NLSY varies by year. From 1979 to 1984 all income values above \$75,000 were truncated to \$75,001. From 1985 to 1990 all income values greater than \$100,000 were truncated to \$100,001. Since this method produced a downward bias in the mean value of income, starting in 1989 all values above the cutoff value were replaced with the average of the true values of income above this level. For our analysis the method used in the later period is acceptable, whereas the method used in the earlier period two periods should not result in a bias in our parameter estimates. To adjust the top-coded values in the early years so that they match the values in the latter years we first compute the mean income for the top ten percent of non-top coded values in all years of the data. We then compute the average of the ratio of the top coded values with the mean of the top ten percent of the non-top coded values, across all of the latter years of the data (1989-2004). We multiplied this ratio by the mean of the top ten percent of the non-top coded values in the early years of the data (1979-1984). Finally we replaced the top coded values in the early years with this new value.

### 7.2.2 Imputing Missing Wages and Income

Once we fixed the top coding problem we then imputed missing wages and income for all individuals in our sample. For individuals who had more than three observations we regressed either log wages or log income on a constant and a time trend and used the results from this regression to impute the missing data. If only one or two values were available, we imputed the missing values with the mean deflated value of the wage or income. After 1994, NLSY74 was conducted every other year. We impute the values for the missing post-1994 years by interpolating the deflated values of the wage or income of adjacent years.

### 7.2.3 Imputing Missing Hours Worked

The NLSY collects information on hours worked each week for every week in the survey. We aggregate these weekly hours worked into hours worked in each year for individuals in our sample. If someone has a missing or invalid value for hours worked in a week we impute the value for that week by taking a weighted mean over all valid values of weekly hours worked in the survey. The weight we use is  $0.5/m$  where  $m$  is the difference between the current week and the week of the valid observation.

## References

- Angrist, J. D., and Evans, W. N. (1996), "Children and Their Parents' Labor Supply: Evidence from Exogenous Variation in Family Size," NBER Working Paper no.5778.
- Angrist, J. D., and Evans, W. N. (1998), "Children and Their Parents' Labor Supply: Evidence from Exogenous Variation in Family Size," *The American Economic Review*, 80, 450-477.
- Axinn, W. G., Clarkberg, M. E. and Thornton, A. (1994), "Family Influences on Family Size Preferences," *Demography*, 31, 65-79.
- Blank, R. M. (1989), "The Role of Part-Time Work in Women's Labor Market Choices over Time," *The American Economic Review, Papers and Proceedings*, 79, 295:299.
- Blank, R. M. (1998), "Labor Market Dynamics and Part-Time Work," in *Research in Labor Economics*, 17, ed. Solomon Polachek, JAI Press, Greenwich, CT.
- Blau, F. D. (1998), "Trends in the Well-Being of American Women (1970-1995)," *Journal of Economic Literature*, 36, 112-165.
- Blau, F. D., Ferber, M. A., and Winkler, A. E. (1998), "The Economics of Women, Men, and Work," Prentice Hall, Englewood Cliffs, New Jersey.
- Brooks, S. P., and Gelman, A. (1998), "General Methods for Monitoring Convergence of Iterative Simulations," *Journal of Computational and Graphical Statistics*, 7, 434-455.
- Brooks-Gunn, J., Han, Wen-Jui, and Waldfogel, J. (2002), "Maternal Employment and Child Cognitive Outcomes in the First Three Years of Life: the NICHD Study of Early Child Care," *Child Development*, vol. 73(4), 1052-1072.
- Browning, M. (1992), "Children and Household Economic Behavior," *Journal of Economic Literature*, 30, 1434-1475.
- Carrasco, R. (2001), "Binary Choice with Binary Endogenous Regressors in Panel Data: Estimating the Effect of Fertility on Female Labor Force Participation," *Journal of Business and Economic Statistics*, 19, 385-394.
- Chib, S., and Greenberg, E. (1998), "Analysis of Multivariate Probit Models," *Biometrika*, 85, 347-361.
- Chib, S., and Greenberg, E. (1995), "Hierarchical Analysis of SUR Models with Extensions to Correlated Serial Errors and Time-Varying Parameter Models." *Journal of Econometrics*, 68, 339-360.
- Chib, S., and Jeliazkov, I. (2003), "Semiparametric Hierarchical Bayes Analysis of Discrete Panel Data with State Dependence and Serial Correlation," unpublished manuscript.
- Folbre, N. (1994), "Children as Public Goods," *American Economic Review*, 84, 86-90.
- Gelman, A. and Rubin, D. F. (1992), "Inference from Iterative Simulations Using Multiple Sequences," (with discussion). *Statistical Science*, 7, 457-511.



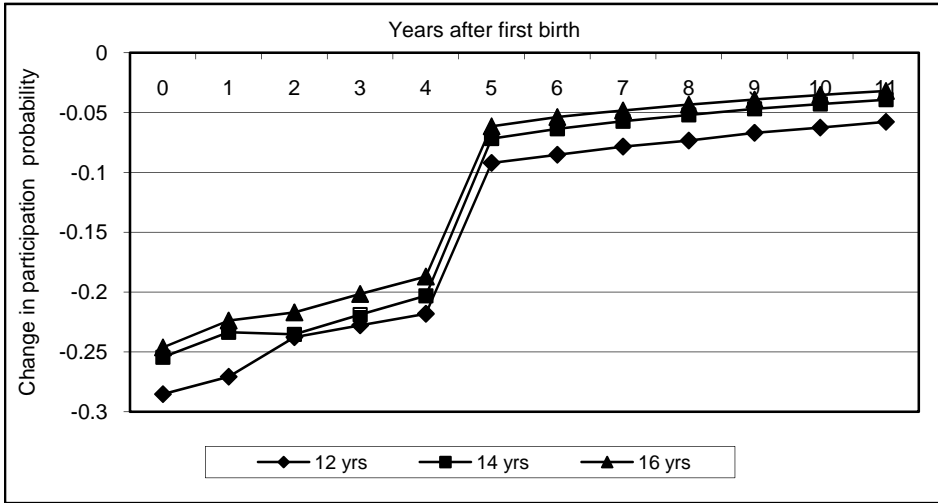
- Geweke, J. (1989), "Bayesian Inference in Econometric Models Using Monte Carlo Integration," *Econometrica*, 57,1317-1340.
- Geweke, J. (1991), "Efficient Simulation from the Multivariate Normal and Student-T Distributions Subject to Linear Constraints," in *Computing Science and Statistics: Proceedings of the 23rd Symposium on the Interface*, eds. E. Keramidas and S. Kaufman, Fairfax Station, VA: Interface Foundation of North American, 571-578.
- Geweke, J. and Keane, M. P., (2000), "Bayesian Inference for Dynamic Discrete Choice Models Without the Need for Dynamic Programming," in *Simulation-Based Inference in Econometrics: Methods and Applications*, eds. R.S. Mariano, T. Schuermann and M. Weeks, Cambridge: Cambridge University Press, 100-131.
- Geweke, J., and Keane, M. P. (2001), "Computationally Intensive Methods for Integrating in Econometrics," in *Handbook of Econometrics*, Vol.5, eds. J. J. Heckman, and E. Leamer, Elsevier, Amsterdam, 3463-3568.
- Geweke, J., Keane, M. P., and Runkle, D. E. (1997), "Statistical Inference in the Multinomial Multiperiod Probit Model," *Journal of Econometrics*, 80, 125-165.
- Giannelli, G. C. (1996) "Women's Transitions in the Labor Market: A Competing Risks Analysis on German Panel Data," *Journal of Population Economics* 9, 287-300.
- Gilks, W. R., Wang, C. C., Yvonnet B., and Coursaget, P. (1993), "Random-Effects Models for Longitudinal Data Using Gibbs Sampling," *Biometrika*, 49, 441-453.
- Gronau, R. (1973), "The Effect of Children on the Housewife's Value of Time," *Journal of Political Economy*, 81, No. 2, Part 2: New Economic Approaches to Fertility, S168-S199.
- Gronau, R. (1977), "Leisure, Home Production, and Work – the Theory of the Allocation of Time Revisited," *Journal of Political Economy*, 85, 1099-1123.
- Hajivassiliou, V. A. (1990), "Smooth Simulation Estimation of Panel Data LDV Models," Department of Economics, Yale University.
- Haurin, R. J, and Mott, F. L. (1990), "Adolescent Sexual Activity in the Family Context: The Impact of Older Siblings," *Demography*, 27, 537-557.
- Heckman, J. J. (1980), "Sample Selection Bias as a Specification Error: An Application to Estimation of Female Labor Supply Functions," in *Female Labor Supply*, ed. J. Smith, Princeton University Press, Princeton, NJ, 206-248.
- Heckman, J. and Robb, R. (1985), "Alternative Methods for Evaluating the Impact of Interventions," in *Longitudinal Analysis of Labor Market Data*, eds J. Heckman and B. Singer. Cambridge University Press.
- Heckman, J. J., and Willis, R. J. (1977), "A Beta-logistic Model for the Analysis of Sequential Labor Force Participation by Married Women," *The Journal of Political Economy*, 85, 27-58.
- Hill, C. R. and Stafford, F. P. (1980)" Parental Care of Children: Time Diary Estimates of Quantity, Predictability, and Variety," *Journal of Human Resources*, 15, 219-239.

- Hogan, D. and Kitagawa, E. (1985), "The Impact of Social Status, Family Structure, and Neighborhood on the Fertility of Black Adolescents," *American Journal of Sociology*, 90, 825-855.
- Hyslop, D., (1999), "State Dependence, Serial Correlation and Heterogeneity in Intertemporal Labor Force Participation of Married Women," *Econometrica*, 67, 1255-1294.
- Keane, M. P. (1994), "A Computationally Practical Simulation Estimator for Panel Data," *Econometrica*, 62, 95-116.
- Klerman, J. A. and Leibowitz, A. (1994), "The Work-Employment Distinction among New Mothers," *Journal of Human Resources*, 29, 277-303.
- Leibowitz, A. (1974), "Education and the Allocation of Women's Time." in *Education, Income, and Human Behavior*, ed. F. Thomas Juster McGraw Hill, New York, 171-197.
- Leibowitz, A., Klerman, J. A., and Waite, L. (1992), "Employment of New Mothers and Child Care Choice: Differences by Children's Age," *Journal of Human Resources*, 27, 112-123.
- McCulloch, R., and Rossi, P. (1994), "An Exact Analysis of the Multinomial Probit Model," *Journal of Econometrics*, 64, 207-240.
- Michael, R. (1973), "Education and the Derived Demand for Children." *Journal of Political Economy*, 81, No. 2, Part 2: New Economic Approaches to Fertility, S128-S164.
- Mincer, J. (1962), "Labor Force Participation of Married Women," in *Aspects of Labor Economics*, ed. H.G. Lewis, Princeton University Press, Princeton, NJ, 63-105.
- Mincer, J. and Polachek, S. (1974), "Family Investments in Human Capital: Earnings of Women," *Journal of Political Economy*, 82, No. 2, Part 2: Marriage, Family Human Capital, and Fertility, S76-S108
- Mincer, J. and Polachek, S. (1978), "An Exchange: The Theory of Human Capital and the Earnings of Women: Women's Earnings Reexamined," *Journal of Human Resources*, 13, 118-134.
- Montgomery, M. R. and Casterline, J. B. (1996), "Social Learning, Social Influence, and New Models of Fertility," *Population and Development Review*, 22, Supplement: Fertility in the United States: New Patterns, New Theories, 151-175.
- Nakamura, A. and Nakamura, M. (1992), "The Econometrics of Female Labor Supply and Children," *Econometric Reviews*, 11, 1-71.
- Nakamura, A. and Nakamura, M. (1994), "Predicting Female Labor Supply. Effects of Children and Recent Work Experience," *Journal of Human Resources*, 29, 304-327.,
- Ondrich, J., Spiess, C.K., and Yang, Q. (1996), "Barefoot in a German Kitchen: Federal Parental Leave and Benefit Policy and the Return to Work after Childbirth in Germany," *Journal of Population Economics* 9, 247-266.
- Powers, D. A. and Hsueh, J., C. (1997), "Siblings Models of Socioeconomic Effects on the Timing of First Premarital Birth," *Demography*, 34, 493-511.

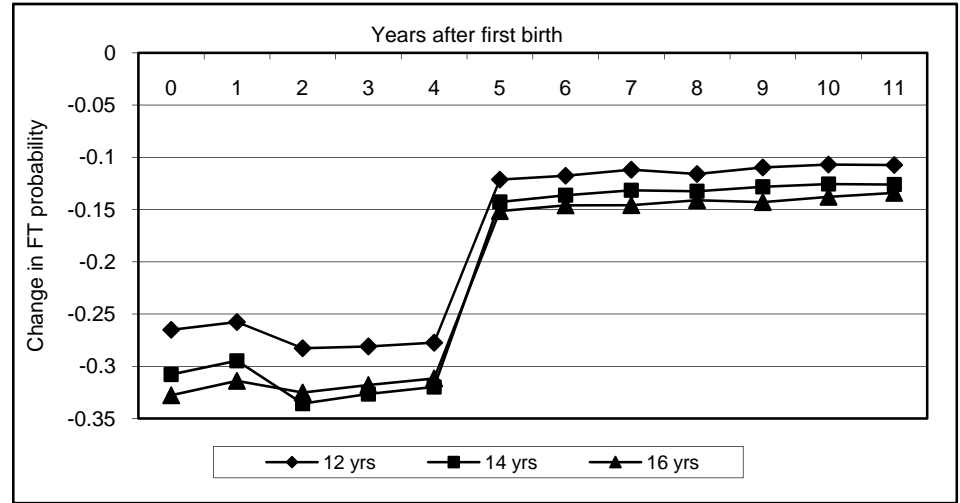
- Rodgers, J. L. and Rowe, D. C. (1988), "Influence of Siblings on Adolescent Sexual Behavior," *Developmental Psychology*, 24, 722-728.
- Rönsen, M. and Sundström, M. (1996), "Maternal Employment in Scandinavia: A Comparison of the After-Birth Employment Activity of Norwegian and Swedish Women," *Journal of Population Economics*, 9, 267-285.
- Rosenzweig, M. R., and Wolpin, K. I. (1980), "Life-Cycle Labor Supply and Fertility: Causal Inference from Household Models," *The Journal of Political Economy*, 88, 328-348.
- Rowe, D. C., Rodgers, J. L., Meseck-Bushey, S., and St. John, C., (1989), "Sexual Behavior and Nonsexual Deviance: A Sibling Study of Their Relationship," *Developmental Psychology*, 25: 61-69.
- Ruhm, C. (2004), "Parental Employment and Child Cognitive Development," *Journal of Human Resources*, vol. 39(1), 155-92.
- Waldfogel, J., Han, Wen-Jui and Brooks-Gunn, J. (2002), "The Effects of Early Maternal Employment on Child Cognitive Development," *Demography*, vol. 39(2), 369-92.
- Willis, R. (1973), "A New Approach to the Economic Theory of Fertility Behavior." *Journal of Political Economy*, 81, No. 2, Part 2: New Economic Approaches to Fertility, S14-S64.

Figure 1. The effect of the first birth on the level of labor market involvement. By education.

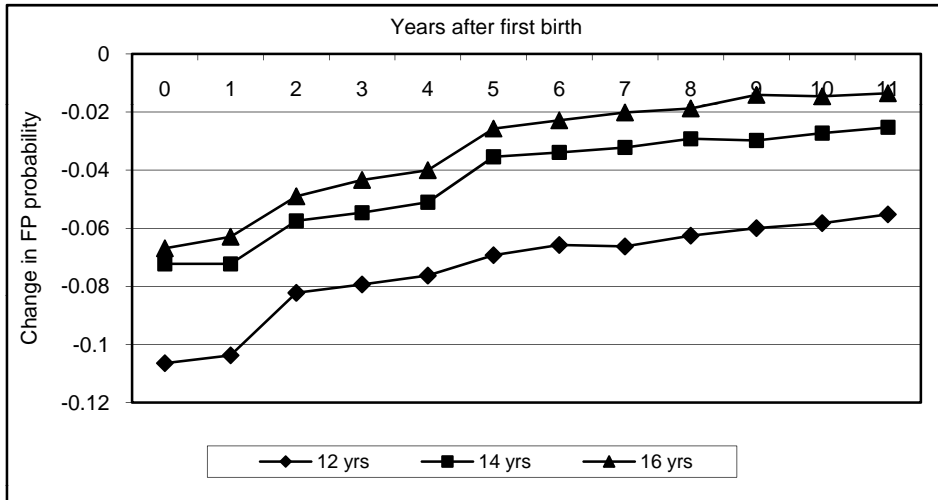
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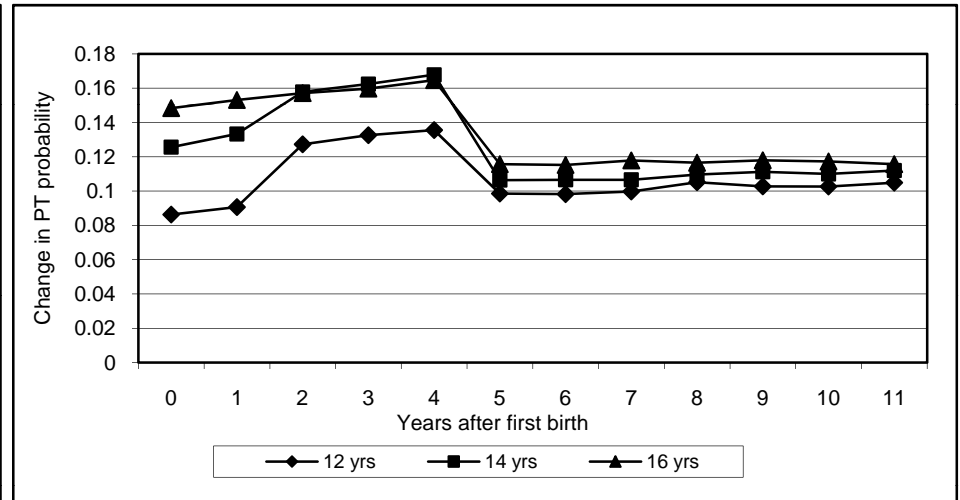
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C. Full time part year

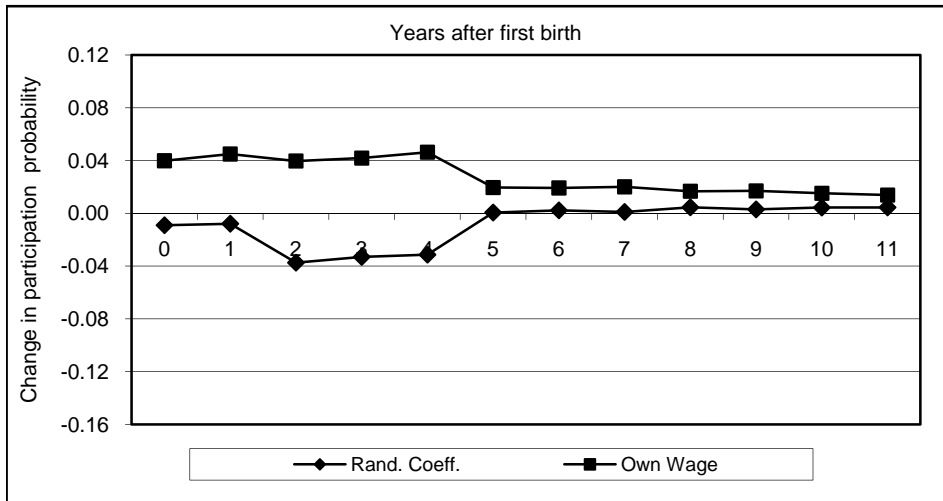


D. Part time

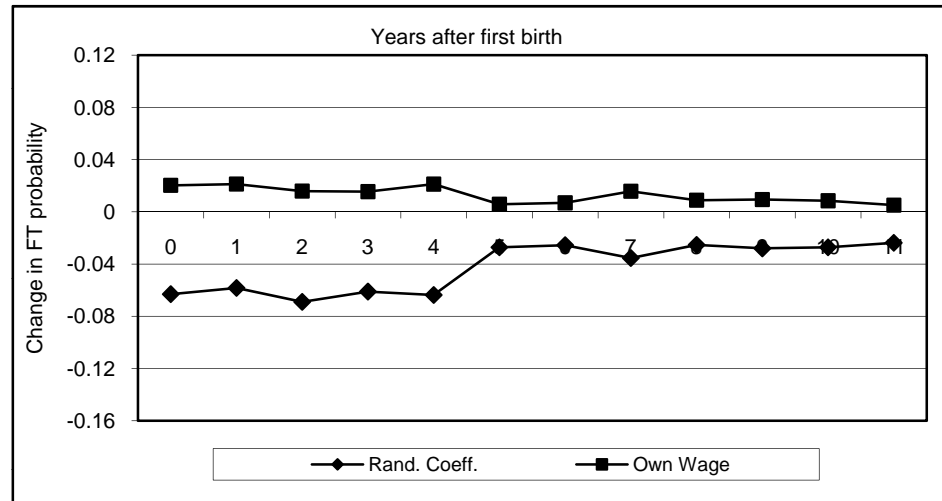


**Figure 2. The components of the total effect of education corresponding to the random coefficients and own wage. First birth.  
Women with 14 years of education compared with women with 12 years of education**

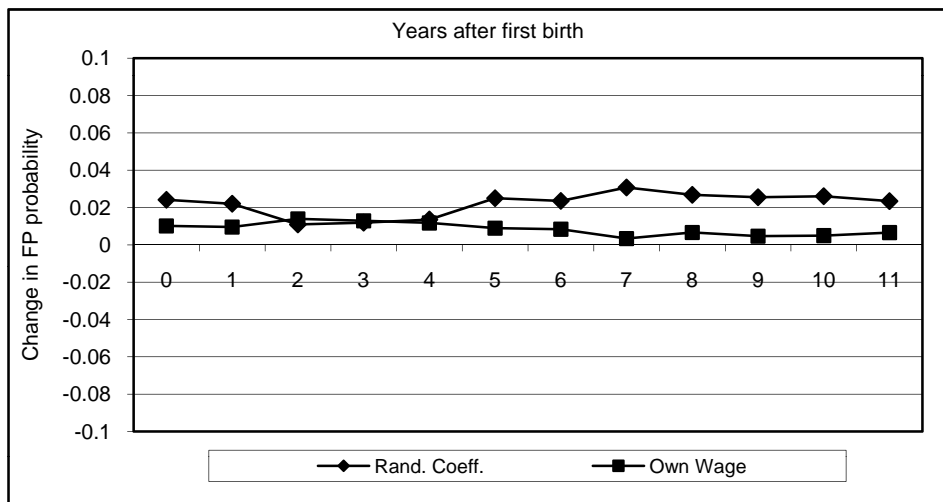
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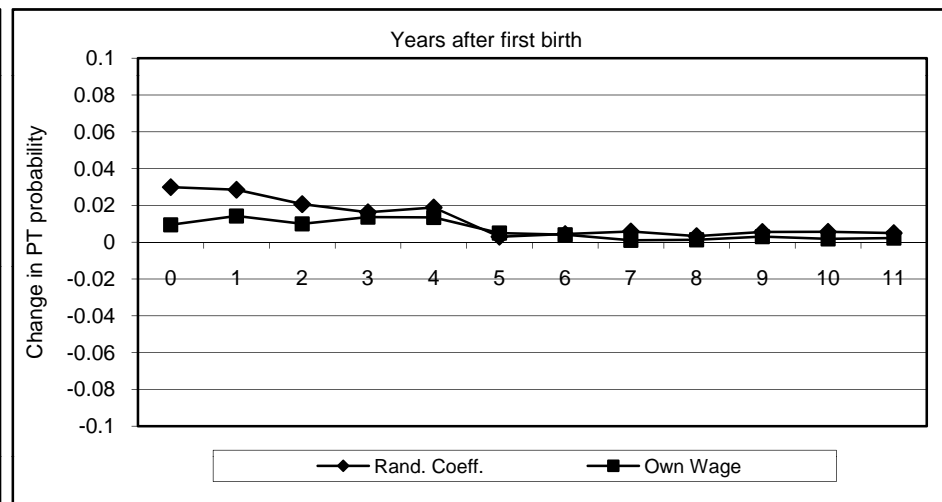
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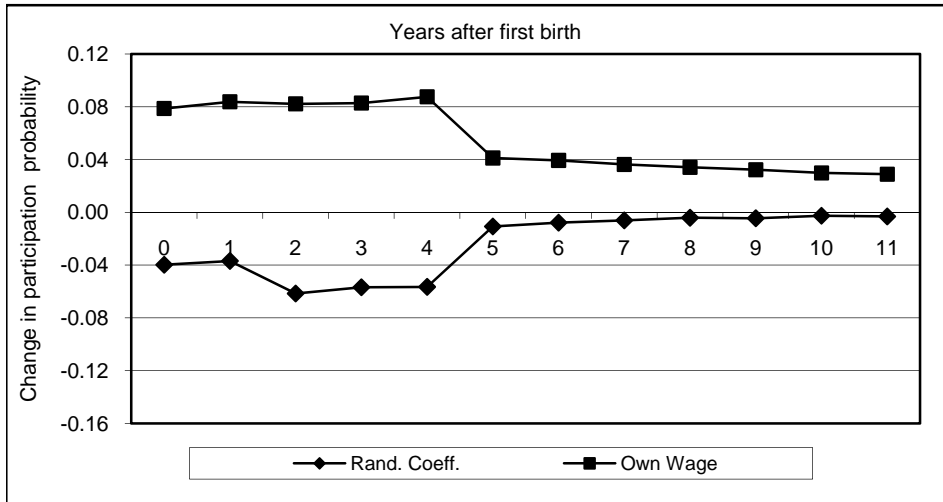


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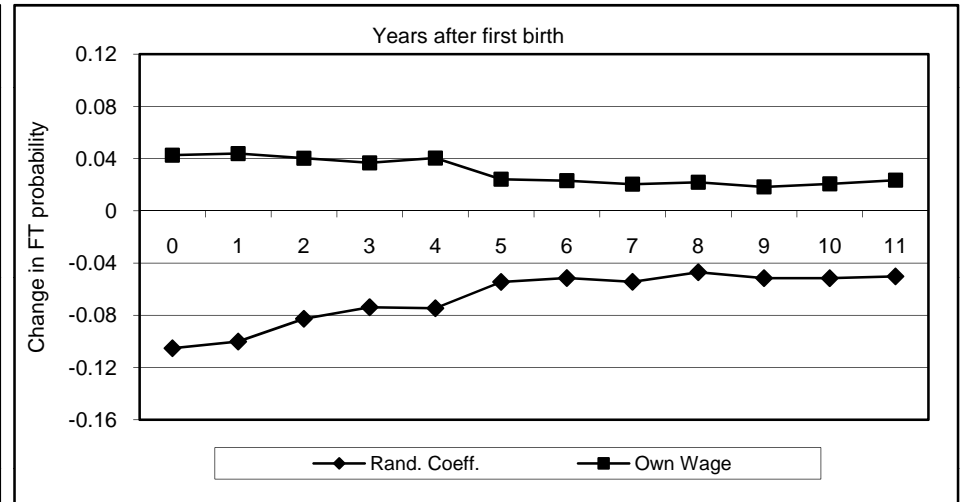


**Figure 3. The components of the total effect of education corresponding to the random coefficients and own wage. First birth. Women with 16 years of education compared with women with 12 years of education**

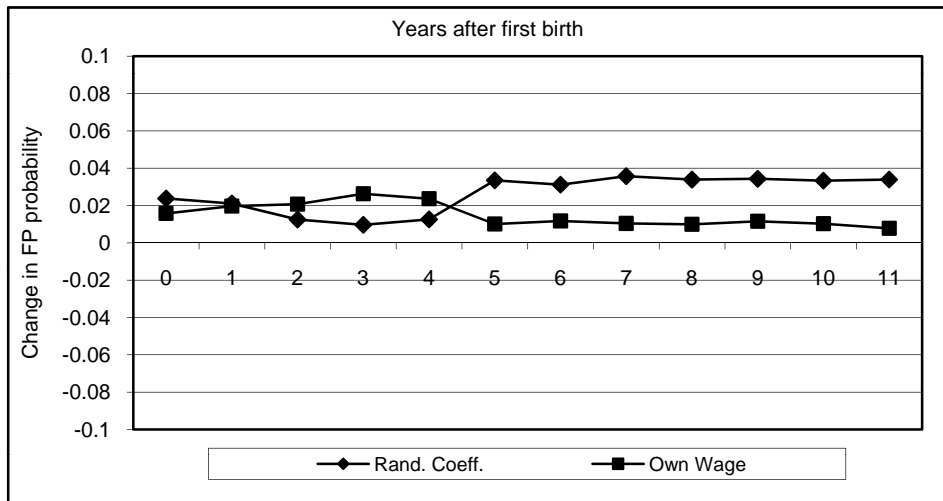
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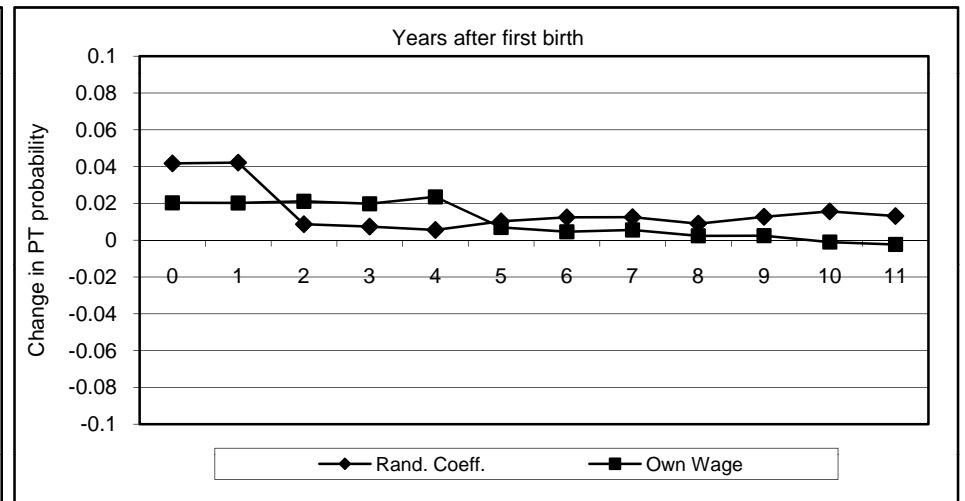
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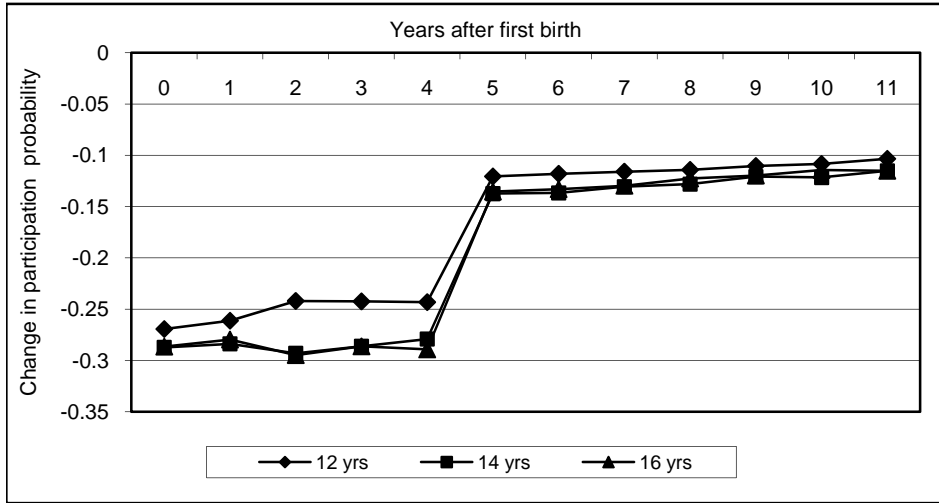


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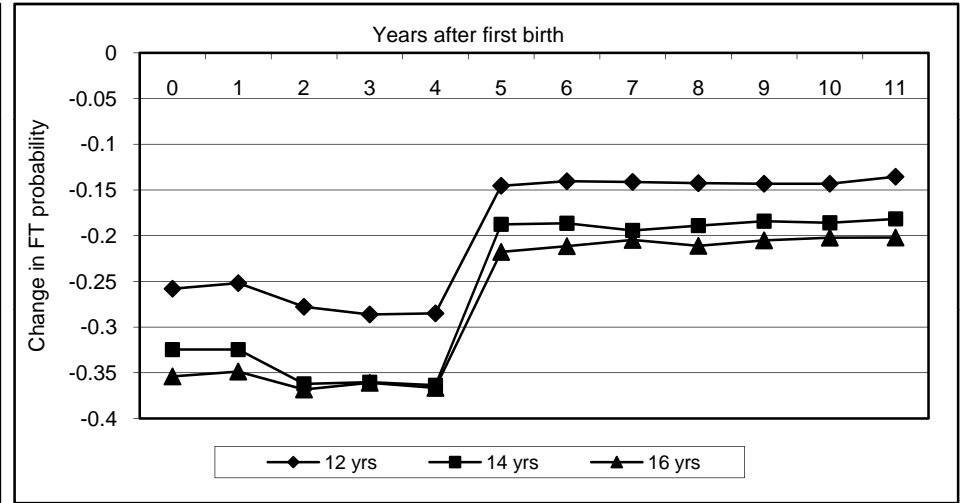


**Figure 4. The effect of the second birth on the level of labor market involvement. By education.**

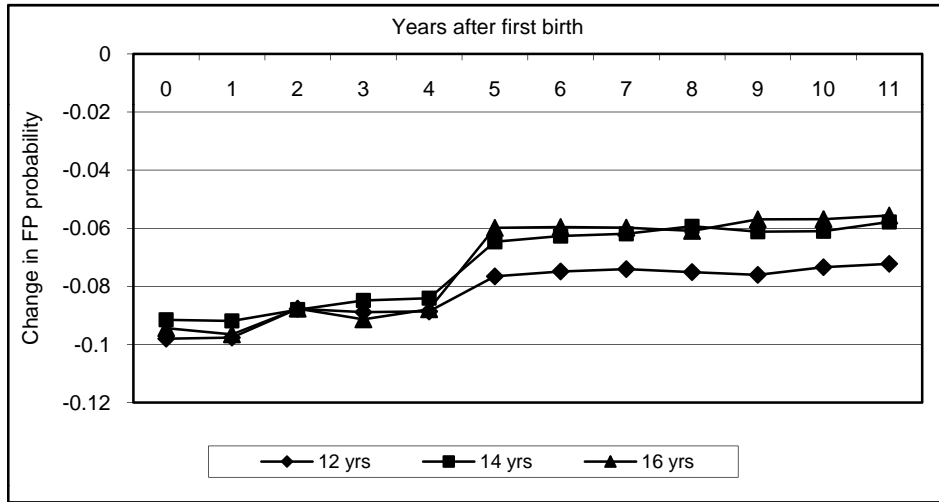
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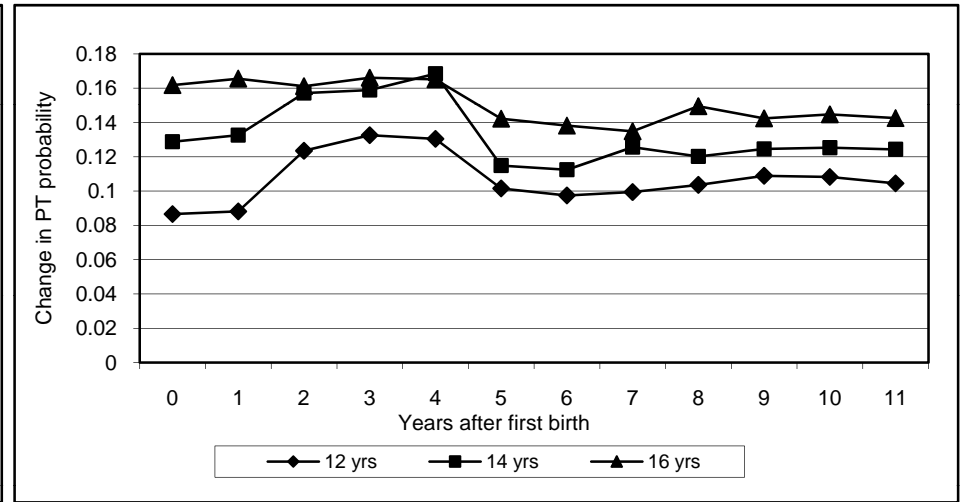
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**C. Full time part year**

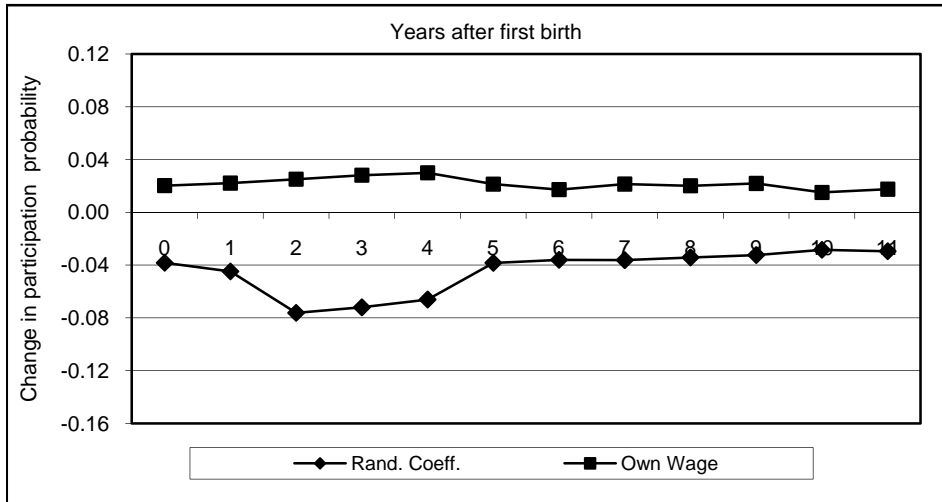


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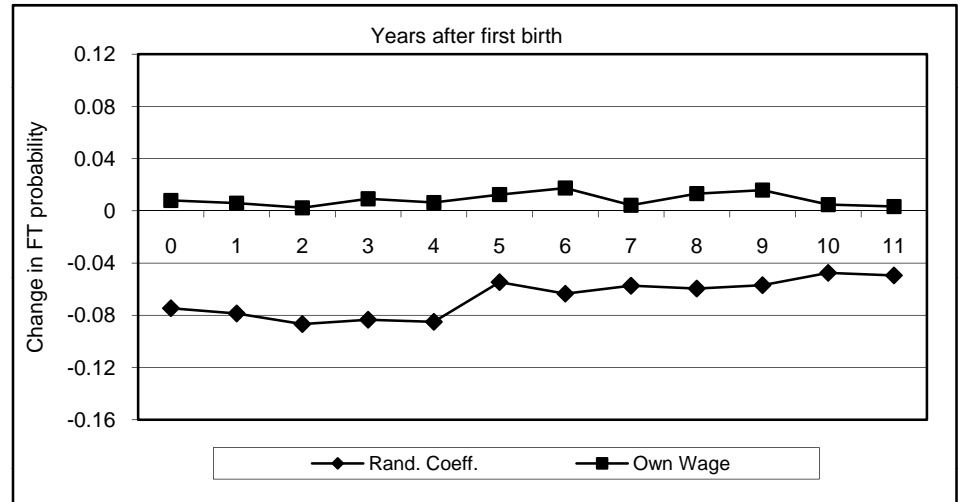


**Figure 5. The components of the total effect of education corresponding to the random coefficients and own wage. Second birth. Women with 14 years of education compared with women with 12 years of education**

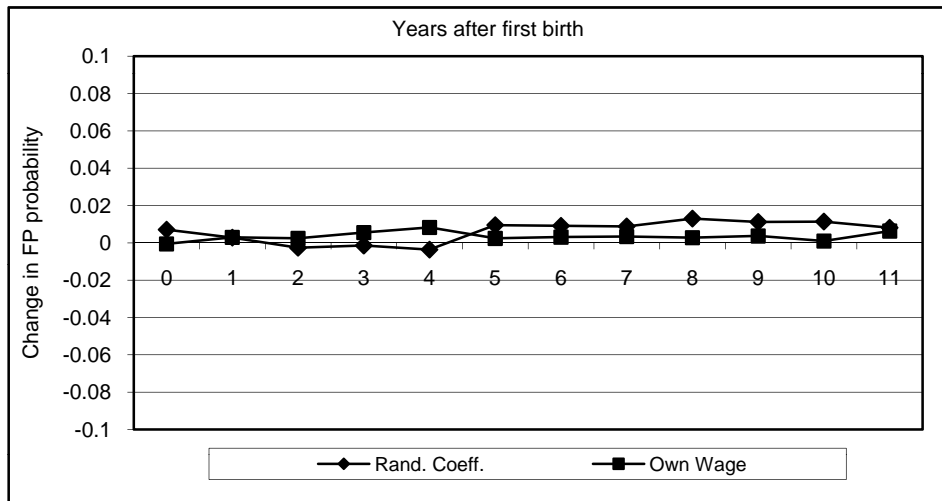
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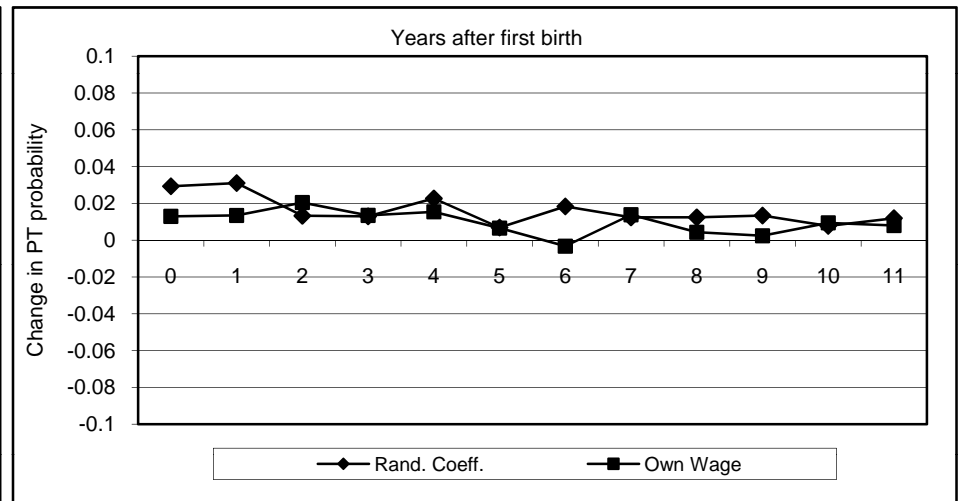
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**C. Full time part year**



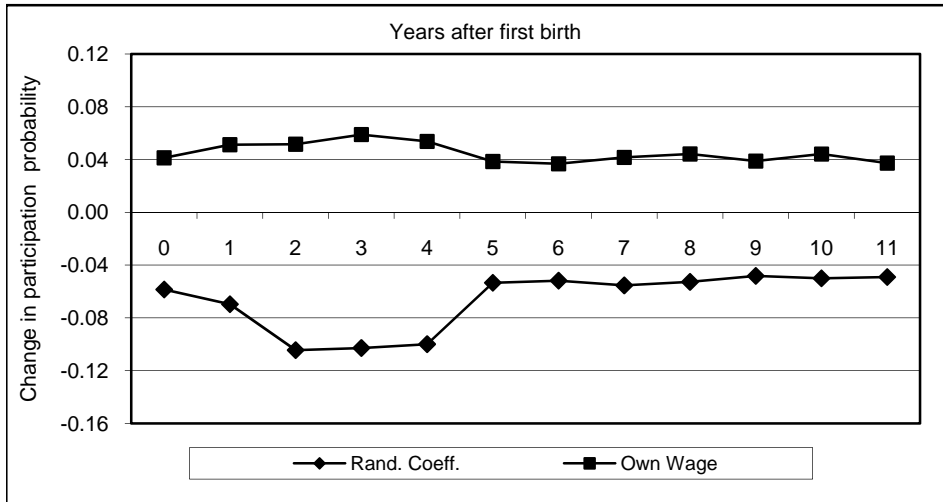
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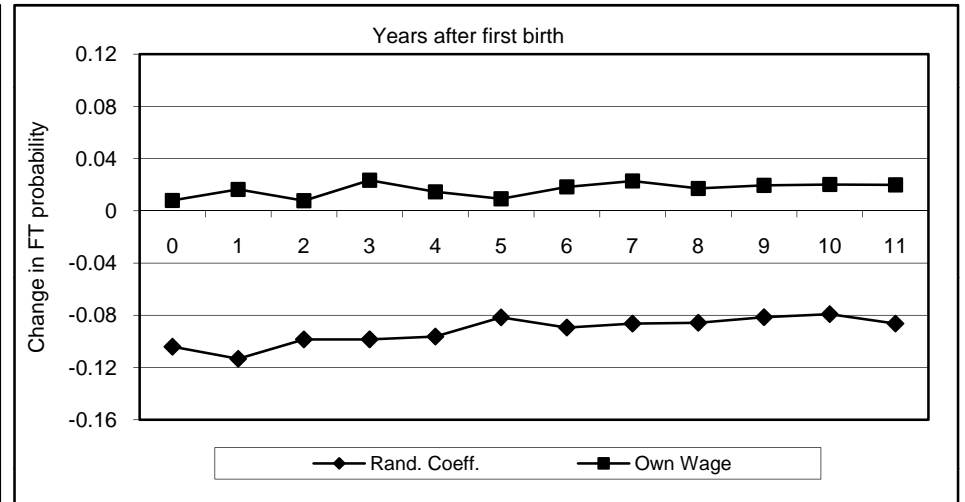


**Figure 6. The components of the total effect of education corresponding to the random coefficients and own wage. Second birth. Women with 16 years of education compared with women with 12 years of education**

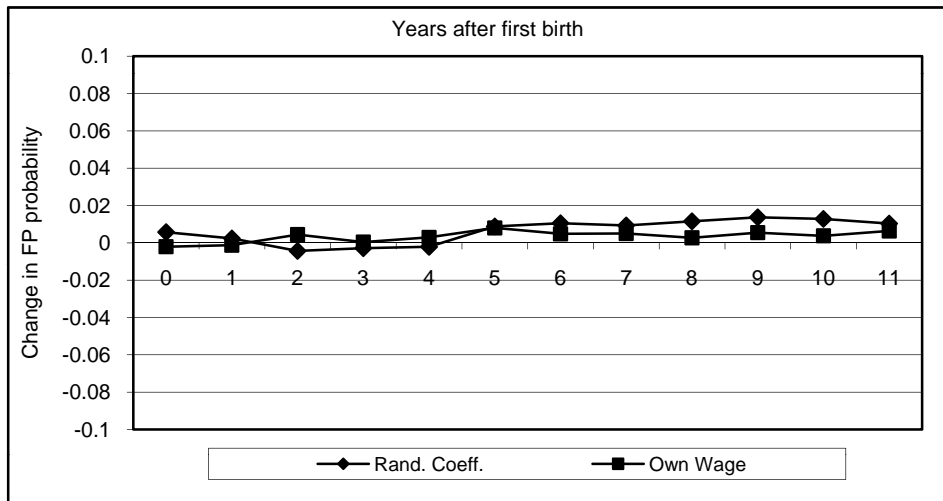
**A. Participation**



**B. Full time**



**C. Full time part year**



**D. Part time**

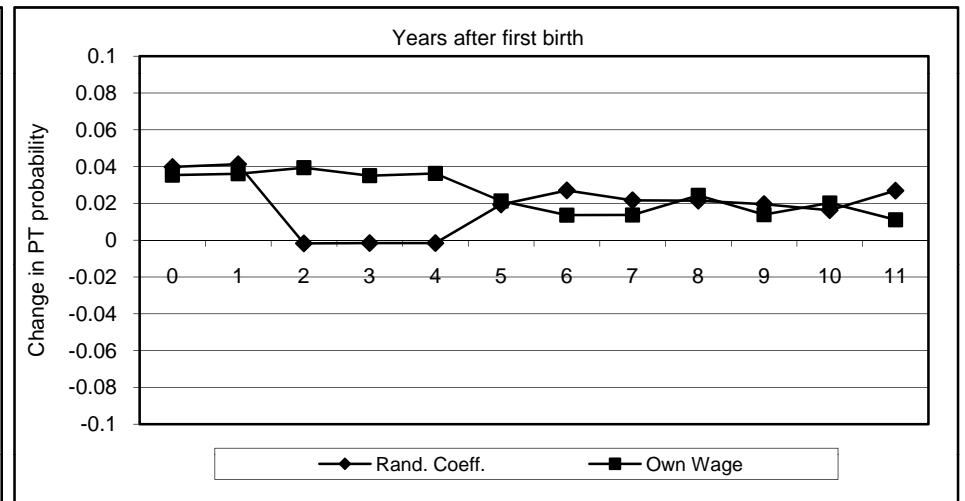
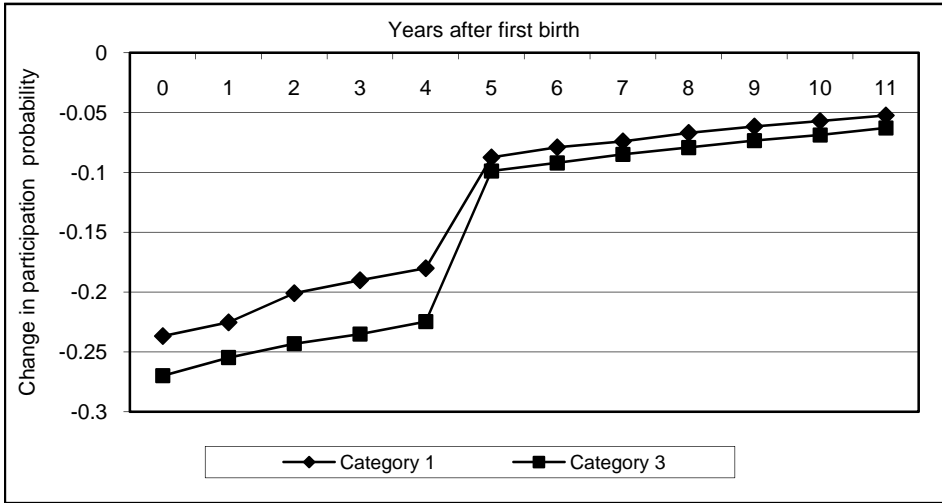
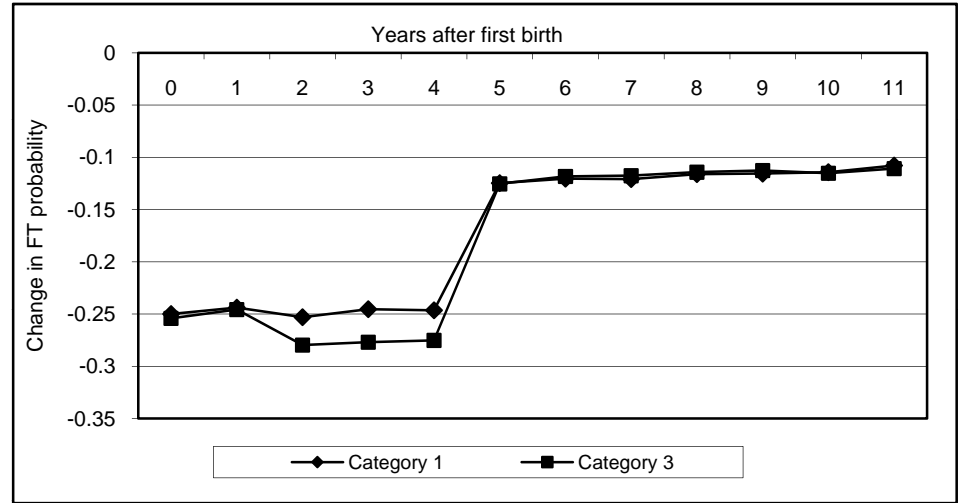


Figure 7. The effect of the first birth on the level of labor market involvement. White women with 12 years of education, by preferences.

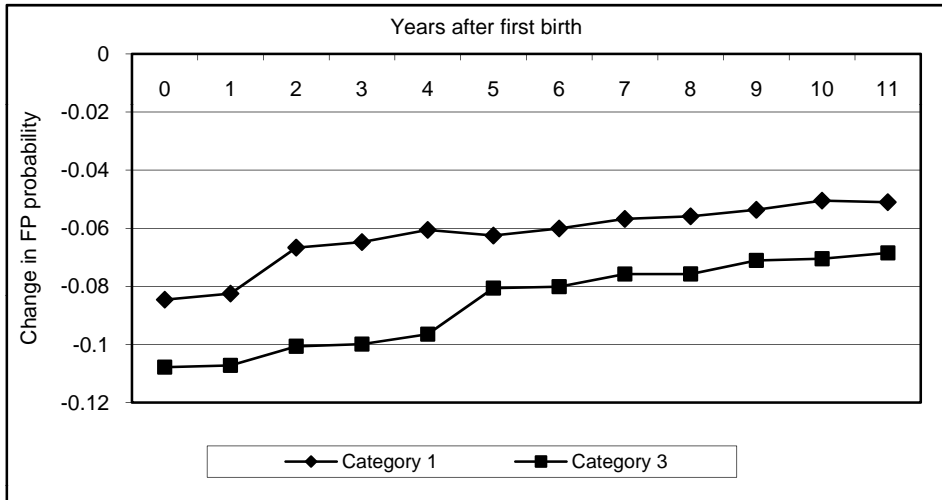
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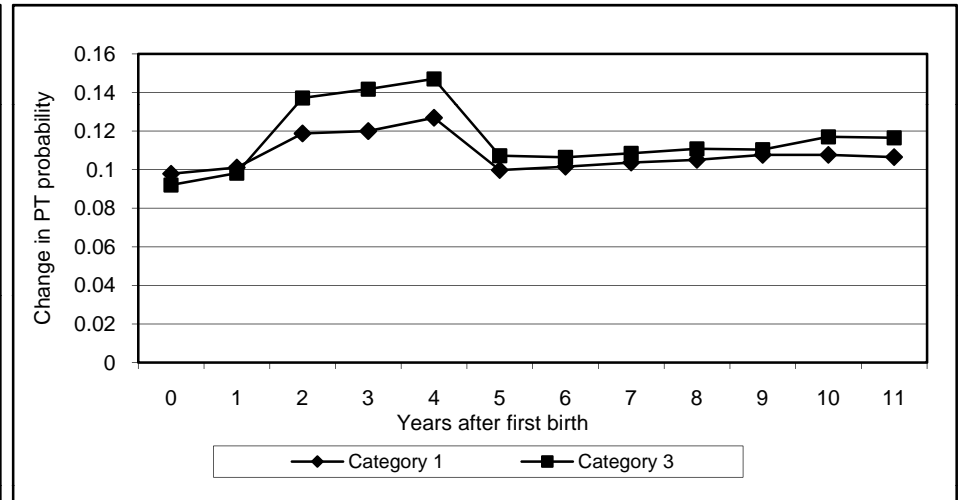
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C. Full time part year

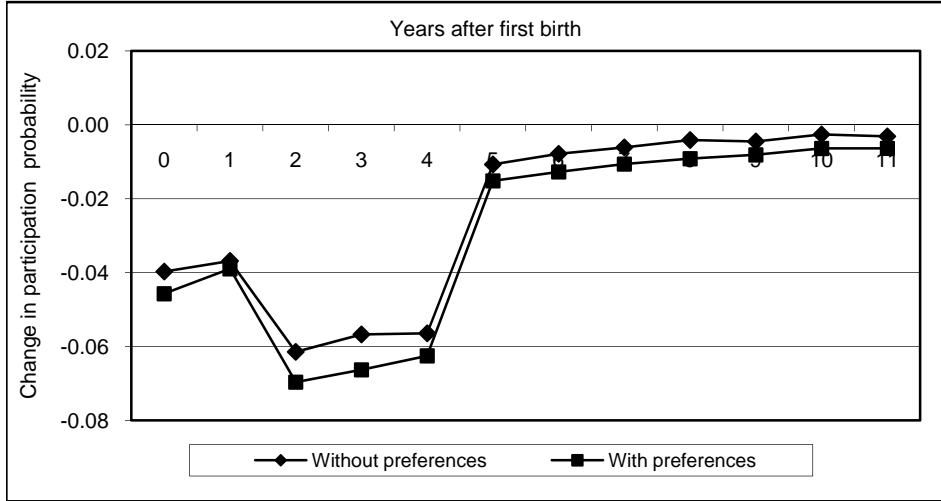


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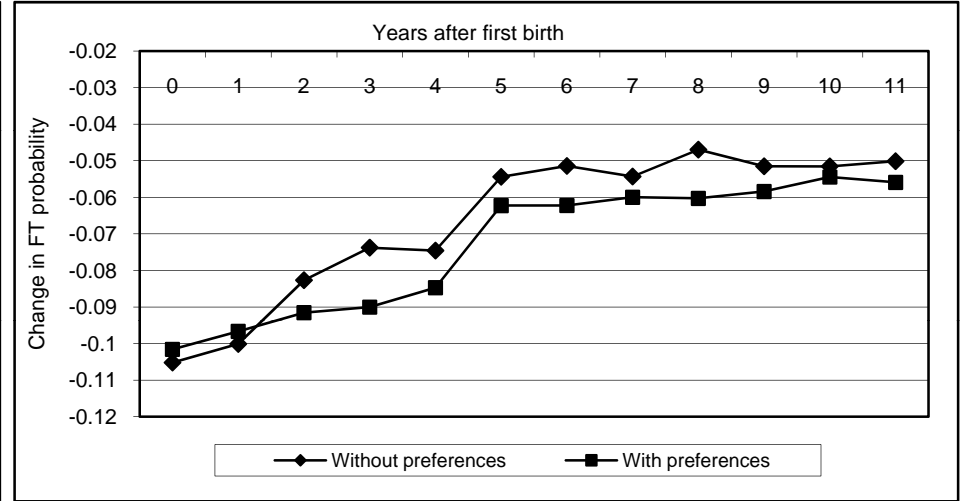


**Figure 8. The component of the total effect of education corresponding to the random coefficients. First birth. Women with 16 years of education compared with women with 12 years of education. Comparison across specifications**

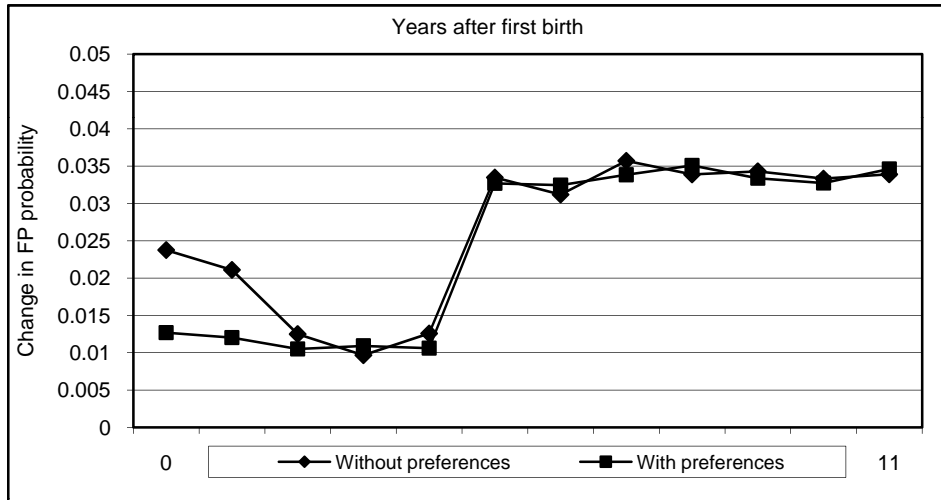
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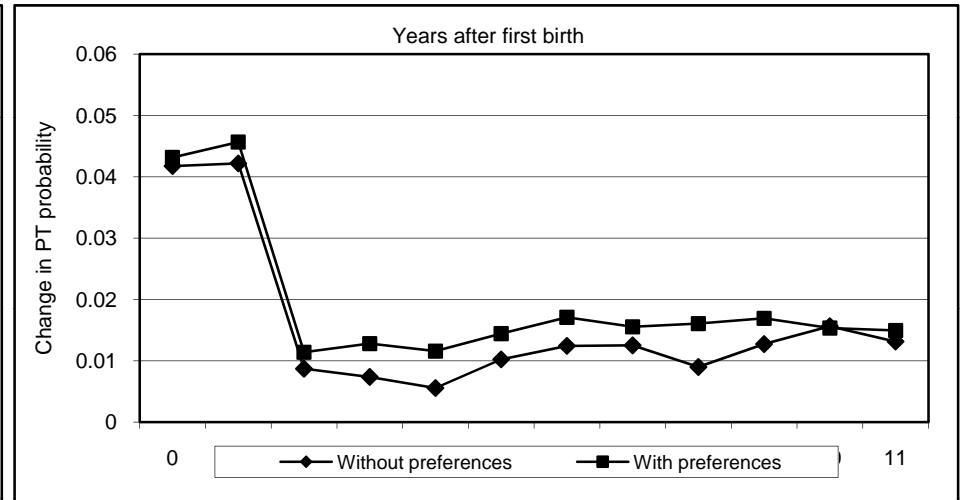
**B. Full time**



**C. Full time part year**



**D. Part time**



**Table 1. Summary Statistics of the Variables in the Data Set**

**A. Time-Varying Characteristics**

Year	Number at Risk	Married	Avg. Husband's Income	Avg. Other Income	Birth Rate	Number of Children per Woman at Risk, by Age			Labor Market Status			
						Age 0 to 1	Age 2 to 4	Age 5+	Full Time	Full Time Part Year	Part Time	Not Working
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1979	116	0.00	0.0	72.4	0.00	0.00	0.00	0.00	0.67	0.18	0.11	0.03
1980	185	0.22	1507.9	123.7	0.00	0.00	0.00	0.00	0.62	0.18	0.14	0.06
1981	263	0.28	2488.6	119.8	0.02	0.02	0.00	0.00	0.57	0.15	0.19	0.08
1982	340	0.34	2725.6	94.5	0.04	0.06	0.00	0.00	0.58	0.15	0.18	0.09
1983	402	0.42	3924.8	221.7	0.05	0.08	0.01	0.00	0.58	0.16	0.15	0.10
1984	455	0.49	5266.3	313.1	0.07	0.11	0.05	0.00	0.58	0.18	0.15	0.09
1985	511	0.55	6157.3	526.6	0.09	0.15	0.08	0.00	0.59	0.15	0.18	0.08
1986	561	0.57	8106.4	646.7	0.09	0.17	0.12	0.01	0.62	0.12	0.17	0.10
1987	606	0.62	8749.0	704.5	0.09	0.17	0.16	0.03	0.61	0.14	0.17	0.08
1988	624	0.67	10373.9	907.7	0.11	0.20	0.21	0.06	0.60	0.11	0.19	0.09
1989	631	0.73	11684.7	963.5	0.12	0.23	0.24	0.12	0.59	0.12	0.17	0.12
1990	636	0.77	13015.5	711.6	0.13	0.25	0.27	0.19	0.59	0.10	0.18	0.12
1991	638	0.80	14435.0	668.0	0.13	0.26	0.32	0.26	0.55	0.11	0.20	0.14
1992	639	0.84	15547.3	698.6	0.13	0.27	0.35	0.35	0.55	0.09	0.23	0.14
1993	642	0.86	15981.3	1123.9	0.13	0.27	0.38	0.45	0.52	0.09	0.22	0.16
1994	643	0.89	18432.9	2213.6	0.13	0.26	0.39	0.57	0.52	0.08	0.22	0.19
1995	644	0.91	18083.1	2066.9	0.12	0.25	0.40	0.70	0.53	0.07	0.21	0.19
1996	644	0.93	20263.3	2104.9	0.10	0.22	0.39	0.83	0.49	0.09	0.23	0.19
1997	645	0.94	19878.5	1481.3	0.09	0.19	0.38	0.96	0.50	0.07	0.23	0.20
1998	645	0.95	21807.5	2149.2	0.09	0.18	0.34	1.09	0.52	0.05	0.23	0.20
1999	645	0.96	19960.9	2291.8	0.06	0.15	0.31	1.22	0.52	0.05	0.23	0.21
2000	645	0.97	23862.0	2768.1	0.06	0.12	0.27	1.34	0.51	0.04	0.24	0.20
2001	645	0.98	22397.7	1829.4	0.03	0.08	0.24	1.44	0.53	0.04	0.24	0.19
2002	645	0.99	24945.3	2838.3	0.03	0.06	0.20	1.53	0.52	0.06	0.24	0.18
2003	645	1.00	23925.9	2315.4	0.02	0.05	0.14	1.61	0.51	0.06	0.22	0.21

**B. Time-Invariant Personal Characteristics and Family Background Variables**

Education	%	Race	%	Mother's LM status	%	Parents' education	%
<=12yrs	36.4	White	69.9	Full-time	31.2	None college	74.6
13-15yrs	26.7	Black	13.8	Other	68.8	One college	16.0
>=16 yrs	36.9	Hispanic	16.3			Both college	9.5

**Table 2. Fertility and Labor Market Outcomes, by Education**

	Education		
	<=12yrs	13-15yrs	>=16 yrs
<b>A. Number of children</b>			
Average	1.966	1.703	1.731
Probability Distribution			
0	0.145	0.174	0.223
1	0.136	0.221	0.126
2	0.481	0.413	0.450
3	0.149	0.140	0.134
4	0.060	0.029	0.050
5	0.021	0.017	0.008
>5	0.009	0.006	0.008
<b>B. Timing of marriage</b>			
Average number of years from entry	4.643	4.640	4.588
<b>C. Timing of the first birth</b>			
Average number of years from marriage	2.637	3.641	3.468
<b>D. The level of labor market involvement before the first birth</b>			
Participation	0.962	0.973	0.981
Full Time	0.704	0.751	0.805
Full time part year	0.125	0.100	0.090
Part time	0.133	0.122	0.086
<b>E. The level of labor market involvement after the first birth, women with one child</b>			
Participation	0.813	0.883	0.943
Full Time	0.548	0.607	0.749
Full time part year	0.083	0.089	0.035
Part time	0.182	0.188	0.159
<b>F. The level of labor market involvement after the second birth, women with two children</b>			
Participation	0.830	0.754	0.820
Full Time	0.475	0.401	0.450
Full time part year	0.094	0.064	0.055
Part time	0.261	0.289	0.314

**Table 3. Estimation Results. Posterior Means and Standard Deviations for the Coefficients.**

Equation	Full Time - Nonwork		Full Time Part Year - Nonwork		Part Time - Nonwork		Fertility	
	Mean	PSTD	Mean	PSTD	Mean	PSTD	Mean	PSTD
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.100	0.266	-0.831	0.196	-1.475	0.248	-1.398	0.071
Children age 0-1	-1.429	0.199	-0.975	0.184	-0.128	0.168	0.285	0.051
Children age 2-4	-1.058	0.201	-0.868	0.173	-0.050	0.137	-0.068	0.050
Children age 5+	-0.530	0.155	-0.429	0.101	0.218	0.093	-0.781	0.069
Married	-1.142	0.153	-0.722	0.129	-0.797	0.167		
Spouse's wage	-0.025	0.012	-0.018	0.010	-0.010	0.012		
Other income	-0.017	0.014	-0.039	0.012	-0.017	0.013	0.029	0.006
Region								
North East	0.288	0.216	0.036	0.147	0.139	0.194	-0.043	0.063
North Central	0.491	0.211	0.336	0.139	0.346	0.185	0.088	0.064
South	0.287	0.200	-0.038	0.132	-0.036	0.176	-0.072	0.062
Urban	0.218	0.111	0.117	0.088	0.093	0.107	0.004	0.047
Wage	0.702	0.017	0.702	0.017	0.702	0.017		
Wage*Children age 0-1	-0.015	0.030	-0.015	0.030	-0.015	0.030		
Wage*Children age 2-4	-0.046	0.022	-0.046	0.022	-0.046	0.022		
Wage*Children age 5+	-0.097	0.010	-0.097	0.010	-0.097	0.010		
Sibling with children							0.028	0.012
$\rho$	0.701	0.018	0.017	0.045	0.724	0.028	-0.278	0.026

**Table 4. Posterior Means of Random Coefficients. Observed Heterogeneity.**

Equation	Full Time - Nonwork				Full Time Part Year - Nonwork				Part Time - Nonwork				Fertility			
	CT	Children			CT	Children			CT	Children			CT	Children		
		0-1	2-4	5+		0-1	2-4	5+		0-1	2-4	5+		0-1	2-4	5+
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
Education																
<=12yrs	-0.330	0.229	0.245	0.179	0.004	0.128	0.174	0.064	0.092	-0.041	0.039	0.015	0.046	-0.032	0.031	-0.003
13-15yrs	0.142	-0.042	-0.099	-0.048	0.031	-0.029	-0.065	-0.033	-0.013	0.000	0.002	-0.021	-0.014	0.008	-0.015	0.001
>=16 yrs	0.188	-0.187	-0.145	-0.130	-0.035	-0.099	-0.109	-0.031	-0.078	0.041	-0.042	0.007	-0.032	0.025	-0.015	0.002
Race																
White	0.125	-0.258	-0.431	-0.325	-0.122	-0.203	-0.124	-0.082	-0.007	0.015	0.038	0.059	-0.044	-0.008	0.025	-0.012
Black	-0.009	0.112	0.254	0.247	0.049	0.064	0.064	0.043	-0.002	0.009	-0.010	-0.021	-0.034	0.000	-0.007	0.005
Hispanic	-0.115	0.146	0.177	0.078	0.073	0.139	0.060	0.039	0.009	-0.023	-0.028	-0.038	0.078	0.008	-0.018	0.007
Respondent's Mother's labor market status																
Full-time	0.139	0.004	0.082	-0.002	0.035	-0.069	0.006	-0.013	-0.003	0.002	-0.010	0.024	0.001	-0.006	0.008	-0.002
Other	-0.139	-0.004	-0.082	0.002	-0.035	0.069	-0.006	0.013	0.003	-0.002	0.010	-0.024	-0.001	0.006	-0.008	0.002
Parents' education																
None college	0.156	0.175	0.036	0.281	0.169	-0.007	0.034	0.042	0.015	-0.036	-0.010	0.026	-0.013	-0.013	-0.018	-0.014
One college	0.008	0.032	-0.048	0.006	0.010	-0.035	-0.017	-0.032	0.001	0.041	0.016	-0.023	0.004	-0.004	0.018	-0.020
Both college	-0.164	-0.207	0.012	-0.287	-0.178	0.042	-0.017	-0.010	-0.016	-0.005	-0.006	-0.003	0.009	0.017	0.000	0.034

NOTE: CT=Constant term; Children 0-1=Number of children 0 to 1years old; Children 2-4=Number of children 2 to 4 years old; Children 5+=Number of children five years old and older. Age is age at last birthday.

**Table 5. Posterior Correlation Matrix for the Effects of Unobserved Individual Heterogeneity**

		FT-NW Children				FP-NW Children				PT-NW Children				Fertility Children			
		CT	0-1	2-4	5+	CT	0-1	2-4	5+	CT	0-1	2-4	5+	CT	0-1	2-4	5+
FT-NW	CT	1	-0.082	-0.080	-0.298	0.917	0.133	-0.031	-0.362	0.550	-0.178	-0.164	-0.434	0.051	-0.259	-0.172	-0.266
	Children 0-1		1	0.990	0.926	0.084	0.960	0.976	0.888	-0.099	0.747	0.845	0.343	0.463	-0.551	-0.946	0.095
	Children 2-4			1	0.936	0.119	0.937	0.978	0.892	-0.008	0.663	0.778	0.254	0.513	-0.588	-0.936	0.129
	Children 5+				1	-0.143	0.796	0.858	0.987	-0.174	0.682	0.782	0.426	0.310	-0.343	-0.838	0.028
FP-NW	CT					1	0.276	0.187	-0.221	0.670	-0.222	-0.143	-0.562	0.422	-0.586	-0.267	0.059
	Children 0-1						1	0.964	0.748	-0.051	0.751	0.837	0.288	0.509	-0.643	-0.950	0.105
	Children 2-4							1	0.805	0.012	0.652	0.766	0.203	0.614	-0.693	-0.918	0.231
	Children 5+								1	-0.297	0.719	0.808	0.531	0.276	-0.292	-0.775	0.059
PT-NW	CT									1	-0.661	-0.564	-0.930	0.240	-0.292	-0.074	-0.094
	Children 0-1										1	0.981	0.830	0.048	-0.147	-0.683	-0.071
	Children 2-4											1	0.761	0.192	-0.288	-0.769	0.017
	Children 5+												1	-0.249	0.240	-0.219	-0.075
Fertility	CT													1	-0.963	-0.328	0.836
	Children 0-1														1	0.479	-0.694
	Children 2-4															1	0.141
	Children 5+																1

NOTE: FT = Full time; FP = Full time part year; PT = Part time; NW = Nonwork; CT = Constant term; Children 0-1 = Number of children 0 to 1years old; Children 2-4 = Number of children 2 to 4 years old; Children 5+ = Number of children five years old and older. Age is age at last birthday.



**Table 6. Simulation Scenarios**

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	year 11	year 12	year 13	year 14	year 15
Marital Status	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Fertility histories														
	1. No births														
Fertility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Children 0-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Children 2-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Children 5+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2. One child born in year 3														
Fertility	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Children 0-1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Children 2-4	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Children 5+	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	3. Two children born in years 3 and 9														
Fertility	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Children 0-1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0
Children 2-4	0	0	0	0	1	1	1	0	0	0	1	1	1	0	0
Children 5+	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2

NOTE: Children 0-1=Number of children 0 to 1years old; Children 2-4=Number of children 2 to 4 years old; Children 5+=Number of children five years old and older

**Table 7a. The Level of Labor Market Involvement Before the Birth of the First Child, by Education**

	<b>Educ. 12 yrs</b>		<b>Educ. 14 yrs</b>		<b>Educ. 16 yrs</b>	
	Prob.	% of Part.	Prob.	% of Part.	Prob.	% of Part.
	(1)	(2)	(3)	(4)	(5)	(6)
Participation	0.913		0.966		0.977	
Full time	0.567	0.621	0.715	0.740	0.745	0.762
Full time part year	0.207	0.226	0.163	0.169	0.158	0.161
Part time	0.139	0.152	0.088	0.091	0.074	0.076

**Table 7b. The components of the total effect of education corresponding to the random coefficients and own wage.**

	<b>Educ. 12 yrs/Educ. 14 yrs</b>		<b>Educ. 12 yrs/Educ. 16 yrs</b>	
	Rand. Coeff.	Wage	Rand. Coeff.	Wage
	(1)	(2)	(3)	(4)
Participation	0.036	0.017	0.035	0.029
Full time	0.131	0.016	0.154	0.024
Full time part year	-0.047	0.003	-0.062	0.013
Part time	-0.048	-0.003	-0.057	-0.008

**Table 8. The Level of Labor Market Involvement Before the Birth of the First Child  
White Women with 12 Years of Education, by Preferences**

	<b>Category 1</b>		<b>Category 3</b>	
	Prob. (1)	% of Part. (2)	Prob. (5)	% of Part. (6)
Participation	0.918		0.898	
Full time	0.610	0.665	0.534	0.594
Full time part year	0.184	0.200	0.227	0.252
Part time	0.124	0.135	0.138	0.153

**Note:** Women in category 1 strongly disagree with statements implying that the place of a woman is in the household  
Women in category 3 strongly agree with statements implying that the place of a woman is in the household

Appendix Table 1. The relationship between fertility and the number of siblings with children. Estimation results of OLS regression with the number of children born between 1979 and 2003

Independent Variable	Model 1		Model 2		Model 3	
	Coeff	Std. Err	Coeff	Std. Err	Coeff	Std. Err
Constant	1.672 **	0.064	1.611 **	0.086	1.702 **	0.122
Change in the number of siblings with children	0.155 **	0.046	0.130 **	0.052	0.101 *	0.052
Number of siblings			0.025	0.023	0.031	0.025
Education						
<=12yrs (omitted)						
13-15yrs					-0.146	0.128
>15 yrs					-0.168	0.130
Race						
White (omitted)						
Black					-0.321 **	0.151
Hispanic					0.194	0.141
Parents' education						
None Collge (omitted)						
One College					0.025	0.144
Both College					0.258	0.185
Observations	645		645		645	
Adjusted R-square	0.016		0.016		0.026	

NOTE: \*\* significant at 95% level of confidence; \* significant at 90% level of confidence