Conception and Contraception failures in a life cycle model of fecundity, fertility and female labor supply

Pablo Lavado*§

CEMFI

PRELIMINARY VERSION.

PLEASE DO NOT QUOTE WITHOUT PERMISSION.

April 2011

Abstract

The effect of fertility on female labor supply has been a topic widely studied. Literature on treatment effects have estimated the effect of second and higher order births on female labor supply. Nevertheless, the effect of the first born child is still subject of interest. I propose to use the fact that couples fail in their intentions of having or preventing children as sources of variation. I develop and estimate a dynamic discrete choice structural model which jointly estimates labor force participation and contraception decisions. Preliminary results considering unobserved heterogeneity in tastes for leisure and children and in the fecundity level show that the effect of the first born child on female labor supply is about -16%. Finally, I compare the results with OLS and IV estimates. In doing this I provide information about the sources of unobserved heterogeneity in the reduced form estimations and explore what are the advantages and disadvantages of all the abovementioned approaches.

JEL CODES: J13, J21

1 Introduction

Economists have been widely interested in studying the effects of fertility on household labor supply, in particular female participation. In fact, OLS estimates show a strong negative association between fertility and female labor supply.[1] However, this is far from being a causal effect. For

* Centro de Estudios Monetarios y Financieros (CEMFI). C/ Casado del Alisal, 5, 28014, Madrid, Spain. E-mail: plavado@cemfi.es.

§I am indebted to Stephane Bonhomme, Pedro Mira and Manuel Arellano for their constant guidance. I wish to thank seminar participants at CEMFI and Center for Applied Microeconometrics (CAM) for helpful comments and discussions. Financial support from the Spanish Ministry of Science and Innovation through grant CSD2006-00016 is gratefully aknowledged.

[1]Papps (2001) document a positive relationship in Germany, Italy and Spain associated to the tax system and which support families through improved availibility of alternatives to domestic child care, rather than through direct child payments. Several recent studies (Ahn and Mira, 2002; Del Boca, Pasqua and Pronzato, 2009) have stressed that across many OECD countries the relationship between female employment and fertility has changed over the last 25 years. While in 1980 there was a clear negative correlation between female employment and total fertility rates, in 2005 some OECD countries with higher rates of female employment also had relatively high birth rates, so that the correlation in these countries is now positive.

instance, women who are more willing to participate in the labor market are less presumably willing to have children and viceversa. Hence, OLS estimates are more negative than the correct causal effects. The literature is well acquainted with the use of two instrumental variables in order to estimate the causal effect of fertility on female labor supply: twins and the sex of the first two children. Based on these, a number of papers have been written being the most popular Rosenzweig and Wolpin (1980), Bronars and Grogger (1994) and Angrist and Evans (1998) and estimating the causal effects of second and higher order births and there is less literature about the effect of the first born child. In recent years there have been some papers estimating the effect of the first born child (Vere (2008), Aguero and Marks (2008), Cristia (2008), Miller (2009), Miller (n.d.), Rondinelli and Zizza (2010) and Chiquero (2010)) based on instrumental variables strategies. This is particularly important for several reasons. It is widely recognized that total fertility rates have been decreasing over the last forty years. In fact, at the beginings of the 21 century the average household in developed countries has less than two children. Furthermore, using data from the US 1995 NSFG the most important reduction in female labor supply is associated with the first born child (approximately 20 percentage points in comparison of 10 percentage points for the second born child, see Figure No. 1). Moreover, evidence on the effect of fertility on female labor supply is mixed: the effect could be negative (Angrist and Evans (1998)), zero (Rosenzweig and Wolpin (1980) and Hotz and Miller (1988)) or positive (recent evidence in developing countries, see Cáceres-Delpiano (2008)). Finally, there is no discussion whether the effects abovementioned are measured in the short or the long run.

The main contribution of this paper is to explore what are the mechanisms behind the effect of the first born child on female labor supply covering a broader population than previous studies have considered and looking at short and long run. I develop a reproduction model taking into account contraception use and contraception and conception failures[2] as sources of variation to identify the effect of the first born child on female labor supply, both in the short and long-run.[3] The conceptual experiment is to compare identical women which at some moment in time have different outcomes related to having a child due to failures, in other words, the only thing that differentiates them is that one has a child and the other does not. From that moment, the model will allow to estimate the effect of this difference in labor supply, both in the short and the long-run. Additionally, I will discuss the differences between the estimates obtained from reduced forms (OLS, panel data and instrumental variables) and the structural model (Heckman and Urzúa

[2]Conception failures (those events where even though couples are not using birth controls, they can not get pregnant) and contraception failures (those events where even though couples are using birth controls, they get pregnant) can be thought as unexpected shocks related to fecundity level of the couple. These shocks may be unrelated to socioeconomic status or unobservable factors affecting labor force participation decisions Rosenzweig and Schultz (1985). However, in Knowles (2009) contraception failures are correlated with the type of work performed by the couple.

[3]Based on NSFG, contraception failures are obtained from self-reported data, thus, provinding no indication of how consistently or correctly the methods are being used. Trussell et al. (1999) observe that of all contraception failures, 68% resulted in unintended pregnancies and of all unintended pregnancies, 47% were not using contraceptive methods. Also see Miller and Pasta (1995), there is a difference between wantedness and planning.

(2009), Bernal (2008) and Bernal and Keane (2010)). The objective is to explore the advantages and disadvanges of the abovementioned approaches and compare the corresponding exogeneity asumptions and different information sets. The interest of this paper rests on the identification strategy, the empirical results and the methodological contribution to the fertility effects on labor supply literature. I use data from US 1995 NSFG which contains retrospective information about labor force participation, use of birth control methods and births.

2 Literature Review

This paper tries to join two branches of the economic literature. In one hand, there is the interest on estimating the effect of the first born child on female labor supply using instrumental variables. There have been some papers which have proposed different alternative in order to estimate as clean as possible this effect, however they have not been fully convincing. The other branch is the use of structural models which jointly estimate the decisions of labor force participation and use of birth controles under imperfect control of fertility.

Regarding the first branch, Vere (2008) uses the chinese lunar calendar as instrumental variable. He argues that since chinese couples are willing to have children in the dragon year due to the belief of having better children, this is generating a source of exogenous variation. However, couples could be planning the arrival of the dragon year so reallocating their time on having children and labor force participation based on this. The effect he finds is a reduction of 30 percent of female labor supply due to the first born child. Something that is left unsolved is that the bias he finds is counterintuitive. It is assumed that the bias of children is negative, making more negative the effect of children on labor supply, but once using instrumental variables, the bias should be corrected towards zero. Nevertheless, he finds a more negative corrected estimated. Other paper is the one written by Cristia (2008) who argues that the final outcome of having a birth or not for women who have had infertility problems and who have seek infertility services is random. So, focused on this specific population, he finds that the first born child reduced female labor supply in approximately 26 percent. Finally, Aguero and Marks (2008) use infertility shocks, conception failures which last for more than twelve months, as an instrumentl variable for children in developing countries. The striking result is that the first born child has no effect on female labor supply. Also, there is not a description about the informational content of this instrument. In sum, here is the first paper which use a structural model which jointly estimates labor force participation and birth control under imperfect control of fertility in order to recover the effect of the first born child on female labor supply.

Related to the second branch of economic literature, the use of structural model which jointly estimate labor force participation and use of birth control under imperfect control of fertility, this paper departs from previous literature in the following ways. Firstly, the theoretical model proposed by Rosenzweig and Schultz (1985) is the pioneer in life-cycle models with imperfect control of fertility. They explore theoretically the mechanisms by which unobserved level of fecundity and transitory shocks in the reproduction function affects decisions to participate in the labor force and use of contraception methods. However, in the empirical section, they estimate the reproduction behavior as a function which is driven by the supply an demand for children. Based on the observed number of children and aggregate time data and estimate the permanent part of the reproduction function, as the time average of the residual by woman, and the transitory shock, once accounted for this permanent component. Therefore, they are not taking into account the dynamic behavior of the reproduction function in the estimation. Hotz and Miller (1988) constructs a theoretical model to explore the effect of child care costs on labor supply and birth spacing. However, since they are using the PSID, they do not have infomation about birth control. Thus, resting on the stochastic behavior of births, they construct a likelihood and estimate some parameters from it. Moreover, they do not include heterogeneity neither in preferences nor in wages. Sylvester (2007) studies the interdependencies of decisions such as schooling, working, marriage and use of birth control within a life-cycle framework. However, she does not consider unobserved heterogeneity. Also, since she is using the NLSY79, she does not have complete information contraception methods, using an imputation method to fill missing years, though. Radhakrishnan (2009) constructs a very complete life-cycle model with imperfect control of fertility and unobserved heterogeneity in order to study the effect of an explansion of a family planning program on labor supply and use of contraception methods for India. Finally, Maheshwari (2009) extends the model written by Sylvester (2007) and includes occupational choice and unobserved heterogeneity, also using the NLSY79. In sum, here I am contributing to literature in proposing the use of an existing framework, and using unexpected events, conception and contraception failures, as sources of identification in order to explore the effect of the first born child on female labor supply, both in the short and the long-run.

3 Data

The US National Survey of Family Growth (NSFG) is a survey which started at 1973 carried by the National Center for Health Statistics (NCHS) of the Center for Disease Control and Prevention (CDC). At the moment, there are seven cycles and the last one was held between 2006-2010.[4] In general, they gather information about family life, marriage and divorce histories, pregnancies histories, use of contraception histories, men's and women's health and labor force participation. However, each survey has particular questions. For instance, Cycle 5 (1995) collects work histories and Cycle 6 (2002) has a monthly calendar of sexual activity. For the purposes of this study, I use Cycle 5 (1995) because it has retrospective information about labor force participation and use of birth control for each pregnancy. In particular, for the five previous years of the survey, there is a monthly calendar of contraceptive use and for previous years I reconstruct infromation with the methodology propose in Trusell and Vaughan (1999) and Trussell et al. (1999). The response rate

[4] http://www.cdc.gov/nchs/nsfg.htm

of these surveys is approximately 80%.

The most serious problem in the the Cycle 5 NSFG data is the absence of histories for wages (both wives and husbands). Other important limitation is the substantial underreporting of induced abortion. However this does not affect this study because the interest rests on the estimation of the effective effect of having children on female labor force participation. Another deficiency of the data is that women who were pregnant at the time of the interview were not asked when the pregnancy began or when they expected to deliver. For that reason, I will not consider previous year data from a woman which is pregnant at the moment of the interview (Trusell and Vaughan (1999)). Finally, since this is not a panel data survey, I am relying on retrospective information. Nevertheless, previous studies on voting choices have shown that respondents misreport their past choices in order to appear more consistent with their current choice. Such retrospective bias leads to inconsistent estimates, especially when there is state dependence in choices. Specifically, observed persistence in retrospective data may be due to (a) true state dependence, (b) unobserved heterogeneity, and (c) retrospective bias in reporting previous choices.[5] However, female labor force participation figures are consistent with BLS statistics and Eckstein and Wolpin (1989). Furthemore, use of birth control statistics are consistent with past NSFG waves. A list of variables used here is presented in the Appendix.

Contraception and conception failures affect the timing on having children but both could be avoided. In one hand, contraception failures could be avoided by aborting. Even though the NSFG 1995 has information about abortions, it is well known that they are misreported. In the other hand, conception failures could be avoided by use of assisted reproduction technology. Up to 1995, use of ARTs had not been widely spread (0.003% of the population had use it, 15% of the 2% who had had an infertility related-medical appointment).[6] The sample consists of continuously married women older than 20 years old between 1970 and 1995.

The sample selection is as follows. The total number of women in the survey is 10847. Keeping just continuosly white married couples older than 20 and younger than 43, the sample reduces to 4252. Dropping sterile couples for non contraception reasons, the final sample is 4085. The total number of women-year observations is 36200. Finally, dropping women-year observations with more than 5 children and with 4 children below 6 years old, the final number of observations is 35969.

3.1 Reduced Form Models

The objective of this section is to estimated reduced form models in order to observe some evidence of correlation between fertility and female labor supply based on two strategies: instrumental variables and panel data fixed effects.

[5]See Eckstein and Shachar (2007)
[6]See Rebar and DeCherney (2004).

The first strategy is to use conception and contraception failures as instrumental variables. Even though there is no clear evidence about their exogeneity assumption with respect to labor force participation decisions there is no empirical evidence on some correlation between conception failure and some osbervable characteristics, IV estimations are presented and interpreted as interesting correlations which are providing some information about the relationship between fertility and female labor supply. Nevertheless, the use of failures as IV are not straightforward. Before estimating, let us explain the conceptual experiment behind failures. Let us think in two identical women, with the same history of labor force participation and contraception decisions. In particular, let us think in two married women who have been using contraception methods since marriage. At the same time, they stop using contraception methods and one succeed in having a child and the other does not. The consequence on labor force participation of this unique difference is the effect of the first born child on female labor supply. So, for the susequent period and so on,I present a series of the following IV estimations by period:

$$h_i = \gamma_0 + \gamma_1 N_i + \gamma_2 X_i + \upsilon_i \tag{1}$$

$$N_i = \beta_0 + \beta_1 F_i + \beta_2 X_i + \epsilon_i \tag{2}$$

where h_i is labor force participation, N_i is whether there is at least one child, X_i is a vector of covariates (education, experience, age of marriage and age), υ_i is the error term, F_i is infertility in the first born child (a conception failure which last for more than twelve months) and ϵ_i is the error term of the first stage equation. So, for contraception failures I took subsamples of women who stop using any birth control method. I took three subsamples: childless women, women with just one child and women with two children. Some of them succeded in having a child. So, I have a sort of a treatment and a control group. This estimations are done up to 17 years after failure. The first and the second are the numerators of a Wald estimand and third one is the denominator of both. So, it is possible to estimate the Wald estimate of the causal effect of the first, second and third born child on labor force participation (column 7 in Figure 2) and the causal effect of the first, second and third born child on labor market experience (column 10 in Figure 2). A similar strategy was followed with contraception failures using subsamples of women who start using any birth control method (Figure 3).

Even though the effect of having an additional children is sizable, it lasts, at most, 5 years. The effect of the first born child on female labor supply ranges from 19% (contraception failures as IV) to 22% (conception failures as IV). But these 5 years are enough to generate permanent differences in the stock of children and in the labor market experience. Couples with failures never catch up in terms of number of children. They have between 0.3 and 1 less child. Furthermore, the effect on labor market experience lasts at least 8 years. Women with failures have, on average, 1 year less of experience (except for the effect of the second born child using conception failures, whose effect lasts 15 years to reduce almos 3 years of experience and the effect of the third born child using conception failures, whose effect is not statistically significant). An expected finding is that the effect of an additional child decreases with the number of children. Furthermore, an interesting result is that the reduction in female labor force participation as a result of the second and the third born children in the short run are similar to the estimations presented by **?** and Angrist and Evans (1998). However, an important caveat in this exercise is the quick reduction in the number of observations as time goes by.

The second reduced form strategy is to estimate the effect by panel data fixed effects:

$$h_{it} = \gamma_0 + \gamma_i + \gamma_1 N_{it} + \gamma_2 X_{it} + \upsilon_{it} \tag{3}$$

where γ_i is and individual component, N includes the stock of children, the stock of children by age group and whether there is at least one child, X is a vector of covariates (experience and its square, age and its square, use of birth control, and pregnancy periods). I am assuming here that the only endogenous variable here is the use of birth control and the stock of children is an outcome depending on these and other unobservables which are included in the fixed effects (i.e. unosberved fecundity). Thus, all variables related to children are assumed to be strictly exogenous.

The effect of the first born child on female labor supply is between -0.18 (short run) and -0.14 (long run). However, an interesting result is that the panel data fixed effects can replicate the correction made by Angrist and Evans (1998) using the sex of the first two children as an IV for women with at least two children. They found a reduction of 10% whereas the panel data fixed effects show a similar coefficient (10% using annual data and 10.6% using monthly data), using the same group of covariates. This is interesting because the variation that Angrist and Evans (1998) are correcting would be pure unosberved heterogeneity absorbed by the fixed effects. But, one additional comment is that for Angrist and Evans one important omitted variable is labor market experience, which presumably affect the opportunity cost of going out the labor market and the state dependence of being working. Adding this variable to the panel data fixed effects estimations, decreases the effect of fertility on female labor supply in Angrsit and Evans (for higher order births) but increases the reduction for the first born child.

These results arises two questions. First, what is the mechanism or the behavior behind infertility shock? How infertility shocks help to identify the effect of the first born child on female labor supply? Second, what is the unobserved heterogeneity that same-sex and fixed effects are absorving? The answer for these questions are not well adressed in the IV literature. In the following section I construct a structural model to attempt an explanation to all these questions.

4 The Model

I develop a dynamic discrete choice structural model which jointly estimates labor force participation and contraception decisions under imperfect control of fertility, following Rosenzweig and

Schultz (1985) and Hotz and Miller (1988).[7] Couples maximize their expected discounted life time utility function. In each period they choose female participation in the labor force ($h = 1$) or not ($h = 0$) and being sterilized ($st = 1$) or not ($st = 0$). If couples choose not to be sterilized, they have to choose to use birth control methods ($bc = 1$) or not ($bc = 0$).[8] Contraception decisions are restricted to a known sub-period corresponding to the fertile period of the woman. If the couple decides to stop using contraception methods, a birth will occur next period with probability lower than one. The probability of conception is unknown by the couple and the econometrician. Nevertheless, the couple will learn about its own fecundability level since first discontinuation of contraception methods up to the first born child. Furthermore, the probability of conception declines according to age, slowly first and quickly in the last fertile years. The couple derives utility from consumption, from children, from leisure, from not being sterilized and from not using any contraception method. Children also affects preferences from leisure, especially when are young. A period in the model lasts twelve months. When women are employed, the couple receive her wages and husband's wages. While women out of the labor force, the couple does not receive any benefits, but husband's wages and enjoy leisure. There is no maternity leave. Working and fertility outcomes are connected in a variety of dimensions. The interruption following a birth depreciates human capital and lowers the opportunity cost of working. Moreover, a child increases marginal utility of leisure but decreases marginal utility of children. Finally, a low probability of conception will induce women to redefined her decisions, increasing the probability of working. The model is estimated using a modified version of EM algorithm. The main sources of identification are conception and contraception failuires.

4.1 Formal Presentation

Let $\Omega_t = (K_t, N_t, N_{6t}, f_t; K_0, mat_0, S, S_h)$ be the vector of endogenous state variables where K_t is accumulated experience up to period t since marriage; N_t is the number of children during period t;N_6 is a dicothomous variable which defines whether there is at least one child younger than or equal to 6 years old; f_t is a dicothomous variable which takes the value of 1 if the couple suffered at least one conception failure and zero otherwise; and predetermined state variables where $K0$ is the experience accumulated previous to marriage, $mat0$ is the age of marriage; S is the woman's schooling level and S_h is the husband's schooling level. Since I am considering imperfect control of fertility, the stochastic behavior of births is given by:

$$p_t = \gamma k_t \tag{4}$$

where γ is the natural fecundity level $\gamma \in [0, 1]$ and

[7] Recent versions of this kind of models are Radhakrishnan (2009) and Maheshwari (2009).

[8] I am abstracting from full time and part time considerations, since it is stable during the period, representing 24-26% of labor force. Furthermore, Francesconi (2002) using a sample of married couples from NLSY from 1968 to 1991, which is cotained in mine, finds that the relevant substitution is between full time work and leisure.

$$k_t = f(age_t)(1 - e.bc_t) \tag{5}$$

where e is the contraception efficiency $e \in [0,1]$ and f is a function which determines the decline in fecundability, according to age. Natural fecundity level follows a learning process where conception failures provide information about the individual capacity of having children. Finally, contraception efficiency can be thought as a production function which depends on contraception failures.

Couples derive utility from their expected earnings, from leisure, children and not using any kind of contraception or sterilization method. I adopt the following functional form for a period-specific utility:

$$u_t = c_t + \alpha_1 l_t + \alpha_2 l_t^2 + \alpha_3 N_t + \alpha_4 N_t^2 + \alpha_5 bc_t + \alpha_6 st_t \tag{6}$$

where l is leisure and is defined as follows:

$$l_t = 100 - x_h h - x_m M - x_n N - x_6 N_6 \tag{7}$$

where c_t is consumption during period t of a composite good; x_m is the time required for child-rearing; M is a dicothomous variable which defines whether there is at least one child within the household; x_h is the time required in the labor market ; x_n is the time required for child rearing; x_6 is the time required for child-under-6 rearing; h_t is a dicothomous variable which defines whether women are working $h_t = 1$ or not $h_t = 0$; bc_t is a dicothomous variable which defines whether women are using birth control $bc_t = 1$ or not $bc_t = 0$; st_t is a dichotomous variable which defines whether couples decide to be sterilized $st_t = 1$ or not $st_t = 0$. The household's budget constraint in each period is [9]:

$$w_t h_t + y_t = c_t \tag{8}$$

The number of children and failures evolve according to:

$$N_t = N_{t-1} + birth_{t-1} \tag{9}$$

$$f_t = 1\left\{bc_{t-1} = 0 \wedge birth_t = 0\right\} \tag{10}$$

The atrophy rate (loss of experience) is a function of the periods out of the labor force. Up to this moment, the model considers a penalty for each non-working period. Work experience (K) and the number of periods out of the labor force ($Inter$) evolve according to:

[9]Due to lack of identification I will assume that the budget parameters are equal to zero. So, it is possible to interpret some coefficients in the utility function as a net utility.See Eckstein and Wolpin (1989).

$$K_t = K_{t-1} + h_{t-1} \tag{11}$$

$$I_t = I_{t-1} + (1 - h_{t-1}) \tag{12}$$

The objective of the household, then, is to maximize:

$$\max_{\{h_t\}_\tau^T;\{bc_t\}_\tau^T;\{st_t\}_\tau^T} E_\tau \sum_{t=\tau}^{T} \beta^t U(N_t, c_t, l_t, bc_t, st_t) \tag{13}$$

Couples have to take the following decisions: whether women participate in the labor force and whether to be sterilized or not. If not sterilized, they have to decide whether to use any birth control method or not. If sterilized, couples just have to take the decision wheter women participate in the labor market or not. The choice-specific value function is:

$$\begin{aligned}
&V_{t,h,bc,st} = \\
&pV_{t,h,bc}(\Omega_t, \nu_t | h_t, bc_t, st_t, b_t = 1) \\
&+ (1-p)V_{t,h,bc,st}(\Omega_t, \nu_t | h_t, bc_t, st_t, b_t = 0) + \epsilon_{t,h,bc,st} \\
&\Omega_t = (K_{t-1}, N_{tj}, N_{6j}, f_t, \epsilon^t; S, S_h, K0, mat0)
\end{aligned} \tag{14}$$

where ϵ is the choice specific preference shock. The dynamic programming solution to the optimization problem is obtained by a process of backwards recursion.

After 42 years old, the choice set just consists on the decision about woman's labor force participation. So, terminal values are equal to the expected discounted utility of working up to 65 years old. After 65 years old, terminal values are assumed to be zero.

$$V_{hT} = P(h_T = 1)U(h = 1) + P(h_T = 0)U(h = 0) + \delta[P(h_{T+1} = 1)V_{k_T+1} + P(h_{T+1} = 0)V_{k_T}] \tag{15}$$

The timing of the decision is:

1. At moment t, individuals observe the preference shock, family size N_t, children under six years old N_{6t}, the accumulated human capital up to time t, K_{t-1}, schooling level S, husband's schooling level S_h, pre-marriage labor experience $K0$ and the age of marriage $mat0$.

2. Given uncertainty in having children, p, couples decide whether to be sterilzed or not st_t, to use contraception or not bc_t and female labor force participation h_t.

3. After observing outcome $birth_t$, return to (1) to make decisions for $t + 1$.

Additionally, I will consider two sources of unobserved heterogeneity. The first one is preferences in children , $\mu^l_{\alpha_4}$. The second source of heterogeneity comes from the well known fact about the serial persistence in labor force participation. The lack of information about evolution of wages avoids to estimate unobserved heterogeneity in equation of wages. However, observationally, unobserved heterogeneity in leisure, which generates heterogeneity in the propensity of participation, generates serial persistence in participation as if it were considered heterogeneity in wages and productivity.[10] Thus, since there is a panel information about the decisions on participation, it is assumed to have unobserved heterogeneity in preferences for leisure, $\mu^l_{\alpha_1}$. Let μ_l be a three element vector which contains the two unobserved parameters to be estimated $\mu_l = (\mu^l_{\alpha_4}, \mu^l_{\alpha_1})$ and which will define L types of individuals. Finally, I make the probability of type 1 a logistic function of the couple's characteristics (labor force experience before marriage, age of marriage, wife's and husband's schooling):

$$Prob(type1|\Omega_0) = \frac{exp(\lambda_1 K_0 + \lambda_2 mat_0 + \lambda_3 S + \lambda_4 Sh)}{1 + exp(\lambda_1 K_0 + \lambda_2 mat_0 + \lambda_3 S + \lambda_4 Sh)} \tag{16}$$

4.2 Constructing the Likelihood Function

The sample consists on I women. The ith woman older thatn 21 years old is observed for T_i periods since marriage. Information about the ith woman consists of:

- The history of work, birth control methods and sterilization decisions: $a_i(h_i, bc_i, st_i)$
- The history of births (conception and contraception failures): b_i
- The matrix Ω of state variables.

The individual contribution to the likelihood is:

$$L_i(\Theta|P_i, X) = \prod_{i=1}^{I} P(a_{it}, b_{it}|X_{it}) \tag{17}$$

$$L_i(\Theta|P_i, X) = L_{a_i}(\Theta|X_i) L_{b_i}(P_i|X_i) \tag{18}$$

where L_{a_i} is the product of all conditional choice probability statements and L_{b_i} is the product of all birth probability statements:

$$L_{b_i}(P_i|X_i) = \prod [\overline{p}_i^{b_i}(1-\overline{p}_i)^{1-b_i}]^{1-bc_i}[((1-e)\overline{p}_i)^{b_i}(1-(1-e)\overline{p}_i)^{1-b_i}]^{bc_i} \tag{19}$$

Furthermore, every woman in the population belongs to one of L types unobserved by the econometrician. Types may differ in their utility function Θ or in their beliefs Γ. Let $(\Theta_j, \Gamma_j, s_l)$ define type l, with s_l the fraction of the population of type l. It is assumed that the unobserved

[10] See Eckstein and Wolpin (1989) and Hyslop (1999)

type is statistically independent of the exogenous variables X_i. The likelihood for the ith woman is:

$$L_i(.) = \sum_{s=1}^{L} s_l.L_{a_i}(\Theta_j, \Gamma_j | X_i).L_{b_i}(P_i|X_i) \tag{20}$$

where s_l is the probability of drawing from each type. The log likelihood for the whole sample is

$$\ell = \sum_{i}^{I} logL_i \tag{21}$$

4.3 Estimation

An important data limitation is that there is just information of husands' and wives' wages for current job in a discrete way. Regarding husband's labor income, I will asume that women form their expectations before the realization of choices, avoiding selection problems.[11] This reflects the hypothesis that women with similar observable characteristics marry husbands with similar expected earnings. Each women would then form these expectations by evaluating the earnings of husbands of women with his schooling level[12] and her labor experience. I estimate the parameters of the husband's equation using a comparable sample from the NLSY79. [13]

$$lny_t = \gamma_1^h + \gamma_2^h K_{t-1} + \gamma_3^h K_{t-1}^2 + \gamma_4^h S_h + \nu_t^h \tag{22}$$

where K_{t-1} is the number of prior periods the woman has worked and S_h is the husband's level of schooling. Wife's earnings are given by the standard Mincer function. [14]

$$lnw_t = \gamma_1^w + \gamma_2^w K_{t-1} + \gamma_3^w K_{t-1}^2 + \gamma_4^w S + \gamma_5^w I_{t-1} + \nu_t^w \tag{23}$$

The random component of wages, ν_t, reflects changes in earnings that are independent of the household decision process.[15] These shocks are assumed $\nu \sim$ N(0,σ_ν^2), $E(\nu_t, \nu_{t-j}) = 0$ for all $j \neq 0$ and observed after the decision, so there is not selection in labor force participation.[16] I

[11] Under this assumption that husband's earnings are realized only after female participation and fertility decisions are made, and if the form of the utility function is linear and additive in consumption, only husband's expected earnings, enter the decision process. See Eckstein and Wolpin (1989)and Van der Klaauw (1996).

[12] Husband's education is classified as follows: i) No primary complete and Primary complete; ii) Secondary complete; iii) University complete or more than university.

[13] See Van der Klaauw (1996) and Francesconi (2002).

[14] Education is classified as follows: i) No primary complete and Primary complete; ii) Secondary complete; iii) University complete; iv) More than University.

[15] Since in the data there is just one observation for wages, it is impossible to estimate any unobserved heterogeneity in this equation. This caveat is explored in the estimation section.

[16] See Eckstein and Wolpin (1989).

use a comparable sample from the NLSY79 and estimate a fixed effects model and recover the coefficient of education from the estimated unobserved heterogeneity. [17]

Let the intrinsec probability of birth be heterogeneous and unobserved for the agents and the econometrician (γ). Couples do not know their true fecundity level γ. They learn it from the first discontinuation of birth control methods and the first conception. Conditional on using contraception decisions, I assume births are generated as independent bernoulli trials with an age-varying, type specific probability of birth. The probability of a birth perceived by a couple in period t is the mean of the beta distribution describing her beliefs about the parameter γ conditional on the prior, on the sequence k_t and on the couple's history of intentions. To derive the model's decision rules, we need to obtain the mean $\overline{p}_t$ (the posterior mean) for every possible history. Formally, the probability of birth is:

$$p_{it} = \frac{\alpha}{\alpha + \beta + f_{it}}.(1 - exp(-g(t+1)))(1 - e.bc_{it}) \tag{24}$$

I assume that the distribution from which women draw their initial endowment is in the Generalized Beta family support $(0, k_t)$ and shape parameters (α, β), which are priors about the average probability of having a baby for the first time when not using any birth control method in the population. The upper bound k_t is a shrink of this probability which depends on the natural decreasing trend of the fecundability level and on using any birth control method which will decrease the probability of getting pregnant by (1-e).

The preference shock, ϵ, is defined as extreme-value type I and iid over time, so it satisfies the Conditional Independence assumption, i.e., it is independent across choices.[18] Women finish the observation period at different ages. Since in the sample just 0.8% of births and less than 0.8% of total contraceptive failures occuring beyond than 37 years old, the terminal period T will be considered 42 years old. After 42 years old, the choice set just reduces to female labor force participation. However, since there is no information about female labor force participation after 45 years old, the terminal value is equal to the expected discounted value of the utility of working. Finally, I am not taking into consideration retirement. This model just refers to the fertile period of women.

In order to do the structural estimation, I will make the following assumptions:

- I assume no distinction between different reversible contraceptive methods an aggregate all of them into a single choice alternative as in Mira and Carro (2006).

- Labor time consumption: (x_h=20).

- Mother time used in child rearing. (x_m=15)

- Child time consumption. (x_6=10)

[17]Other alternative could be to take the coefficients from alternative studies.

[18]See Gayle and Miller (2006), Mira and Aguirregabiria (2008) and Radhakrishnan (2009).

- Child time consumption just for children younger than or equal to six years old. (x_6=2)

Estimation with a concentrated likelihood is not feasible because there are unobservables in L_b affecting the decision of using birth control methods. There are two potential sources of heterogeneity: individual heterogeneity in natural fecundity level and unobservables that affect both the decision to use birth control methods and births which are not being taken into account or because non-linearities or dynamics. I will estimate the model in a recursive way using the Nested Pseudo Likelihood (NPL) method proposed by Aguirregabiria and Mira (2007). So, I will maximize the likelihood subject to an initial guess of Conditional Choice Probabilites (CCPs). Then, given the new set of parameters, a new set of CCP is obtained. With this new set of CCPs, the likelihood will be maximized again, and so on, until achieve convergence. Unobserved heterogeneity is estimated with an extension of the EM algorithm.

We modify a version of the EM algorithm. The algorithm is initialized with an arbitrary vector of parameters, the value of each type and their corresponding weights: $\widehat{\theta}_0, \widehat{S}_0, \widehat{p}_0$. Given this, we solve the model and compute the conditional choice parameters $\widehat{P}_0$, that we call the step P, and obtain a new vector $\widehat{\theta}_1, \widehat{S}_1, \widehat{p}_1$ applying sequentially the next steps:

1. E step:

   - Compute $p_{il0} \equiv$Pr(l|$\widetilde{a}_i$,$\widetilde{\Omega}_i$,$\widehat{\theta}_0, \widehat{S}_0, \widehat{p}_0$) as

$$\frac{\widehat{p}_{l0} L_i(\widehat{\theta}_0, \widehat{s}^l_0)}{\sum_l \widehat{p}_{l0} L_i(\widehat{\theta}_0, \widehat{s}^l_0)} \tag{25}$$

   - Estimate (λ) as the arg max of the weighted logit of the probability of type 1.

2. M-step: For p_{il0} fixed, obtain $\widehat{\theta}_1, \widehat{W}_1, \widehat{p}_1$ using:

   - $\widehat{p}_{l1}=\frac{1}{N}\sum_{i=1}^{N} p_{il0}$
   - $(\widehat{\theta}_{b1})$=arg $max_{\theta_b} \sum_{i=1}^{N}\sum_{l=1}^{L} p_{il0}[\sum_{t=1}^{T_i} logP(b=1|a_{it}, \Omega_{it}, \theta_b)]$
   - $(\widehat{\theta}_{u1}, \widehat{p}_1)$=arg $max_{\theta_b} \sum_{i=1}^{N}\sum_{l=1}^{L} p_{il0}[\sum_{t=1}^{T_i} logP(a_{it}|\widehat{P}_0, \Omega_{it}, \theta_u)]$

Then, use $\widehat{\theta}_1, \widehat{S}_1, \widehat{p}_1$ as the initial value and compute $\widehat{P}_0$ and apply sequentially the E and M steps. We proceed until convergence in $\widehat{\theta}, \widehat{S}, \widehat{p}$. This is a slight modification of Arcidiacono and Jones (2003) and Arcidiacono and Miller (2010).

4.4 Identification

Parameters of the utility function, like in all discrete choice models, are identified only up to a base. The variance of the unobserved preference for leisure is identified by the persistent differences over time across individuals in labor force participation conditional on observables. Heterogeneity in preferences for children is identified by variations in the decision of continuing or discontinuing to use birth control methods across individuals conditional on observables. Conception failures allow to identify the observed heterogeneity in natural fecundity level, weheras contraception failures allow to identify contraception efficiency.

4.5 Parameter of Interest

The contribution of this paper is to study the effect of the first born child on female labor supply, taking into consideration contraception decisions and using contraceptive and conception failures as marginal sources of variations.

Let us keep in mind two identical women, in terms of all their observable state variables Ω_t, their unobservables and shocks. However, at some moment in time, one has a birth $b_{t-1} = 1$ and becomes a mother and the other does not, $b_{t-1} = 0$, and keeps childless. What would be the effect on labor force participation? This difference can be estimated both in the short run, one step ahead of the moment of the shock t and in the long-run, until the end of fertile period T.

$$
\begin{aligned}
TE =& P(h_{t+s} = 1)|\Omega_t, N_t + 1) - P(h_{t+s} = 1)|\Omega_t, N_t) \\
P(h_{t+s} = 1)|\Omega_t, N_t + 1) =& [P(h_{t+s} = 1, bc_{t+s} = 1, st_{t+s} = 0|\Omega_t, N_t + 1) \\
&+ P(h_{t+s} = 1, bc_{t+s} = 0, st_{t+s} = 0|\Omega_t, N_t + 1) \\
&+ P(h_{t+s} = 1, bc_{t+s} = 0, st_{t+s} = 1|\Omega_t, N_t + 1)](1 - st_{t+s-1}) \\
&+ P(h_{t+s} = 1|\Omega_t, N_t + 1)st_{t+s-1} \\
P(h_{t+s} = 1)|\Omega_t, N_t) =& [P(h_{t+s} = 1, bc_{t+s} = 1, st_{t+s} = 0|\Omega_t, N_t) \\
&+ P(h_{t+s} = 1, bc_{t+s} = 0, st_{t+s} = 0|\Omega_t, N_t) \\
&+ P(h_{t+s} = 1, bc_{t+s} = 0, st_{t+s} = 1|\Omega_t, N_t)](1 - st_{t+s-1}) \\
&+ P(h_{t+s} = 1|\Omega_t, N_t)st_{t+s-1} \\
&\forall s = 1, 2, ..., T
\end{aligned}
\tag{26}
$$

An increase in the number of children will affect participation in several ways. An additional child is supposed to bring utility and consume time. It seems that utility brought from children is higher than child cost, therefore, participation decreases. This is in an static environment. However in a dynamic environment, having a child will prevent women of going to work, losing potential experience due to interruptions, stagnating human capital and making her less productive. Also, there is a timing effect which mainly affects to unexpected mothers.

Note that this difference is controlled for history and all the state variables, Ω_t. Contraception and conception failures are functions of birth control. Therefore, in reduced forms using cross-section data, identification is not achieved as long as there is no exclusion restriction because those failures are correlated with the decision to participate due to the simultaneity between birth control and labor force participation. Depending on the failure, identification will depend on contraception use.

4.6 Preliminary Results

Table IX shows estimates of the parameters wage equations parameters using a comparable sample from the NLSY. The estimates present the expected sign and giving more return to higher levels of education. Furthermore, there is a statistically significant penalty for the number of periods out of the labor force. Table X shows maximum likelihood estimates of the model's structural parameters of the utility function and the probability of birth. The (quadratic) baseline utility is concave in the number of children and in leisure. The estimate of the cost parameter of sterilization is very large given the low rate of sterilization. Using contraceptives also produces disutility, although it is very low. Regarding the probability of birth, the probability of conception for couples whose female partner is 21 years old and who are not using contraception methods is 0.95, while using it is 0.07 when using contraception methods. If these couples have a conception failure, they update their conception probability and the new conception probaility is 0.34.

The effect of fertility on female labor supply depends on the type of women and her education. The average reduction is 0.19 right after birth, similar to the reduced form models presented in section 2. This difference is lower for high educated women with low preferences for leisure and children (Figure 9). The most important reduction is for high educated women with high preferences for leisure and children (Figure 7). However, this differences are not persistent over time and after 3 years the probability of working is similar. The more persistent effect is seen in low educated women with low preferences for leisure and children (Figure 8). This may be the group that drives the bias in OLS estimates. But the most important result is observed in wages. Women who have children, leave labor market for a period of time and this depreciates the human capital acquired by experience in the labor market. And this is dramatic for women with low preferences for leisure and children, in other words, women who are more willing ti participate in the labor market and who do not want to have children (Figures 12 and 13). Furthermore, the effect is higher for high educated women (Figure 13).

The model's predictions of working and contraception actions are in Tables XI and XII. A comparison with the corresponding sample statistics reveals that the model replicates the reduction in the probability of working by parity (Table XII)and is close to the sample statistics (Table XI). The difference can be attributed to the non comparable sample between real data and simulated data. Further results will present a comparable sample from simulated data. Furthermore, with simulated data an indirect inference analysis will show how close are reduced form estimates of those estimates from real data. Finally, this will be useful to analyze the advantages and disadvantes of reduced form methods and the structural estimates.

5 Final Remarks

Preliminary results show that the first born child reduces the likelihood of female labor force participation in the US for about 16 percentage points and this reduction decreases over time. However, the most important result is the permanent effect that has conception and contraception failures in labor market experience over the life cycle. Moreover, this would have negative effects in the wage profile of women. The main mechanism behind this result is the time required for being a parent in comparison of the time required for the marginal child. Once estimated the structural model, it will allow to observe the change in the expected profile of wages and explore whether the reduction of the likelihood of a failure should be addressed as a contraception policy. If this is true, it could be argued that contracpetion policies are not only important to reduce the likelihood of sexually transmitted diseases, but also to reduce the likelihod of unexpected events which affect the wage profiles of women.

Figure 1: Labor Force Participation of Married Women in US by age and stock of children before and after birth, 1970-1995

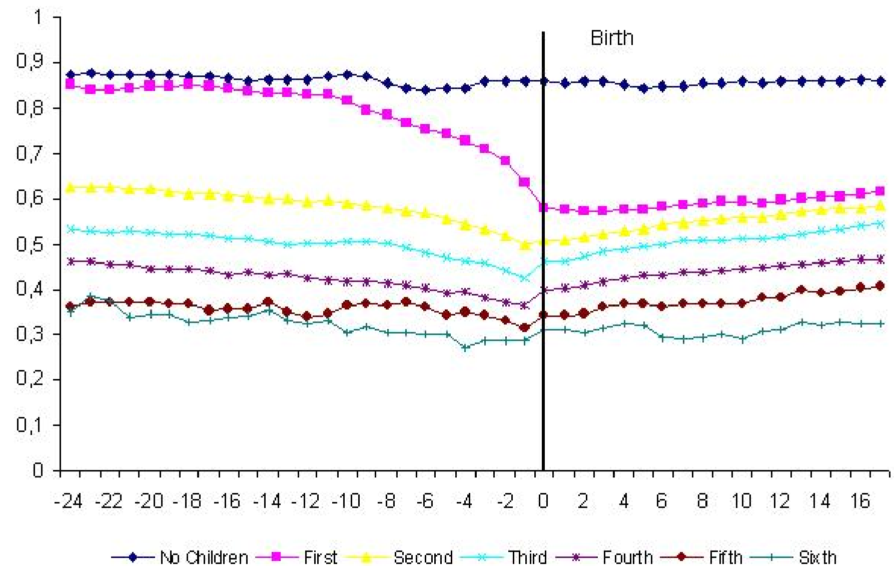


Figure 2: Wald estimates of the effect of an additional birth on female labor supply using conception failures as instrumental variable

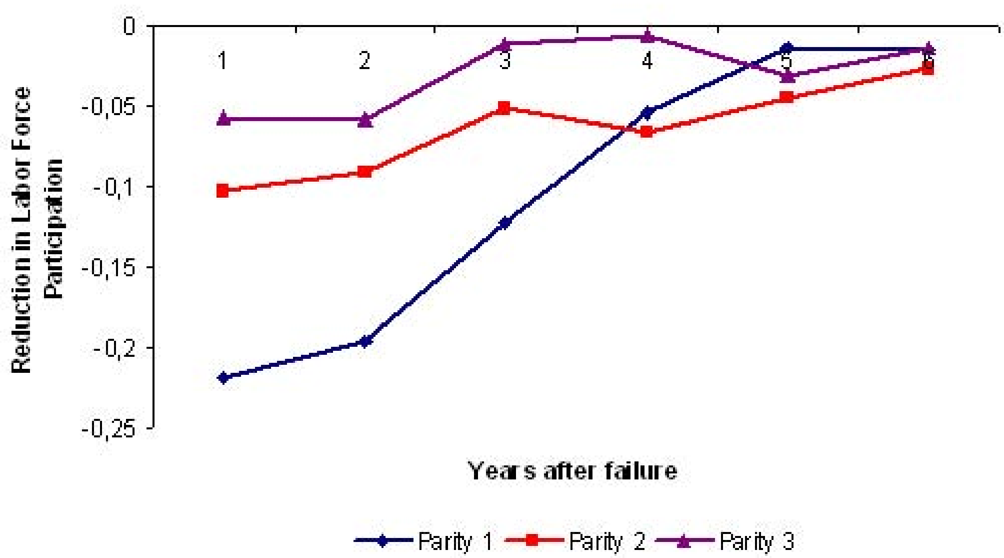


Table I: Literature Review: Structural models of labor force participation and birth control under imperfect control of fertility

Paper	Model	Objective	Data and Sample	Limitations
Rosenzweig and Schultz (1985)	Simple Theoretical model of dynamic LS and a reproduction function (RF)	Mechanisms by which fecundity and transitory shocks in the RF affects labor supply and birth control	1970-1975 NFS USA	Empirical section estimate the reproduction without accounting for dynamics
Hotz and Miller (1988)	Complete Theoretical Model	Effect of child care cost on labor supply and birth spacing	PSID women with at at least one child	No information on contraception methods No unobserved heterogeneity
Sylvester (2007)	Schooling, Marriage Birth Control, Labor Supply	Study the interdenpendecy of these decisions	NLSY 1979-1999	No unobserved heterogeneity No complete information Just 8 of 18 waves
Radhakrishnan (2009)	Labor Supply and Birth Control	Effect of the expansion of of a family planning on labor supply and birth control in India	IFLS	Loss of information in estimation of probability of birth
Maheshwari (2009)	Schooling, Marriage Birth Control, Labor Supply Occupational choice	Why women choose certain occupations	NLSY	No complete information on contraception methods

Figure 3: Wald estimates of the effect of an additional birth on cumulative experience using conception failures as instrumental variable

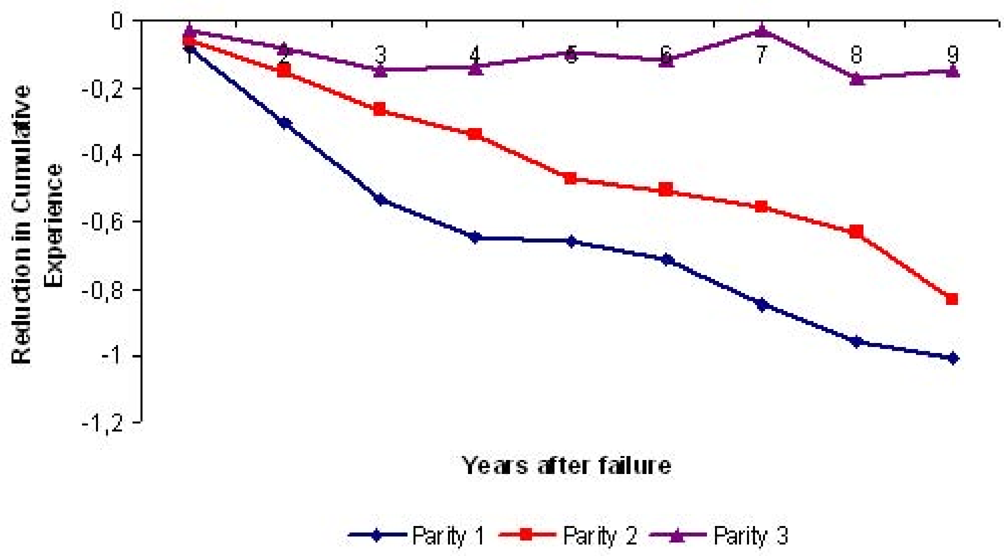


Figure 4: Wald estimates of the effect of an additional birth on female labor supply using contraception failures as instrumental variable

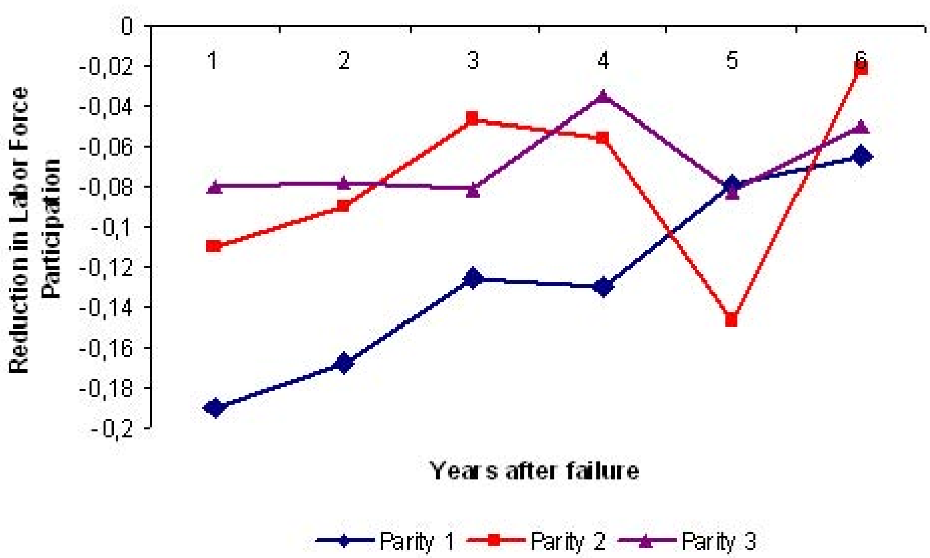


Figure 5: Wald estimates of the effect of an additional birth on cumulative experience using contraception failures as instrumental variable

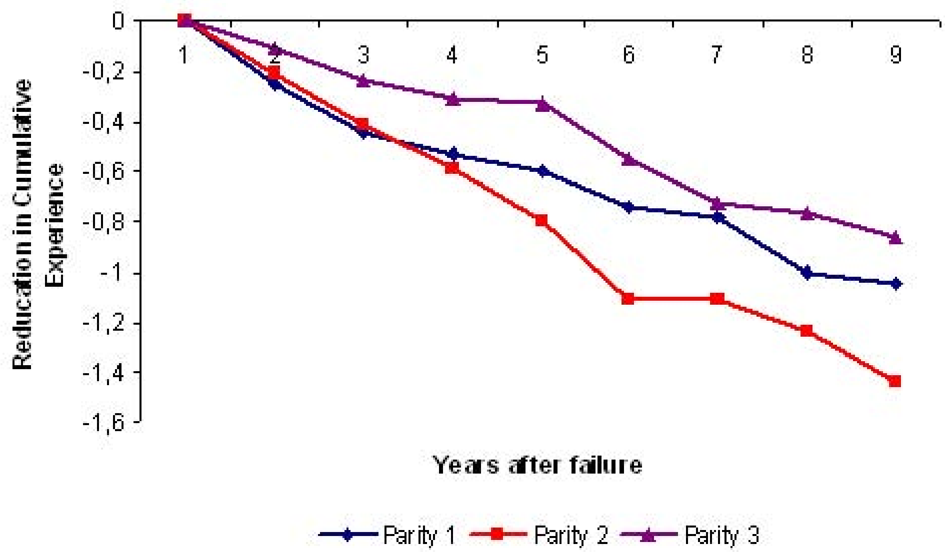


Table II: Descriptive Statistics

Variable	Monthly	Std. Dev.	Annual	Std. Dev.
Women	4530		4085	
Number of Observations	459137		35969	
Average number of observations per women	101		9	
Almost 50% of women (more thanĚ)	8 years		8 years	
Age	386	56	30	5.5
Stock	1.74	1.23	1.47	1.23
Experience	117	66	4.76	4.51
Sterilization	0.21	0.40	0.20	0.40
Children under 6 years old	0.73	0.80	0.76	0.83
Education	2.20	0.75	1.27	0.67
Husband's education	2.17	0.67	1.22	0.60
Births	0.01	0.10	0.12	0.32
Pregnant	0.08	0.28	0.07	0.25
Proportion of births beyond 40	0.73		0.77	
Use of birth control	0.67		0.52	
Number of births	4778		4753	
Birth (contraception failures)	0.14		0.11	
Conception failures more than 12 months	2764		2764	
Period with conception failures	0.27		0.32	
Prob of working	0.69		0.64	
Prob of working using birth control	0.70		0.70	
Prob of working without birth control	0.66		0.54	
Prob of working sterilized	0.71		0.69	
Prob of working not sterilized	0.69		0.62	

Table III: Panel Data Fixed Effects Estimation

Independent Variables	Estimates	
Experience	$.006^{***}$	(.0004)
Experience^2	$-1.6x10^{-5***}$	$(1.35\text{x}10^{-6})$
Motherhood	$-.070^{***}$	(.017)
Stock of children	$-.065^{***}$	(.018)
Children 0-2	$-.043^{***}$	(.016)
Children 3-5	-.007	(.014)
Children 6-11	.014	(.013)
Children 12-18	.017	(.011)
Edad	$-.060^{***}$	(.013)
Edad^2	$8.7x10^{4***}$	(.0002)
Birth Control	$.014^{**}$	(.006)
Pregnant	$-.044^{***}$	(.007)
Constant	1.49^{***}	(.193)
Number of observations	252 162	
Number of women	5812	
R2	0.34	

NOTE: Continuously married women between 21-45 years old from the 1995 NSFG, using monthly information. Standard errors clustered by individual.

Table IV: Wage Equations

Wive's Equation: Fixed effects panel data		
Estimates		**s.e.**
Experience	0.13	0.01
Experience^2	-0.03	0.0006
Interruptions	-0.02	0.01
Constant	5.75	0.05
Number of Observations		4096
R2		0.2032
Wive's Equation: Unobserved Heterogeneity (OLS)		
Estimates		**s.e.**
SecondaryComplete	0.06	0.11
UniversityComplete	0.21	0.10
MorethanUniversity	0.63	0.12
Constant	-0.20	0.10
Number of Observations		642
R2		0.08
Husband's Equation		
Estimates		**s.e.**
Experience	0.04	0.005
Experience^2	-0.0009	0.0002
SecondaryComplete	0.10	0.07
UniversityComplete	0.41	0.07
MorethanUniversity	0.83	0.07
Constant	9.58	0.07
Number of Observations		4475
R2		0.2078

NOTE: Mincer equations using samples of couples from NLSY79. The first two panels refer to wive's wages. The first of them is the panel data fixed effects and the second one is an OLS estimation using the residuals of the panel data fixed effects to capture the correlation of schooling with wages. The third panel refers to husband's wages. This is an OLS estimation. This difference is because in the 1995 NSFG there is retrospective information for wives but not for husbands.

Table V: Logit of the probability of type 1

Estimates		s.e.
γ_1	0.10	
γ_2	-0.69	
γ_3	0.06	
γ_4	0.02	

Table VI: Structural Estimates

Probability of birth		
Estimates		**s.e.**
α	0.01	
β	0.85	
g	0.05	
e	1.00	
Conditional Choice Probabilities		
Estimates		**s.e.**
α_1^1	0.31	
α_1^2	0.22	
α_2	-0.0009	
α_3^1	3.13	
α_3^2	1.56	
α_4	-0.08	
α_5	-0.07	
α_6	-1.06	
w_1	0.32	

Table VII: Model Fit

Statistics	Data	Model
Proportion working	0.75	0.68
Proportion using birth control methods	0.59	0.38
Proportion sterilized	0.16	0.24
Mean age	30.2	31.5
Mean accumulated experience	5.56	8.12
Mean number of children	1.47	1.43
Mean interruptions	2.07	3.38
Mean conception failures	0.28	0.33

Table VIII: Proportion of working by number of children

Stock	Data	Model
Parity zero	0.89	0.91
Parity 1	0.73	0.65
Parity 2	0.69	0.52
Parity 3	0.67	0.45
Parity 4	0.62	0.40

Figure 6: Effect of the first born child on female labor supply: low educated women with high preferences for leisure and children

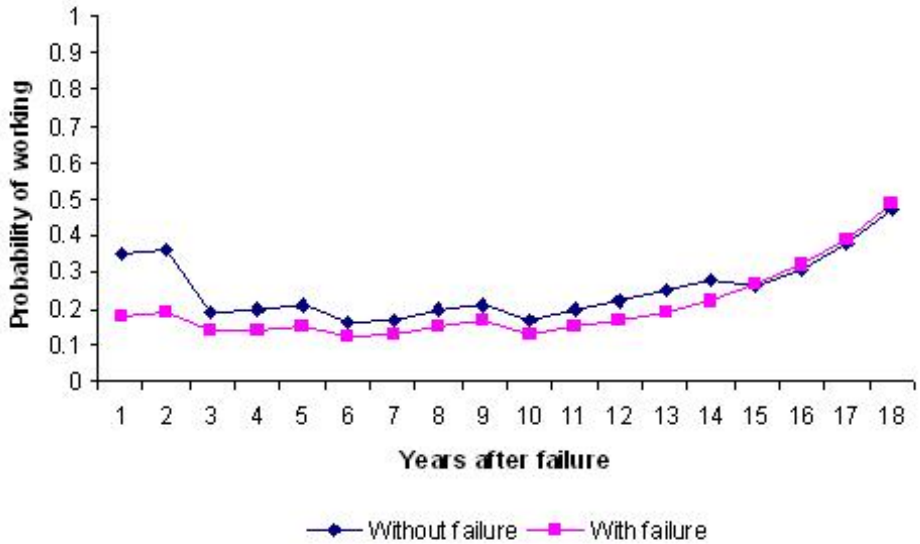


Figure 7: Effect of the first born child on female labor supply: high educated women with high preferences for leisure and children

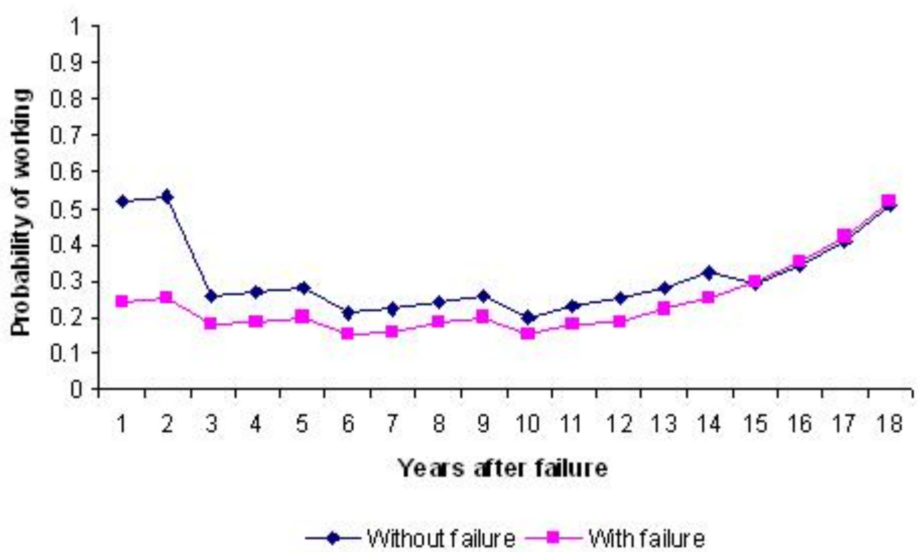


Figure 8: Effect of the first born child on female labor supply: low educated women with low preferences for leisure and children

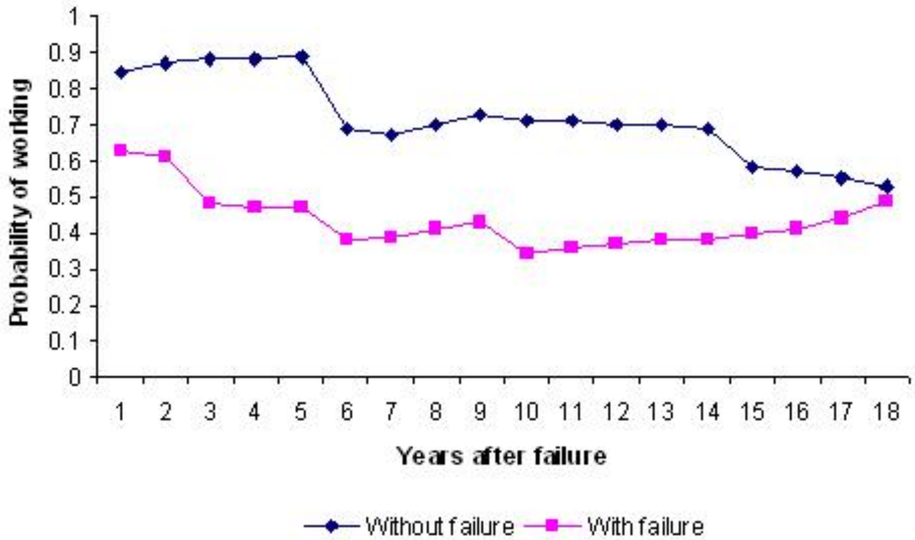


Figure 9: Effect of the first born child on female labor supply: low educated women with low preferences for leisure and children

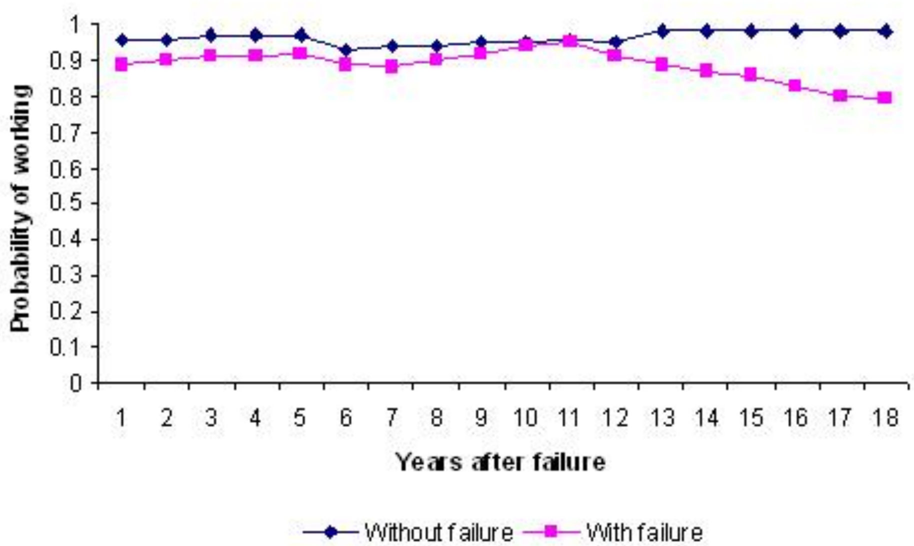


Figure 10: Effect of the first born child on wages: low educated women with high preferences for leisure and children

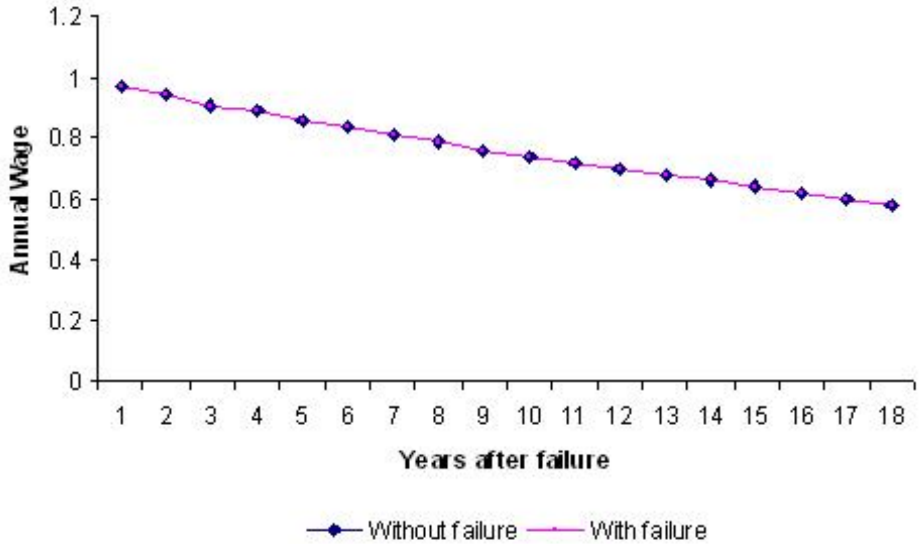


Figure 11: Effect of the first born child on wages: high educated women with high preferences for leisure and children

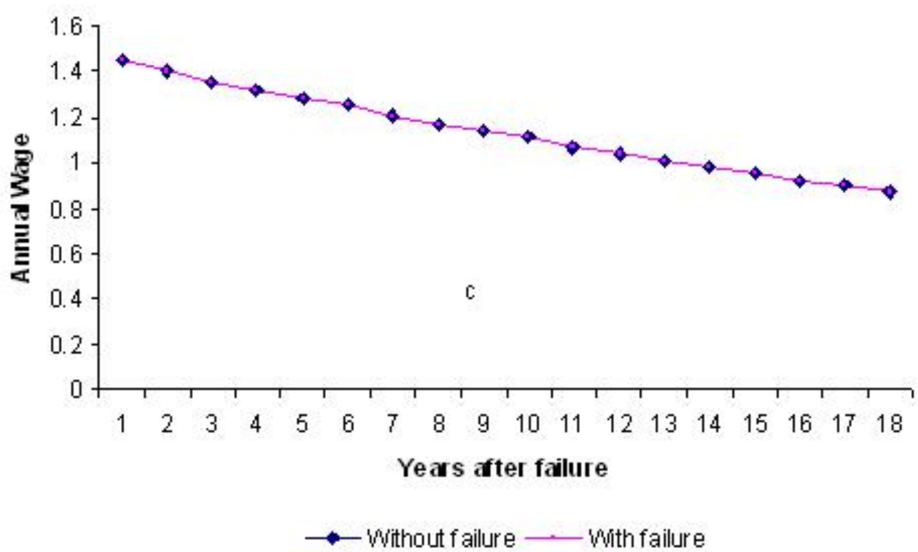


Figure 12: Effect of the first born child on wages: low educated women with low preferences for leisure and children

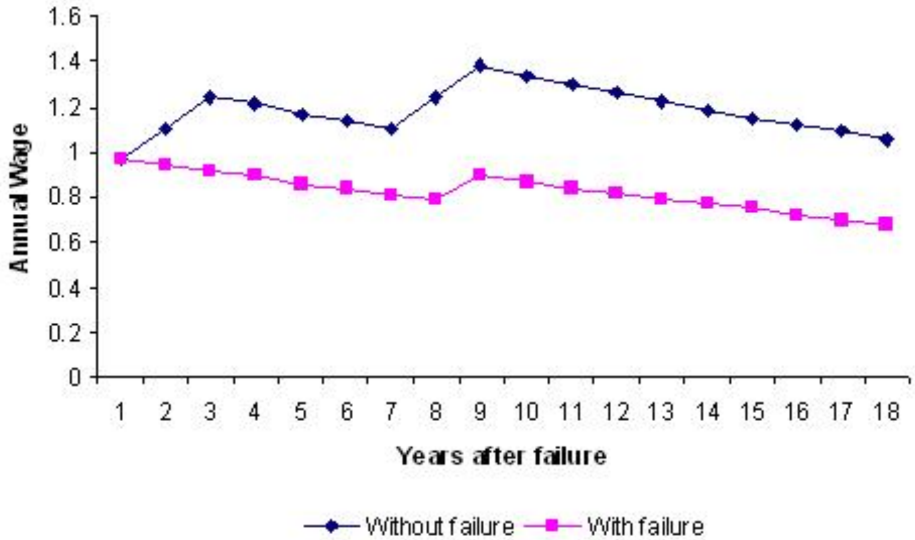
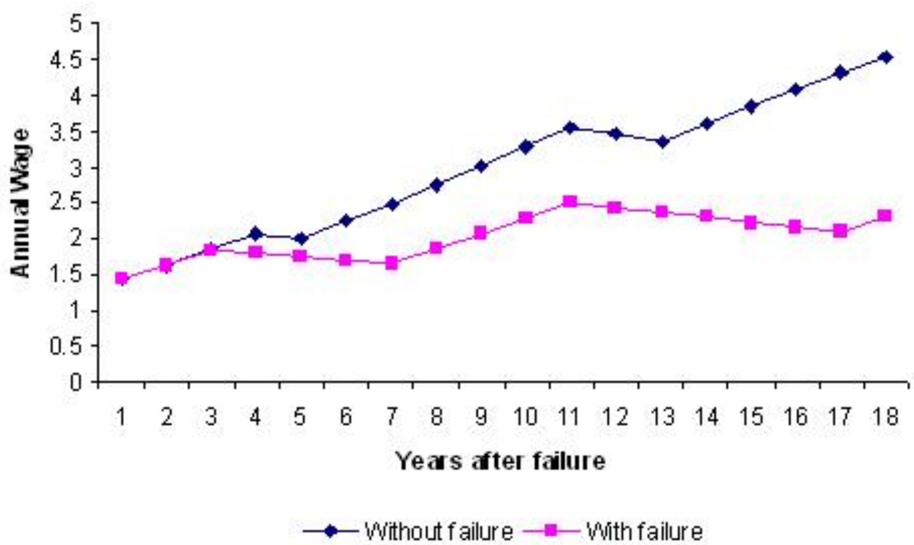


Figure 13: Effect of the first born child on wages: high educated women with low preferences for leisure and children



References

Aguero, Jorge M. and Mindy S. Marks, "Motherhood and Female Labor Force Participation: Evidence from Infertility Shocks," *American Economic Review: Papers and Proceedings*, May 2008, *98* (2), 500–504.

Angrist, Joshua D and William N Evans, "Children and Their Parents' Labor Supply: Evidence from Exogenous Variation in Family Size," *American Economic Review*, June 1998, *88* (3), 450–77.

Bronars, Stephen G and Jeff Grogger, "The Economic Consequences of Unwed Motherhood: Using Twin Births as a Natural Experiment," *American Economic Review*, December 1994, *84* (5), 1141–56.

Cáceres-Delpiano, Julio, "Keeping the best for last. Impact of fertility on mother's employment. Evidence from developing countries," Technical Report, Universidad Carlos III, Departamento de Economía November 2008.

Chiquero, Ana Nuevo, "The Labor Force Effects of Unplanned Childbearing," Job Market Paper, Boston University November 2010.

Cristia, Julian P., "The Effect of a First Child on Female Labor Supply: Evidence from Women Seeking Fertility Services," *Journal of Human Resources*, 2008, *43* (3), 487–510.

der Klaauw, Wilbert Van, "Female Labour Supply and Marital Status Decisions: A Life-Cycle Model," *Review of Economic Studies*, April 1996, *63* (2), 199–235.

Eckstein, Zvi and Kenneth I Wolpin, "Dynamic Labour Force Participation of Married Women and Endogenous Work Experience," *Review of Economic Studies*, July 1989, *56* (3), 375–90.

_ **and Ron Shachar**, "Correcting for bias in retrospective data," *Journal of Applied Econometrics*, 2007, *22* (3), 657–675.

Francesconi, Marco, "A Joint Dynamic Model of Fertility and Work of Married Women," *Journal of Labor Economics*, Part 2002, *20* (2), 336–380.

Gayle, George-Levi and Robert A. Miller, "Life-Cyle Fertility Behavior and Human Capital Accumulation," 2006 Meeting Papers 784, Society for Economic Dynamics December 2006.

Heckman, James J. and Sergio Urzúa, "Comparing IV with Structural Models: What Simple IV Can and Cannot Identify," IZA Discussion Papers, Institute for the Study of Labor (IZA) January 2009.

Hotz, V Joseph and Robert A Miller, "An Empirical Analysis of Life Cycle Fertility and Female Labor Supply," *Econometrica*, January 1988, *56* (1), 91–118.

Hyslop, Dean R., "State Dependence, Serial Correlation and Heterogeneity in Intertemporal Labor Force Participation of Married Women," *Econometrica*, November 1999, *67* (6), 1255–1294.

Maheshwari, Rachna, "A Dynamic Analysis of Career and Family Choices of Women," Job Market Paper, University of Virginia June 2009.

Miller, Amalia, "Motherhood Delay and the Human Capital of the Next Generation," *American Economic Review: Papers and Proceedings*, May 2009, *99* (2), 154–158.

_ , "The Effects of Motherhood Timing Career Path," *fothcoming Journal of Population Economics.*

Miller, W. and D. Pasta, "Behavioural intentions: which ones predict fertility behaviour in married couples?," *Journal of Applied Social Psychology*, 1995, *25*, 530–555.

Mira, Pedro and Jesús M. Carro, "A dynamic model of contraceptive choice of Spanish couples," *Journal of Applied Econometrics*, 2006, *21* (7), 955–980.

_ **and Victor Aguirregabiria**, "Dynamic Discrete Choice Structural Models: A Survey," *Journal of Econometrics*, Forthcoming 2008.

Radhakrishnan, Uma, "A Dynamic Structural Model of Contraceptive Use and Employment Sector Choice for Women in Indonesia," Job Market Paper, University of Virginia February 2009.

Rebar, Robert W. and Alan H. DeCherney, "Assisted Reproductive Technology in the United States," *The New England Journal of Medicine*, April 2004, *350* (16), 1603–1604.

Rondinelli, Concetta and Roberta Zizza, "(Non)persistent effects of fertility on female labour supply," Temi di discussione (Economic working papers) 783, Bank of Italy, Economic Research Department December 2010.

Rosenzweig, Mark R and Kenneth I Wolpin, "Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment," *Econometrica*, January 1980, *48* (1), 227–40.

_ **and T Paul Schultz**, "The Demand for and Supply of Births: Fertility and Its Life Cycle Consequences," *American Economic Review*, December 1985, *75* (5), 992–1015.

Sylvester, Michelle Sheran, "The Career and Family Choices of Women: A Dynamic Analysis of Labor Force Participation, Schooling, Marriage and Fertility Decisions," *Review of Economic Dynamics*, July 2007, *10* (3), 367–399.

Trusell, J. and B. Vaughan, "Contraceptive failure, method-related discontinuation and resumption of use: results from the 1995 National Survey of Family Growth," *Family Planning Perspectives*, 1999, *31*, 64–72,93.

Trussell, Vaughan, and Stanford, "Are all contraceptive failures unintended pregnancies? Evidence from the 1995 National Survey of Family Growth," *Family Planning Perspectives*, Sept-Oct 1999, *31* (5), 246–247,260.

Vere, James P., "Dragon Children: Identifying the Causal Effect of the First Child on Female Labour Supply with the Chinese Lunar Calendar," *Oxford Bulletin of Economics and Statistics*, 06 2008, *70* (3), 303–325.