THE EFFECT OF A CHILD ON FEMALE WORK WHEN FAMILY PLANNING MAY FAIL

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Abstract

This paper develops a structural empirical model of contraception and participation choice under imperfect control of fertility, learning and unobserved heterogeneity to identify, estimate and give a behavioral content to the effect of the first born child on female labor supply. Family planning failures are exploited as sources of identification. The data are drawn from the 1995 US National Survey of Family Growth (NSFG) which no one has used before for this purpose and which contains full retrospective information on participation, contraception and children. The model is estimated combining the Nested Pseudo Likelihood Estimation and the Expected-Maximization algorithm. Key factors driving the importance of the effect are education, labor market experience, child's age and preferences for leisure and children. From a policy perspective, this heterogeneity is important in designing maternity leave and child care policies. Additionally, twins and gender composition of children are used as sources of variation in the model to estimate the effect of the second and the third born child. The Average Treatment Effect (ATE) of the first is -12.4%, of the second is -5.6% and of third born child is -4.9%. Finally, based on the dynamic model a weighting procedure is proposed to understand the Local Average Treatment Effects (LATE) found in the non-structural literature.

JEL Codes: J13, J21.
Keywords: Fertility, female labor supply, family planning failures, marginal treatment effects, average treatment effects, local average treatment effects, dynamic discrete choice models, conditional choice probability, unobserved heterogeneity.

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1 Introduction

The quantitative effect of fertility on female market work has attracted the attention of labor economists for long time. A strong negative association between fertility and female labor supply has long been documented for many datasets and countries.[1] However, the interpretation of these correlations, mainly based on least squares estimates, as causal is problematic due to unobserved heterogeneity and reverse causality: women who are more willing to participate in the labor market are presumably less willing to have children and viceversa; moreover, fertility and participation can be regarded as joint decisions. The literature is well acquainted with two instrumental variables that have been used to correct this problem: twins (Rosenzweig and Wolpin (1980), Bronars and Grogger (1994)) and gender composition of children (Angrist and Evans (1998)). The importance of these instruments is that they allow estimating of causal effects of the second and the third born children on female work. Nevertheless, much less is known about the effect of the first born child.

Measuring the effect of the first born child on female work is arguably more important than estimating the effect of higher order births. Fertility rates have been decreasing over the last forty years in most developed countries. At the beginnings of the 21 century a typical household in a developed country has less than two children on average. In particular, between 1980-1995, the period of interest in this paper, the total fertility rate in the US was 1.90.[2] Furthermore, looking at labor force participation rates in the US before and after births of different order is possible to note that the most important reduction in female work is associated with the first born child (a reduction of approximately 20 percentage points in comparison to 10 percentage points for the second born child, see Figure G1).[3] Yet, it is difficult to correct the endogeneity of the first born child.

Using family planning failures in cross-sectional settings have recently received attention as exogenous sources of variation to estimate the causal effect of the first born child on female work (Aguero and Marks (2008); Miller (2009); Miller (2011)). There are two types of family planning failures. First, a conception failure which happens when a couple fails to have a child despite not using contraception methods for a year. Second, a contraception failure which happens when a couple has a child despite using contraception methods. When speaking about the first born child, biology and economic literature argue that these events are exogenous to preferences. The key

[1] Apps and Rees (2004) document a positive relationship in Germany, Italy and Spain associated to the tax system and to the improved availability of alternatives to domestic child care, rather than through direct child payments. Several recent studies (Mira and Ahn (2002); Boca et al. (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.

[2] See http://esa.un.org/unpd/wpp/

[3] Data from the 1195 US National Survey of Family Growth (NSFG). Attanasio et al. (2008) show that for women who have the first born child between 1981 and 1994, labor force participation decreases approximately 30 percentage points around birth with respect to before getting pregnant. But participation recovers 20 points after one year. However, the overall reduction is about 10 points. In this data, the same difference is about 15 points.

identification aspect is that they can split a population with the same intentions into two groups, one having a child and the other not having a child.

One objective of this paper is to estimate the effect of the first born child on female work exploiting family planning failure information using the 1995 US National Survey of Family Growth (NSFG), a rich micro database which has not been used before for this purpose. The main feature of the 1995 US NSFG, in contrast to the PSID or the NLSY, is that it contains full retrospective information on three key variables: participation, children and contraception.[4] The wealth of data available in this survey opens up new opportunities for estimating the effect of fertility on female work.

Another objective of this paper is to develop a structural empirical model as a tool for looking at the relationship between fertility and female work in the US NSFG data, taking into account imperfect control of fertility with learning about fecundity and unobserved heterogeneity. In this model, women choose participation and contraception taking into account past experience, existing children and expected family size. Furthermore, couples face uncertainty about an idiosyncratic component of fecundity about which they learn from births or family planning failures. The general idea follows the same spirit of Todd (2006) and Attanasio et al. (2012). Despite not having experimental data, the identification strategy relies on 'natural' experiments (family planning failures, twins and gender composition of children) and they are used in combination with the panel data and the structural model to establish a causal relationship between fertility and female labor supply.

One advantage of the structural model is that it provides a precise interpretation of the 'effect' of fertility on female work in a context where households jointly decide on participation and contraception. In this model children are not 'decisions' per se but outcomes of contraception decisions and nature. The presence of a child may affect work in three different ways. First, children require time reducing leisure and increasing its marginal utility, therefore inducing women to reduce their supply of work. As time goes by, children age and free time, decreasing the marginal utility of leisure, therefore inducing women to work. Second, in a dynamic environment, time out of the labor market (due to childbearing) prevents the accumulation of labor experience and depreciates the existing stock of experience making women less productive. Third, children may affect work depending on the timing (younger women have a higher participation probability) and spacing of their arrival (two children below six years old consume more time than one below and one above 6 years old).[5]

Another advantage of the structural model is that it allows exploiting family planning failures in a broader population without the need of selecting the sample. Family planning failures are

[4]The PSID does not have information on contraception choices and the NLSY has information every each year (just 8 of out 18 waves).

[5]Children may also increase female work because they need market goods. This channel is not explicitly modeled due to the absence of market prices and lack of identification, but it is implicitly considered in the utility function. See the Model for details.

events which are inevitably conditioned on contraception choice. For that reason, papers using failures as IV either select the sample or do not consider the contraception choice linked to the particular failure (Cristia (2008); Aguero and Marks (2008); Miller (2009); Miller (2011)). Sample selection makes difficult to interpret the estimated effect.

Additionally, the structural model allows conditioning on these random sources of empirical variation without imposing exclusion restrictions as in instrumental-variable equations (Rosenzweig and Wolpin (2000)). In the non-structural approach the exclusion restriction assumption states that an instrumental-variable should not be correlated with the outcome directly but just through the input or policy variable of interest. The model explicitly defines a reproduction function which depends on the joint fecundity level of the couple. This natural endowment is unknown soon after marriage but learnt from family planning failures. Realizing the true joint fecundity level could influence subsequent behavior ruling out the exclusion restriction assumption. The model also incorporates twins and gender composition of children, both of them affecting marginal utility of leisure (twins require more childbearing time than two spaced children and it is more enjoyable to play with children of different sex). Even though these sources of variations are considered exogenous to preferences, under the scenario described above they could not be valid instruments in a linear IV equation.

Furthermore, the model allows estimating Average Treatment Effects (ATE). Literature building bridges between structural approaches and local average treatment effects (Heckman and Vytlacil, 1999, 2005 and 2007) is based on static models. In this paper, I propose a weighting procedure to explore the link between a dynamic model and LATE estimates. This procedure is useful to identify who are the compliers when using family planning failures, twins and gender composition of children as instrumental variables in the estimation of the effect of fertility on female labor supply.

Finally, the structural model is useful to implement counterfactual analysis. The following experiments are considered. First, having the first born child at different ages and with different years of labor market experience. This exercise sheds light about the moment in the women fertile period at which the effect of fertility on female work is minimized, and more generally about the effect of fertility over the life cycle. Second, a world with perfect control of fertility. This exercise quantifies the welfare loss due to the imperfectness of fertility control understood as frictions in the process of having children.

The model is estimated combining two approaches in a novel way. First, the Nested Pseudo Likelihood Estimation which allows reducing the computational time. Second, the Expectation-Maximization algorithm which is used to estimate the model under unobserved heterogeneity. This strategy has been recently proposed in Arcidiacono and Miller (2011). Despite providing a theoretical framework and the properties of this estimator, a practical description of the estimation procedure is absent.

This paper contributes to the literature in the following ways. First, it uses richer information on family planning failures to estimate the effect of the first born child on female work. Second, this is the first paper modeling empirically family planning failures allowing for unobserved heterogeneity and specifying a reproduction function and learning about the fecundity level in order to give a behavioral content to the effect of interest. Third, in addition to family planning failures, it incorporates twins and gender composition of children in the same model to account for all the sources of exogenous variation found in the fertility literature. Fourth, the dynamic model allows characterizing the distribution of the 'effect' of fertility on female work and proposes weights to estimate treatment parameters such as Average Treatment Effect (ATE) and Local Average Treatment Effect (LATE). Finally, it develops a practical way to implement Conditional Choice Probability estimation under unobserved heterogeneity.

The results show that four factors play an important role in the magnitude of the effect of the first born child on female work: education, past experience, child's age and preferences for leisure and children. The most important reduction in female work is experienced by women with low education level and high preferences for leisure and children, independently of their age (between 10 and 20 percentage points (pp) in the short run and between 7 and 17 pp in the long run). The least reduction is experienced by women with high education and low preferences for leisure and children (between 2 and 6 pp in the short run and between 2 and 3 pp in the long run). However, the effect on labor market experience is higher and permanent, worsening human capital accumulation and potential wages. The most important reduction in potential wages is accounted for women with low education and high preferences for leisure and children (between 4 and 6 percent in the short run and between 7 and 16 percent in the long run). The least reduction is experienced by women older than 35 years old. However, empirically there is less than 5% of this kind of woman. So excluding these women, the second least effect is for women with high education and low preferences for children and leisure (up to 1 percent in the short run and between 1 and 2 percent in the long run). This heterogeneity is important from a policy perspective because it allows targeting

The ATEs are -12.4 pp, -5.6 pp and -4.9 pp in the short run for the first, second and third order birth, respectively, for women between 21 and 35 years old, reflecting the fact that the effect of earlier births are stronger. Then, LATEs were estimated based on a novel weighting procedure. The LATEs are -12.3 pp, -3.8 pp and -5.6, for the first, second and third order birth, respectively, for women between 21 and 35 years old. The LATE for the second born child is lower than the third for two reasons. First, the IV for twins favors economies of scale. Second, compliers of the gender composition of the first two children are less educated and with high preferences for leisure and children. Finally, the paper gives some welfare considerations, understood as lifetime expected discounted utility differential. Living in a world with perfect control of fertility increases utility in approximately 35 thousand dollars per woman on average.

The organization of the paper is as follows. In the next section I will present the literature related to the paper. The data will be described in the third section. In the fourth section the model will be developed. Next, I will discuss the estimation method, the sources of identification and the parameter of interest. In the sixth section, results will be shown. Then, the characterization of distribution of effects and the estimation of treatment parameters will be presented. In the eighth section I will discuss counterfactual exercises. Finally, in the ninth section I will conclude.

2 Literature Review

This paper joins two strands of economic literature. First, the estimation of the effect of the first born child on female labor supply, using non-structural approaches. Second, the use of structural approaches which jointly model the decisions of female participation and contraception under imperfect control of fertility.

On the one hand, non-structural approaches have emphasized causal validity in linear IV equations using cross-section data. Within this context, in recent years efforts have been devoted to estimate the effect of the first born child on female work exploiting variation in beliefs based on the chinese lunar calendar (Vere (2008)) or the final outcome of fertility treatments for women who had an infertile episode and sought fertility treatments (Cristia (2008)). They find a reduction between 26 and 30 percentage points in female work. In addition to this, family planning failures have been recently received attention in cross-sectional settings (Rosenzweig and Schultz, 1985): self reported infertility Aguero and Marks (2008) and contraception failures (Miller, 2009 and 2011). In particular, the former estimates the effect of the first born child on female work using Demographic and Health Surveys (DHS) for developing countries and women between 20 and 44 years old. The latter estimates the effect of age at first birth on hours worked, earnings and child's cognitive level using the NLSY79 for women with at least one child between 21-33 years old. Whereas Aguero and Marks (2008) find no effect, Miller (2009) and Miller (2011) finds a reduction in the variables abovementioned between 6 and 10 percent.[6] However, family planing failures are outcomes conditioned on contraception decisions. Thus, these papers either restrict the sample or do not take into account the contraception decision which was made at the moment of the failure. One objective of the paper is to exploit family planning failures using the 1995 US NSFG that has not been used before for this purpose and which contains full retrospective information on three key variables: participation, children and contraception.[7] Additionally, with this panel information, random effects endogeneity can be allowed helping in establishing causality in the relationship between fertility and work.[8]

[6]Research in progress are Herr (2011) using contraception failures and Schott (2010) using conception failures. Chiquero (2010) estimates the effect of unplanned pregnancies using miscarriages as instrumental variable. See Appendix for a survey.

[7]Work in progress using this information are Knowles (2011) to estimate how much of changes in female labor force participation and occupational choices can be explained by technological changes in birth control since 1960 and Choi (2011) to account for the importance of fertility risks in explaining fertility outcomes in the life cycle.

[8]Research addressing endogeneity of children in panel data context are Hyslop (1999), Carrasco (2001), Arellano and Carrasco (2003), Carro (2007), Fernández-Val (2009) and Michaud and Tatsiramos (2011).

On the other hand, structural approaches have emphasized interpretability in a model of individual choice. Within this context, there are some papers which have jointly modeled female work and contraception decisions. Some of them have assumed perfect control of fertility (Francesconi, 2002 and Troske and Voicu (2010)). Others have developed the model under imperfect control of fertility. The latter have been used to estimate the effect of child care cost on labor supply and birth spacing (Hotz and Miller, 1988) and to study the interdependencies of decisions such as schooling, working, marriage and use of birth control (Sylvester, 2007). Nevertheless, empirically they do not have complete information on contraception decisions (Hotz and Miller (1988) using the PSID) or if so it is just every other year (Sylvester (2007) using the NLSY79). Another objective of the paper is to develop a structural model as a tool for looking at the relationship between fertility and female work using the 1995 US NSFG. The model jointly estimates female work and contraception decisions under imperfect control of fertility (Bongaarts, 1975 and Sheps and Menken, 1973) and considering heterogeneity in preferences for work (Hotz and Miller, 1988) and children. In this model, women choose participation and family planning taking into account past experience, existing children and expected family size. Furthermore, couples may face uncertainty about an idiosyncratic component of fecundity and they learn about it following births or family planning failures. In particular, two aspects are interesting to add in the structure. First, the model allows learning about the fecundity level based on family planning failures. Second, twins and preferences for gender composition affect the marginal utility of leisure.[9] The most closely related work are Knowles (2011) and Choi (2011) using the 1995 US NSFG on a model with imperfect control of fertility. The former estimates the impact of contraception technology on female work and occupational choices whereas the latter quantifies the importance of fertility risk to explain fertility outcomes in the life cycle.

Using the structural empirical model I characterize distributions of treatment effects and estimate treatment parameters (Average Treatment Effects, Treatment on the Treated, Treatment on the Untreated, Local Average Treatment Effect). The literature has proposed some alternatives to characterize distributions of potential outcomes or treatment effects and to estimate different treatment parameters following either structural or non-structural approaches. The former develops the concept of Marginal Treatment Effects, MTE (Heckman and Vytlacil, 1999, 2005 and 2007). The latter proposes non-parametric and semi-parametric strategies to empirically estimate MTE (Imbens and Rubin (1997), Abadie (2002), Angrist and Fernandez-Val (2011), Carneiro and Lee (2007) and Carneiro, Heckman and Vytlacil, 2010). This paper proposes and applies a methodology to estimate different treatment parameters and uses two well known IVs (twins at first birth and sex of the first two children) and family planning failures to estimate LATEs from the structural model. The paper adds to previous work in that this strategy is developed based on a behavioral model for discrete instruments and considering a discrete distribution of unobservables.

[9] Research in progress are Radhakrishnan (2009), Maheshwari (2009) and Adda et al. (2011). See the Appendix for a survey.

3 Data

The data are drawn from the 1995 US National Survey of Family Growth. The US National Survey of Family Growth (NSFG) started at 1973 carried by the National Center for Health Statistics (NCHS) of the Center for Disease Control and Prevention (CDC). There are seven cycles and the last one was held in a continuous way between 2006-2010.[10] In general, the NSFG gathers information about family life, marriage and divorce histories, pregnancies histories, use of contraception histories, men's and women's health and labor force participation. Nevertheless, each cycle has its own particular features. Cycle 5 (1995) collects labor force participation histories since 18 years old and Cycle 6 (2002) has a monthly calendar of sexual activity. For the purpose of this study, I use the retrospective information about labor force participation and contraception decisions from Cycle 5. The history on female work comes from surveyed employment and unemployment spells where starting and stopping dates for each spell are gathered. The history on contraception decisions is composed of two pieces of information. First, for the five previous years at the date of the survey, there is a monthly calendar of contraceptive use. Second, for years before the latter contraception decisions are recovered from pregnancies histories where starting and stopping dates of contraception use are gathered for each pregnancy (Trussell and Vaughan (1999) and Trussell et al. (1999)).

The sample selection is as follows. The total number of women in the survey is 10847. Keeping just continuously white married couples older than 20 and younger than 41, the sample reduces to 2967.[11] This group may bias the estimates in the sample if unobservables affecting marriage continuity are correlated with contraception and labor force participation decisions. However, in terms of some descriptive statistics, there is no large difference between ever married women (who are married at the interview date) and continuously married women (Table F4) in terms of participation and contraception use. Dropping sterile couples for non contraception reasons, the final sample is 2880.[12] This selection may bias the estimation if unobservables affecting the permanent inability of having children are correlated with labor force participation decisions. These couples may have substituted time with children for more work (to maintain the marriage) or leisure (in case that unosbervables reveal some permanent low productivity). However, comparing some descriptive statistics, dropping sterile women for non contraception reasons does not present signficant differences in terms of participation and contraception use.

A woman's life after marriage was broken into 12-month-long periods corresponding to her

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

[11] Approximately, among all continuously married white women 0.02% of births occur beyond 40 years old. However, the mean of age at first marriage among continuously married white women is 22 years old. Approximately 50% of women have married before 21 years old. The final sample include those women since 21 years old and a control of marriage before 21 is included as initial condition. An extension is considered to include marriage since 16 years old.

[12] This is a large sample compared with other studies such as 5 times Francesconi (2002), 6 times Troske and Voicu (2010), 3 times Sylvester (2007) and 2 times Miller (2009 and 2011).

chronological age. Live births were assigned to the period during which they occurred but they contribute to the total number of children in the following period. The period that includes the 40^{th} birthday was taken to be the last fertile period.[13] Pregnancies that did not end in live births are avoided.[14] The total number of women-year observations is 35968.[15]

The most serious problem in the Cycle 5 NSFG data is the absence of histories on wages (for both wives and husbands). Thus, a comparable sample from the NLSY79 is used to impute wages. Other 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 data from 1995 (Trussell and Vaughan (1999)). Finally, retrospective information is subject to recall bias (Eckstein and Shachar (2007)). However, female labor force participation figures are consistent with BLS statistics and Eckstein and Wolpin (1989) and use of birth control statistics are consistent with past NSFG waves.[16]

3.1 Family Planning Failures

This paper exploits family planning failures as source of variation to estimate the effect of the first born child on female work. There are two types of family planning failures. First, a conception failure happens when a couple fails to get a live birth despite using contraception. These events are observed in data if in period t, couples were not using birth control methods ($bc_t = 0$) and the following period the number of children remains the same ($N_{t+1} = N_t$). Second, a contraception failure happens when a couple get a live birth despite using contraception methods. These events are observed in data if in period t, couples were using birth control methods ($bc_t = 1$) and the following period the number of children increases in 1 ($N_{t+1} = N_t + 1$).[17]

The intuition for using family planning failures is the following. Take two ex-ante identical women each of them married with two identical husbands. First, suppose they were not using birth control methods when childless. After 12 months, one couple has a child and the other does not, having a conception failure. From this moment, the effect of participation due to an additional child would be the average difference between participation rates.

The exogeneity of family planning failures has been studied in medical and economic literature.[18] Family planning failures are exogenous for married couples in richer or high educated populations (Ronsenzweig and Schultz, 1985). Moreover, medical literature is not in agreement

[13] The proportion of births from women older than 40 years old is 0.02%.

[14] The proportion of pregnancies that do not ended in live births is 17.7 percent of all births and 18.7 percent of pregnancies for childless couples: abortions (4.1 percent) are underreported. Furthermore, miscarriages and stillbirths (13 percent) are treated in literature as exogenous and ectopic pregnancies account for less than 1 percent. All abortions are considered as if the couple were using birth control methods. The other events were assigned as conception failures provided the couple were not using contraception methods for a year.

[15] See the Appendix for a detailed explanation on data aggregation.

[16] Detailed evidence of reliability of the survey can be found in the appendix.

[17] Detailed assignment of failures is explained in the Appendix.

[18] See the Appendix for a detailed discussion from both literatures.

about what other characteristics, such as, smoking, diet, weight, stress and type of occupation correlate with family planning failures (Weinberg and Dunson, 2000). Recent studies in economics find no statistically significant correlation between family planning failures and other observable characteristics such as socioeconomic status and education (Miller, 2009 and 2011 and Herr, 2010). But Knowles (2011) argue that contraception failures are correlated with education. Finally, based on the sample used in this paper, I estimate the likelihood of a conception failure and I also estimate the likelihood of a contraception failure for childless couples and I do not find any statistical significant correlation with age, education, experience and smoking (Tables B1 and B2).

Family planning failures could provide information about the relationship between fertility and participation. OLS regressions over time are run, clustering people in two groups according to contraception use. I took subsamples of women who stopped (were) using any birth control method when childless. Some of them had a family planning failure, in particular a conception (contraception) failure, and due to this did not (did) have the first child. These estimations were done separately for each t and up to 15 years after failure. Three equations were estimated: i) labor force participation on failures (the reduced form version); ii) stock of children on failures and; iii) labor force experience on failures. All regressions were controlled by education, age, age at marriage and previous experience (Angrist and Evans, 1998).

Table F8 and F9 present the results. The effect of the first born child on female work is 25 percentage points soon after birth but it vanishes after 7 years: older children require less time releasing time to work. However, this reduction is enough to generate permanent differences in experience: after 15 years the differences is about 1.8 years for conception failures and 1 year for contraception failures. This difference could be explained by thinking about the type of women who are more likely to use contraception methods: women who prefer working instead of having children and given a birth they will return to the labor market as soon as possible. Finally, a family planning failure also generates permanent differences in the number of children: 1.7 more children for couples without conception failures and 0.6 more children for couples with contraception failures. This result is driven by the fact that a couple who has a conception failure is more likely to have structural problems to conceive whereas a contraception failure may be a problem of optimal timing. However, the difference is still statistically significant different from zero. This is particularly important because it turns out that failures are not sources of variation in timing but also in the final stock of children.

4 The Model

I develop a dynamic discrete choice structural model of female labor force participation and contraception decisions under imperfect control of fertility and learning.[19] A period in the model

[19]Related models are Hotz and Miller (1988) and Sylvester (2007). Recent versions of this kind of models are Radhakrishnan (2009), Maheshwari (2009), Adda et. al. (2010) and Knowles (2011)

corresponds to an age of the women fertile period.[20] In each period couples derive utility from consumption, children, leisure and the gender composition of children. On the contrary, use of sterilization services and contraception methods imply psychic costs. Children consume time, especially when they are young or when they are twins. Family income is composed by husbands' and wives' wages. The model does not consider savings, unemployment benefits, maternity leave or child care.[21] Couples choose each period female work and being sterilized.[22] Sterilization is an absorbing state, in other words, if couples decide to be sterilized, they will not be ale to conceive more children. In the contrary, if couples do not choose to be sterilized, they will decide about using contraception methods. Nevertheless, fertility control is imperfect. This means that a birth could occur with some probability independently of using contraception methods. This probability depends on the natural endowment of fecundity specific to each couple, woman's age and contraception efficiency. The natural fecundity endowment is unknown by couples soon after marriage but they learn about it from births or family planning failures. Finally, heterogeneity is considered in two levels. First, hetergoeneity in the fecundity level (first unobserved by the couple and the econometrician but learnt) and heterogeneity (unobserved to the econometrician) in preferences for children and leisure.

4.1 Formal Presentation

The timeline of the model corresponds to the woman fertile period. At each period (t) couples derive utility from consumption (c), leisure (l), children (N) and gender composition of children ($Same$) and incur in disutility from using contraception methods (bc) or sterilization services (st). Moreover, it is expected that leisure and children have decreasing marginal utilities captured but their squared terms and that leisure and preferences for children's sex composition were complements. The period-specific utility is:

$$u_t = c_t + \alpha_1 l_t + \alpha_2 l_t^2 + \alpha_3 N_t + \alpha_4 N_t^2 + \alpha_5 bc_t + \alpha_6 st_t + \alpha_7 Same_t + \alpha_8 Same_t l_t \tag{1}$$

where c is consumption of a composite good; l is leisure; N is the number of children; bc is a dichotomous variable which defines whether women are using birth control methods ($bc = 1$) or not ($bc = 0$); st is a dichotomous variable which defines whether couples decide to be sterilized in that period ($st = 1$) or not ($st = 0$) and $Same$ is a dichotomous variable which defines whether the

[20] Women have a shorter fertile life than men (DeCherney and Berkowitz (1982)).

[21] Lack of information prevents of considering all those issues. Moreover, it is not the objective of this paper to study smooth consumption. The only way to intertemporally substitute consumption is through changing labor supply and in a model with returns to experience, through the future wage (Attanasio, Low and Sanchez-Marcos, 2008).

[22] There is no friction in getting a job. Women get a job as soon as they decide to work. This model abstracts from full time and part time considerations. The proportion of women in part-time jobs is stable between 1980-1995 in the US, representing 25% of labor force (http://www.bls.gov/cps/wlf-table20-2009.pdf). Furthermore, Francesconi (2002) using a sample of married couples from NLSY79 finds that the relevant substitution is between full time work and leisure (p. 373).

two first children are of the same sex ($Same = 1$) or not ($Same = 0$) for couples with $N_t = 2$.[23] Leisure (l) is net of all time consuming activities as follows:

$$l = 100 - x_h h - x_m M - x_N N - x_6 N_6 - x_{Tw} Twin \tag{2}$$

where x_h is the time required in the labor market; h is a dichotomous variable which defines whether women are working ($h = 1$) or not ($h = 0$); x_m is the time required for child-rearing; M is a dichotomous variable which defines whether there is at least one child within the household; x_N is the time required for child rearing; x_6 is the variable time required for child-under-6 rearing; N_6 is the number of children younger than 6 years old;[24] x_{Tw} is the time required for twins rearing and $Twin$ is a dichotomous variable which defines whether the first born child is a twin ($Twin = 1$) or not ($Twin = 0$).[25]

This economy has two sources of family income. First, the wife receives a wage w if she decides to work. This wage is defined by the standard Mincer function depending on her education level (S is a dichotomous variable which defines whether women has more than Secondary education or not), labor market experience (K is number of working periods after marriage) and time out of labor market (I is the number of non working periods after marriage):[26]

$$lnw_t = \gamma_1^w + \gamma_2^w K_t + \gamma_3^w K_t^2 + \gamma_4^w S + \gamma_5^w I_t \tag{3}$$

where $I_t = (t - 20) - K_t$ and work experience (K) evolves according to:

$$K_t = K_{t-1} + h_{t-1} \tag{4}$$

The second source of family income comes from the husband, whom is asummed to be always working and receiving a wage y.[27] Similarly to women, husband's wages are defined by the standard Mincer function. Nevertheless, due to lack of histories on male participation but just males' education (S_h), the model assumes possitive assortative matching. This assumption translates to marriages between women and men with similar characteristics in terms of labor market experience and expected earnings (Van der Klaauw (1996) and Francesconi (2002)). Therefore, husbands' wages depend on their schooling (S_h is a dichotomous variable which defines whether a man has more than Secondary education or not) and their wives' market experience (K_t):

[23]This assumption rests in the intention to mimic the exercise made in Angrist and Evans (1998), where the probability of having a third born child is higher for couples with two children of the same sex (Rosenzweig and Wolpin, 2000). An extension of this assumption is to switch on this term for all parities greater than 1.

[24]Nakamura and Nakamura (1992) suggest three age categories (0-1; 2-4; +5) to capture the effects of children. I estimated a panel data fixed effects of the probability of work and the coefficient of older than 5 years old was not statistically significant.

[25]The model assumes (Hotz and Miller (1985) and Aguiar and Hurst (2009)): x_h=20; x_m=15; x_N=10; x_6=2 and x_{Tw}=5.

[26]At present, the model considers a penalty for each non-working period.

[27]The proportion of men working is close to and stable around 90% between 1970-1995 (http://www.bls.gov/cps/wlf-table20-2009.pdf).

$$lny_t = \gamma_1^h + \gamma_2^h K_t + \gamma_3^h K_t^2 + \gamma_4^h S_h \tag{5}$$

Total family income is used for consumption:

$$w_t h_t + y_t = c_t \tag{6}$$

The model assumes no savings. Without savings, the only way to substitute consumption intertemporally is through changing labor supply and the future wage rate if considering returns to experience. Monetary costs of children, of using contraception methods and of sterilization services are not considered separately in the budget constraint and in the utility function due to lack of joint identification. Since the utility function is linear and additive in consumption the parameters in the utility function can be interpreted as net utilities of monetary costs.

Regarding the evolution of children, this model considers imperfect control of fertility which implies that the probability of a birth is larger than zero and lower than one ($p \in (0, 1)$) independently of using contraception methods. In particular, when using contraception methods, the probability of having a birth is greater than zero and when not using contraception methods the probability of having a birth is lower than 1. Because of this imperfection family planning failures happens. There are two classes of family planning failures. First, conception failures which are those events where even though couples were not using contraception methods in t ($bc_t = 0$) the number of children in $t+1$ does not change ($N_{t+1} = N_t$). Second, contraception failures which are those events where even though couples are using contraception methods in t ($bc_t = 1$) there is an additional child in $t+1$ ($N_{t+1} = N_t + 1$). The probability of a birth (p_t) is defined as follows:

$$p_t = \gamma k_t (1 - e.bc_t) \tag{7}$$

where γ is the couple specific natural fecundity endowment $\gamma \in [0, 1]$; e is the contraception efficiency which is assumed to be constant[28] and $e \in [0, 1]$ and k_t is a function which determines the natural decline in fecundity according to woman's age, stable up to 30 years old and quickly decreasing afterwards up to the end of fertile period, which is assumed to be 40:[29]

$$k_t = \begin{cases} 1 & if\ age \leq 30 \\ 1 - exp(-g(40 - t + 1)) & if\ age > 30 \end{cases} \tag{8}$$

This is the biological process that the reproduction function follows (Bongaarts (1975)). However, the natural fecundity level is not fully observed. Right after marriage, joint natural fecundity

[28] At present this is just a parameter (Carro and Mira, 2002). In the next version of the model I will parametrize contraception efficiency depending on education and types of contraception methods.

[29] Women have a shorter fertile life than men and it starts declining between 30 and 35 years old (DeCherney and Berkowitz, 1982). Regarding the end of fertile period, among continously married women of all ages in the NSFG 95 there are just 2 births occurring after 40 years old, representing 0.02% of all births. In 1998, the proportion of births for white women older than 40 years old is 0.04% (www.cdc.gov/nchs/data/nvsr/nvsr48/nvs48_03.pdf) (Francesconi (2002)).

level (γ) is unknown by the couple (and the econometrician). Nevertheless, each couple learns about its own fecundity based on a Bayesian updating process. Conditional on using contraception methods, 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 posterior distribution which describes its beliefs about the parameter γ conditional on the prior (a beta distribution with shape parameters (α, β)), on the natural decline of fecundity (the sequence k_t) and on the couple's history of outcomes which reveal information about the true fecundity level (the first birth and conception failures when childless). To derive the model's decision rules, it is necessary to obtain the posterior mean $\widetilde{\gamma}_t$ for every possible history (see Appendix for the derivation of the posterior mean). The probability that the couple uses to make decisions is $\widetilde{p}_t = \widetilde{\gamma}_t k_t(1 - e.bc_t)$. This is a source of heterogeneity which is ex-ante unobserved by the couples (and the econometrician) but ex-post it is known (by couples and the econometrician).

Regarding other sources of heterogeneity (unobserved to the econometrician), two more are considered: from preferences for leisure (α_1) and from preferences for children (α_4). The former allows matching the serial persistence in labor force participation which generates. This heterogeneity is observationally equivalent as if it were considered in wages or productivity under no savings decisions and linearity of consumption in the utility function (Eckstein and Wolpin (1989), Hyslop (1999) and Francesconi (2002)).[30] This economy has 2 types.[31] The probability of type 1 follows a logistic function conditioned on Ω_0, the couple's initial conditions previous to marriage (K_0 is a dichotomous variable which defines whether a women has less than to 3 years or experience previous to marriage; Mat_0 is a dichotomous variable which defines whether the female age of marriage is after 21 years old; wife's and husband's schooling, S and S_h, respectively):

$$Prob(type1|\Omega_0) = \frac{exp(\lambda_0 + \lambda_1 K_0 + \lambda_2 Mat_0 + \lambda_3 S + \lambda_4 S_h)}{1 + exp(\lambda_0 + \lambda_1 K_0 + \lambda_2 Mat_0 + \lambda_3 S + \lambda_4 S_h)} \tag{9}$$

The household problem is to maximize the expected lifetime discounted utility function:

$$\max_{\{h_t\}_\tau^T;\{bc_t\}_\tau^T;\{st_t\}_\tau^T} E_t \sum_{t=\tau}^{T} \beta^t U(N_t, c_t, l_t, bc_t, st_t, Same_t) \tag{10}$$

subject to a standard budget constraint:

$$w_t h_t + y_t = c_t \tag{11}$$

Let $\Omega_t = (K_t, N_t, N_{6t}, \bar{t}^F, Est_t, Same_t, Twin_t, \epsilon^t)$ be the vector of endogenous state variables where t is age; K is the number of female working periods after marriage; N is the number of children; N_6 is the number of children below 6 years old; F is the number of conception failures when childless; $\bar{t}^F$ is a vector of length F with the dates of conception failures when childless;

[30] Lack of information about evolution of wages avoids to estimate unobserved heterogeneity in equation of wages.

[31] Future exercises will increase the number of types.

Est is whether the couple has been sterilized or not; $Same$ is a dichotomous variable which define whether the first two children are from the same sex; $Twin$ is a dichotomous variable which defines whether the first born child is a twin and ϵ is a vector which contains Extreme Value Type I choice specific shocks.[32] Let $\Omega_0 = (K_0, Mat_0, S, S_h)$ be the vector of exogenous state variables where K_0 refers to female working previous to marriage; Mat_0 refers to age of marriage; S is the woman's schooling level and S_h is the husband's schooling level.[33]

Couples make the following decisions: whether women participate in the labor force (h) and whether to be sterilized (st). If not sterilized, they have to decide whether to use any birth control method (bc). If sterilized, couples just make decision about female participation. The choice-specific value function is $V_{t,h,bc,st}$ (for simplicity, all is conditioned on Ω_0):

$$
\begin{aligned}
V_{t,h,bc,st}(\Omega_t) =& U_{t,h,bc,st}(\Omega_t) + \\
& \beta E\left[\widetilde{p}_t V_{t+1}(\Omega^+_{t+1}) + (1-\widetilde{p}_t)V_{t+1}(\Omega^-_{t+1})\right] + \epsilon_{t,h,bc,st}
\end{aligned}
$$

$$
\begin{aligned}
V_t &= max\left\{V_{t110}, V_{t100}, V_{t010}, V_{t000}, V_{t101}, V_{t000}\right\} \quad if \quad Est = 0 \\
V_t &= max\left\{V_{t1}, V_{t0}\right\} \qquad\qquad\qquad if \quad Est = 1
\end{aligned}
$$

where Ω^+_{t+1} is the state space where $N_{t+1} = N_t + 1$; Ω^-_{t+1} is the state space where $N_{t+1} = N_t$, V_t is the maximum choice specific value function for period t. I set the discount factor (δ) to 0.95. After ending the fertile period, the choice set just consists on the decision about woman's labor force participation, independently on their sterilization state (Est). The terminal value at the end of fertile period (V_{T_f+1}) is equal to the expected discounted utility up to the end of working life ($T = 65$) evaluated on the states at T_f+1 (Ω_{T_f+1}).[34] After ending working life, terminal values are assumed to be zero. The dynamic programming solution to the optimization problem is obtained by a process of backwards recursion.

4.2 Constructing the Likelihood Function

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

- The history of participation, contraception and sterilization decisions: $a_i(h_i, bc_i, st_i)$
- The matrix of endogenous state variables: Ω_t

[32] Independent across alternatives, individuals and across time (Gayle and Miller (2006) and Mira and Aguirregabiria (2008)).

[33] Variables are defined as follows: K_0 is a dichotomous variable which defines whether labor market experience previous to marriage is higher than 3; Mat_0 is a dichotomous variable which defines whether the age of marriage was after 21 years old; S and S_h are dichotomous variables which define whether the schooling level is higher than Secondary or not.

[34] The NSFG 1995 just has information for women between 15 and 45 years old. The sample in this study is composed of women between 21 and 40 years old. The terminal value is solved by backwards recursion from 65 to 45.

- The matrix of exogenous state variables: Ω_0

The individual contribution to the likelihood is (for simplicity all is conditioned on Ω_t and Ω_0:

$$L_i(\Theta) = L_{a_i}(\Theta_U) L_{b_i}(\Theta_b) \tag{12}$$

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:

$$L_{b_i}(\Theta_b) = \prod_t [p_i^{b_i}(1-p_i)^{1-b_i}]^{1-bc_i}[((1-e)p_i)^{b_i}(1-(1-e)p_i)^{1-b_i}]^{bc_i} \tag{13}$$

where b is a dichotomous variable which defines whether there is a birth ($b = 1$) or not ($b = 0$). Furthermore, every woman in the population belongs to one of L types unobserved by the econometrician. At present, I assume L=2. Let (Θ^l, q_l) define type l, with q_l the fraction of the population of type l. The likelihood for the ith woman is:

$$L_i(.) = \sum_{l=1}^{L} q_l.L_{a_i}(\Theta_U^l, \Gamma).L_{b_i}(\Theta_b) \tag{14}$$

where Γ represents belief regarding the fecundity level. The log likelihood for the whole sample is

$$\ell = \sum_i^I logL_i \tag{15}$$

5 Estimation

Before explaining the estimation method, it is important to mention that a limitation in the 1995 NSFG is the absence of history on wages. There is just information of husbands' and wives' wages for those who were working at the date of the interview. Thus, the parameters of wives' equations are estimated using a comparable sample from the NLSY79.[35] The parameters of the husbands' equation are estimated using the only observation available in the 1995 US NSFG. The model assumes that women form their expectations before the realization of productivity shocks.[36]

[35]The NLSY79 contains a representative sample of individuals between 14 and 21 years old in 1979. These individuals are surveyed every year between 1979 and 1994. The estimation method consists on regressing a panel data model with fixed effects and recover the coefficient of education from regressing the estimated fixed effects on education. Other alternative could be to take the coefficients from alternative studies. Troske and Voicu (2010) follow the same strategy to impute wages for different labor market states: full-time and part-time.

[36]Under the 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 (Eckstein and Wolpin (1989)and der Klaauw (1996)). Moreover, selection problems are avoided.

A concentrated likelihood is not feasible because there might be unobservables in the probability of birth (L_b) affecting the decision of using birth control methods. Therefore, the model is estimated combining two approaches: the Nested Pseudo Likelihood proposed by Aguirregabiria and Mira (2007) and the Expectation-Maximization algorithm introduced by Arcidiacono and Jones (2003) and Arcidiacono and Miller (2010). Developing this estimation represents a contribution in providing a practical way to estimate this kind of models.

The estimation method is as follows. The algorithm is initialized with an arbitrary vector of parameters $\widehat{\Theta}_0$,$\widehat{\Lambda}_0$. A new vector $\widehat{\Theta}_1, \widehat{\Lambda_1}$ is obtained applying sequentially the next steps:

1. Outer loop: P step, the model is solved and the conditional choice probabilities (CCP) are computed $\widehat{P_0}$ as well as $L_{il0}(\widehat{P_0})$.

   - E step:
     - Compute $\tilde{q}_{il0}$ as

$$\frac{q_{il0} L_{il0}(\widehat{\Theta}_0, \widehat{\Lambda}_0)}{\sum_l q_{il0} L_i(\widehat{\Theta}_0, \widehat{\Lambda}_0)} \tag{16}$$

       where

       - q_{il0}=$P(type1|\widehat{\Lambda}_0)$

   - M-step: For $\tilde{q}_{il0}$ fixed, obtain $\widehat{\Theta}_1$ and $\widehat{\Lambda}_1$ using:
     - $(\widehat{\Lambda}_1)$=arg $max_{\Lambda} \sum_{l=1}^{L} \tilde{q}_{il0} \sum_{i=1}^{I} logP(type1|\Omega_{i0}, \Lambda)$
     - $(\widehat{\Theta}_{b1})$=arg $max_{\Theta_b} \sum_{i=1}^{I} \sum_{l=1}^{L} \tilde{q}_{il0} [\sum_{t=1}^{T_i} logP(b = 1|a_{it}, \Omega_{it}, \Theta_b)]$
     - $(\widehat{\Theta}_{U1})$=arg $max_{\Theta_U} \sum_{i=1}^{I} \sum_{l=1}^{L} \tilde{q}_{il0} [\sum_{t=1}^{T_i} logP(a_{it}|\widehat{P}_0, \Omega_{it}, \Theta_U)]$

Then, use $\widehat{\Theta}_1, \widehat{\Lambda}_1$ as the initial value and apply sequentially the P, E and M steps. We proceed until convergence in $\widehat{\Theta}, \widehat{\Lambda}$.

5.1 Parameter of Interest

The contribution of this paper is to study the effect of the first born child on female work. The ideal experiment is to compare two identical women which at some moment of time one has a child and the other does not. This is the effect of a child on female labor supply, independently of expectations or preparations that proceed conception. A child appear exogenously, without being a consequence of family planning decisions. Once setting the initial conditions (the women of interest: unobserved type, education level, husband's education level, experience previous to marriage and age at marriage), histories are simulated to observe the effect of a child on female work. For both women, the one who had the child and the one who did not, probabilities of working over the life cycle were calculated based on the Conditional Choice Probabilities (CCP), which are the optimal decision rules depending on the state variables and estimated parameters.

Finally, the differences between CCPs over time are the effects of fertility on female work over the life cycle.

The presence of a child may affect work in three different ways. First, children require time reducing leisure and increasing its marginal utility, therefore inducing women to reduce their supply of work. As time goes by, children age and free time, decreasing the marginal utility of leisure, therefore inducing women to work.[37] Second, in a dynamic environment, time out of the labor market (due to childbearing) prevents the accumulation of labor experience and depreciates the existing stock of experience making women less productive.[38] Third, children may affect work depending on the timing (younger women have a higher participation probability) and spacing of their arrival (two children below six years old consume more time than one below and one above 6 years old).[39]

5.2 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 (α_1) is identified by the persistent differences over time across individuals in labor force participation conditional on observables. Heterogeneity in preferences for children (α_3) is identified by the persistent differences over time across individuals in children conditional on observables. The curvature of marginal utility of leisure (α_2) is identified by the differences in labor force participation by parity conditional on observables (variation in the square number of children below 6 years old). This coefficient sums up substitution and income effects of fertility on female work.[40] The curvature of marginal utility of children (α_4) is identified by the proportion of couples using contraception methods by parity conditional on observables (variation in the square number of children). The parameter of preferences for gender composition (α_5) is identified by the proportion of couples with three children that have the first two of the same sex conditional on observables (variation in the sex of the first two children). The interaction between preferences for children's sex and leisure (α_6) is identified by the proportion of working women with two children by the sex of their children conditional on observables (variation in twins and the number of children below six years old for couples with two children). The psychic cost of using birth control (α_7) is identified by the proportion of women using contraception methods conditional on observables, variations in fecundity level by age, family planning failures (γ,e) and

[37]Other mechanisms are through child care, unemployment benefits and maternity leaves policies. These elements affect the cost of a child. Even though they are not explicitly defined in this model, they could be embedded in the interpretation of the net utility of children.

[38]Interruptions due to childbearing generates more damage in wages than other transitory interruptions. However this is not considered in this model.

[39]Children may also increase female work because they need market goods. This channel is not explicitly modeled due to the absence of market prices and lack of identification, but it is implicitly considered in the utility function. See the Model for details.Moreover, the assumptions of linearity and separability of consumption in the utility function rules out this effect.

[40]Since it just represents the substitution effect, in the estimation it will be biased towards zero.

births. The psychic cost of using sterilization services (α_8) is identified by the proportion of sterilized couples conditional on observables.

In principle, correction of the endogeneity problem is necessary to estimate the effect of fertility (the stock of children) on female work. The model considers two sources of endogeneity: unobserved heterogeneity in preferences and dynamics. First, heterogeneity in preferences for leisure and children generates permanent attitudes towards work and children decisions: women more willing to participate in the labor market are less willing to have children. Second, current decisions are correlated with past shocks: the stock of children is the result of past decisions and shocks. These two sources of endogeneity bias the estimated effect of fertility on female work. Within this context, in addition to panel data information, family planning failures are exploited as sources of variation exogenous to preferences and shocks.[41]

6 Results

6.1 Estimates

The estimation has four sets of estimated parameters from: wage equations, the utility function, the reproduction function and the (unobserved) type 1 probability. Regarding wage equations, Table F10 presents the results. In general, the signs of the coefficients are the expected: positive on experience with decreasing marginal returns (negative on its square), negative on periods out of labor market and positive on education. Husbands' estimates correspond to their education level and their wives' experience. This explains husbands' lower return to experience in comparison to wives' return: women have less experience than men. Thus, given an experience level, the dispersion of husbands' wages are greater, reducing, on average, the return to experience.

Table F11 presents maximum likelihood estimates of structural parameters. Top panel shows the estimates of the parameters of the utility function. The signs of the coefficients conform to expectations: leisure and children increase utility with decreasing marginal returns. There are two unobserved types: women with high preferences for leisure and children (type 1) and women with low preferences for leisure and children. The optimal number of children is approximately 1.82 for the former and 0.68 for the latter. On the contrary, use of contraception methods and use of sterilization services decrease utility. Whereas, the cost of contraception methods is small, the once and for all cost of sterilization services is equivalent to two thirds of an annual salary of a woman in their late thirties. Finally, having two children of the same sex decrease utility, inducing women to have a third child to change sex composition, but increase marginal utility of leisure.

The middle panel shows the estimates of the parameters of the reproduction function. The

[41] Since I am assuming that the choice specific shocks are Extreme Value Type I, I am avoiding any type of correlation between choices. Moreover, in this model, observed fertility is not a decision but an outcome. The decision refers to contraception choice. Therefore, without unobserved heterogeneity the model rules out reverse causality between these two decisions i.e. between female work and the intention to have an additional child.

expected perceived probability of conception for couples whose female partner is 21 years old and who are not using contraception methods is 0.65 and when using contraception methods is 0.02. The average probability of conception for high fecund women is 0.83 after the first birth.[42] The overall contraception efficiency is 0.95.[43] The perceived probability of conception decreases to 0.34 when having a conception failure before the first birth.[44]

The bottom panel shows the estimates of the parameters of the probability of (unobserved) type 1: a woman with high preferences for leisure and children. Having low levels of market experience previous to marriage, being married before 21 years old and having low education levels for both women and men, increases the probability of being type 1.

Some statistics predicted by the model, given parameter estimates, can be compared with the actuals observed in data. Table F12 shows actual and predicted proportion of women working, using contraception methods, sterilized women, number of children, labor market experience, number of conception failures and number of periods out of labor market. Moreover, Table F13 shows female work by parity. These statistics are seen to be close to those predicted by the model.

6.2 The effect of the first born child

In order to gauge the effect of the first born child on female work, the estimated structural model was used to simulate histories of women over time and compare working probabilities over time after birth between those who at some moment had a child and those who did not.[45] This procedure allows the characterization of the distribution of the effects of the first born child on female work. To narrow comparisons[46], the following considerations were made with respect to some characteristics of women:

1. Women with 21, 25, 30 and 35 years old.
2. Women with zero labor market experience and the maximum experience level that could be achieved at a given age in (1), beginning from 21 years old.
3. Women from all states of exogenous variables and (unobserved) types.

[42]The average probability of having a birth without using any contraception method is similar to 0.85 (Trussell (1999)). In Carro and Mira (2006), for women below 25 years old is 0.60, conditional on not having a birth in the previous period. In Petrozza and Sabatini (2008), the probability of conception is about 0.93)

[43]Using data from the PSID 1970-1979, Hotz and Miller (1988) find that the monthly probability of having a birth using contraception methods is 0.02 and not using is 0.37. Other figure is the unconditional average effectiveness which is between 0.80 and 0.90 in Hatcher et al. (1998).

[44]The decline in fertility can be compared with Coale and Trussell (1974), Wilson et al. (1988) and B M van Noord-Zaadstra and Karbaat (1991).

[45]Other possibility to estimate the effect of a first child is the following: The difference in the probability of working between two identical women in terms of endogenous and exogenous variables, but one has a child of age s and the other does not have a child. This is a pure effect of presence of a child, net of timing. However, the drawback of this approach is the likelihood of having the same endogenous variables after s years.

[46]The state space is 725.195.520 points.

Table F14 shows the effect of the first born child on female work. Child's age, past experience, women's education and preferences for leisure and children play an important role in configuring the effect. Nevertheless, the latter is more important for women with low education level. Let us define a short run period as the 5-year period after birth and long run as the time after this 5-year period up to 40 years old. The most important reduction in female work is experienced by women with low education level and high preferences for leisure and children, independently of their age (between 10 and 22 percentage points in the short run and between 7 and 17 pp in the long run). The smallest reduction is experienced by women with high education and low preferences for leisure and children (between 2 and 6 pp in the short run and between 2 and 3 pp in the long run). For the other two groups, in the short run the reduction is lower for women with low education and low preferences for leisure and children if women have accumulated experience and higher if not. However, in the long run, reduction is higher for women with low education and low preferences for leisure and children than for women with high education and high preferences for leisure and children. In general, delaying the first birth increases the reduction in female work, but is mitigated when having accumulated experience. Finally, reduction in female work is mitigated if the first birth appears between 21 and 25 years old having accumulated experience.

However, regarding potential wages (Table F15), the story is quite different. The least reduction is experienced by women older than 35 years old. Excluding these women, the second most important reduction in wages is accounted for women with low education and high preferences for leisure and children (between 2 and 6 percent in the short run and between 7 and 16 percent in the long run), while the least effect is for women with high education and low preferences for children and leisure (between 0 and 1 percent in the short run and between 1 and 2 percent in the long run). But, women with low education and low preferences for children and leisure experience a lower reduction (between 1 and 3 percent in the short run and between 3 and 5 percent in the long run) than women with high education and high preferences for leisure and children (between 1 and 4 percent in the short run and between 2 and 5 percent in the long run), independently of how much experience is being accumulated.

6.3 The effect of the second and third born children

In addition to the effect of the first born child, the model is useful to estimate the effect of the second and the third born children. In particular, the effect of the second born child on female labor supply is 50 percent lower than the effect of the first born child. However, the effect vanishes in the long run (approximately after 7 years) except for women with low education and high preferences for leisure and children and women with high education and high preferences for leisure and children. The reduction is mitigated when a second birth appears between 25 and 30 years old having accumulated experience. In the same vein, the effect of the third born child is in all cases less than 5 percent. Regarding potential wages, the effect of the second born child is 50 percent less dramatic than the first born child and the effect of the third born child is less than 5 percent in all cases.

7 Distribution of effects and IVs

Estimating the causal effect of fertility on female work poses an empirical challenge due to selection to treatment. Instrumental variables have been used to overcome this problem and to estimate effects for the compliers, those more likely to be affected by variations in the instrument. This estimate is called the Local Average Treatment Effect (LATE). The main concern about LATEs is whether they are externally valid and if not what they are estimating. Recent papers have proposed strategies to answer these questions and to compare LATEs with other treatment parameters (Average Treatment Effects, ATE; Treatment on the Treated TT; Treatment on the Untreated, TUT) estimated from a distribution of potential outcomes or a distribution of treatment effects either following structural (Heckman and Vytlacil (2005)) or non-structural (Imbens and Rubin (1997), Abadie (2002) and Angrist and Fernandez-Val (2011)) approaches. The former develops the concept of marginal treatment effects (MTE) and the latter uses non-parametric and semiparametric alternatives or restrictions over the source of heterogeneity to estimate MTEs or conditional LATEs.

In this paper I use the structural empirical model to characterize distributions of treatment effects, to estimate Average Treatment Effects (ATE) and to propose a weighting procedure to estimate Local Average Treatment Effects (LATE). The objective is to shed light on the relationship between ATE and LATE of fertility on female work using a dynamic structural empirical model. Other papers establish this relationship in a static context with a continuous distribution of unobservables (Heckman and Vytlacil, 2005). This is the first paper in estimating conditional Average Treatment Effects (ATEs) from a dynamic structural empirical model with a discrete distribution of unobservables using discrete instrumental variables and proposing a method to bridge these results with the LATEs estimates found in the non-structural literature.

7.1 Distribution of effects

The distribution of treatment effects of parity N is computed as follows:

1. In order to reduce the large state space[47], some points have been selected to characterize the distribution of treatment effects. These points represent limits in which a priori the effect is expected to be the highest and the lowest.[48] First, I take all these points when parity is

[47] The state space has 725.195.520 points.

[48] These points are the same in the last section, used to estimate the effect of children on female work: (i) women with 21, 25, 30 and 35 years old; (ii) women with zero labor market experience and the maximum experience level that could be achieved at a given age in (1); (iii) women from all states of exogenous variables and (unobserved) types.

equal to $N-1$.

2. Second, for each of all previous points and each unobserved type, I simulate R histories up to the end of fertile period and for each period I average over these R histories.

3. Third, for each of all previous points and each unobserved type, I simulate R histories up to the end of fertile period adding exogenously a child, such that the number of children is N, and for each period I average over these R histories.

4. Fourth, for all previous points, I take differences by period: (2)-(3) for each combination. These differences are called conditional ATEs (Heckman and Vytlacil 1999, 2005, 2007).[49]

Figures G2-G10 show the distributions of the effect of the first, second and third born children on female work by (unobserved) type. As expected, distributions from women with high preferences for leisure and children are displaced to the left than distributions for women with low preferences for leisure and children. Moreover, distributions for older births are displaced to the right.

7.2 Treatment Parameters: ATE and LATE

The importance of having distributions of treatment effects is that Average Treatment Effects (ATE), Treatment on the Treated (TT), Treatment on the Untreated (TUT) and Local Average Treatment Effects (LATE) can be computed as weighted averages (Heckman, 2010 and Angrist and Fernandez-Val, 2011). Additionally, helps to study heterogeneity and its importance for evaluating policies. Heckman and Vytlacil (1999, 2005, 2007) and Heckman (2010) propose weights, conditional on observables and a continuous distribution of unobservables and continuous instruments which drive the probability of treatment between zero and one, however these instruments are rare in empirical work. Thus, literature uses non-parametric and semiparametric strategies (Imbens and Rubin (1997), Abadie (2002), Carneiro and Lee (2007) and Carneiro, Heckman and Vytlacil (2010)) and Angrist and Fernandez-Val (2011) proposing weights for discrete instruments. One contribution of this paper is to estimate ATE for the first, second and third born children and proposing weights for discrete instruments based on a dynamic behavioral model and conditioning on observables and a discrete distribution of unobservables to study the effect of fertility on female work.[50]

For ATEs, each point of the distribution has the same weight (Heckman and Vytlacil (2010)). Considering women in the sample between 21 and 35 years old at the moment of the interview[51], the ATE of the first born child is -12.4 pp, for the second child is -5.6 pp and for the third born child is -4.9 pp.

[49] These conditional ATEs may be a class of Marginal Treatment Effects, assuming a discrete distribution of unobservables. See Appendix for a detailed explanation.

[50] It is left for future work the estimation of Treatment on the Treated and Treatment on the Untreated.

[51] A comparable sample with Angrist and Evans, 1999.

For LATEs, each instrumental variable generates a particular weight for each point of the distribution. See Appendix E for a detailed description of weights.[52] Figures G11-G13 show the results. The LATE for the first born child is -12.3 pp (conception failures), for the second born child is -3.8 pp (for twins) and for the third born child is -5.6 pp (for sex of the two first children). It is remarkable the closeness of the LATE and ATE for the first born child. The LATE for twins is smaller than the LATE for same-sex, even though the LATE for same sex refers to a higher order birth. This is because in the case of twins, younger women receive more weight and households with twins enjoy economies of scale whereas in the case of same-sex, women with high preferences for leisure and children and older receive more weight.

8 Counterfactuals

Once the model is estimated it is useful to implement counterfactual exercises to observe how the mechanisms are interacting. The measure of welfare used in these experiments is the expected discounted lifetime utility at each point in time. This quantity is calculated simulating histories in the same way they were done to check how well the model fit the data. Hence, to start simulations the first observation for each women from the sample was taken. Two counterfactual exercises were explored. First, a world without family planning failures. In the model, children are outcomes of birth control decisions and nature. However, imperfect control of fertility means that exist frictions which impede to have a birth when stopping contraception use and which impede to avoid a birth when using contraception methods. These frictions produce inefficient outcomes: births out of optimal time and spacing. Thus, the objective of this exercise is to quantify the welfare gain due to perfect control of fertility. Even though changes in main proportions are not dramatically different, benefit from a frictionless world is high. The individual benefit of living in a world where fertility control is perfect is approximately to 43.31 thousand dollars.[53]

The second counterfactual exercise explores a world where contraception methods and sterilization services costs are high enough to decrease contraception and sterilization rates. The objective of this exercise is to quantify welfare loss due to high costs of contraception methods, maintaining preferences constant. I set the prevalence of contraception methods in 27 percent and sterilization rate to 2 percent.[54] The birth control cost is increased to 1.75 (1750 times from baseline) and sterilization cost is increased to 25 (8 times from baseline). The individual loss of welfare due to higher contraception costs is equivalent to 115.5 thousand dollars per women.

[52]Each point of the distribution is described in the previous section. In a nutshell, each point of the distribution corresponds to the difference of the probability of working between a woman who had a child and other who did not s years after birth (being s the age of the child). See section 7.1 for a description of distributions.

[53]I am assuming that annual earnings for 25 year old men are approximately 35 thousand dollars (1997 dollars) and for women is 23 thousand (65 percent of men). Source: US Census Bureau, Current Population Surveys, March 1998, 1999, 2000 (http://www.census.gov/prod/2002pubs/p23-210.pdf). Assuming this gap is constant, the utility should be divided by 1.65 times man's salary.

[54]Figures for Africa in 2001, taken from United Nations Population Division. http://www.un.org/esa/population/publications/contraceptive2005/2005_World_Contraceptive_files/WallChart_WCU2005.pdf

9 Final Remarks

This paper addresses the estimation of the effect of fertility on female work, particularly the effect of the first born child exploiting family planning failure information from the 1995 US National Survey of Family Growth (NSFG) which has not been used before for this purpose. I develop a dynamic structural empirical model of contraception and female participation decisions under imperfect control of fertility, learning and unobserved heterogeneity. This model helps interpreting the estimated effect, exploiting family planning failures taking into account contraception decisions in contrast to cross-sectional work, abstracting from exclusion restrictions from non-structural approaches, characterizing distributions of effects and estimating Average Treatment Effects for the first, second and third born children, comparing ATEs with LATEs, and comparing the positive results with counterfactual environments. Finally, I propose a practical way to implement the estimation of Conditional Choice Probabilities (CCP) under unobserved heterogeneity.

The results show that four factors drive the importance of the effect of the first born child on female work: preferences for leisure and children, education, labor market experience and child's age. Even though the effect on female work decreases over time, the effects on the stock of children and on years of experience are permanent. The effect of the second born child is lower than that of the first and higher than that of the third. The estimated Average Treatment Effects are -12.4%, -5.6% and -4.9% for the first, second and third born child, respectively, within the 5 years after birth. The Local Average Treatment Effects are -12.3%, -3.8% and -5.6% for the first, second and third born child, respectively. It is remarkable the closeness of the LATE and ATE for the first born child. However, the LATE for twins is smaller than the LATE for same-sex, even though the LATE for same sex refers to a higher order birth. This is because in the case of twins, younger women receive more weight and enjoy economies of scale whereas in the case of same-sex, women with high preferences for leisure and children and older receive more weight. Finally, in a world with perfect control of fertility the welfare gain, understood as the net present value of lifetime utility, is approximately 43 thousand dollars per woman and the welfare loss in a world with costly contraception is approximately 115 thousand dollars per women.

The exact comparability between cross section estimates and dynamic structural estimates is left for discussion. The LATEs obtained from the structural model come from estimated Treatment Effects computed as the difference in the probability of working between two identical women who at some moment of time one had a child and the other did not. These differences are calculated soon after that first birth up to the end of the fertile period. The concern is that the effect is a mix of the timing and the presence of a child effects. Another possibility, not explored in this paper, is to estimate the same difference but one has a child of age s and the other does not. The problem here is how likely is that two women were identical if one has a child of age s and the other does not have any child due to the presence of endogenous variables which started to change soon after birth. These are comparability problems useful for discussion to shed light about what LATE are estimating in cross-sectional studies using in a dynamic context.

Appendix

A Reliability of Retrospective History in the 1995 US NSFG

The main feature of the 1995 US NSFG is that it has retrospective information about contraception decisions and labor force participation for women between 15 and 45 years old. Regarding contraception decisions, the survey has two sources of information. The first one is a monthly calendar from January 1991 to the interview date (1995). The second source is a pregnancy history module which records contraception decisions before each pregnancy. It records starting months (if the couple was using any contraception method) and stopping months (if the couple stopped before a pregnancy). With respect to labor force participation, the survey collects information about employment and unemployment spells since 18 years old. Specifically, the survey has starting and stopping months for each spell.

However, longer spells of retrospective history may be subject to recalling bias. There are two studies that test the confidence of this data. First, Teachman, et al. (1998) found the NSFG Cycle 5 data concerning labor participation history to be of high quality. They concluded that the employment information matches the Current Population Survey (CPS) data reasonably well, although the data on employment spells had not been validated using external records (Cristia, 2008).

Second, Martin and Wu (1999) analyzes the contraception calendar. They study three types of errors: first, if a woman reported using birth control pills, injectable hormonal contraceptives, morning-after pills, or female barrier methods not including female condoms, at exactly two months before a live birth; second, if a woman reported three or more consecutive months of no sexual intercourse and if the middle of the three months coincides with a conception that led to a live birth, and, third, if a couple was using a condom or female barrier method of three consecutive months of no sexual intercourse. According to their definitions of errors, none of them would be affecting a true contraception failure because the definition of a contraception failure used in this paper is based on observing a month where simultaneously happens that a couple were using contraception methods and a birth.

Moreover, external sources use this information in order to estimate contraception failures in medical literature (Trusell et. all. 1999a,b). In addition to the latter, numerous reports have been written for developing countries using contraceptive calendars in demographic surveys (Demographic and Health Surveys, DHS) following the same method to gather restrospective information as the NSFG. Finally, I compared trends of participation, use of birth control and sterilization with older NSFG and they coincide (Table F6).

B Exogeneity of conception and contraception failures

Conception and contraception failures are the result of observing contraception decisions and birth outcomes. A conception failure happens when a couple is not using contraception methods and a birth is not observed. This study considers those conception failures which last for more than twelve months, which is the standard definition of infertility in medical literature. A contraception failure occurs when a couple is using contraception methods and a birth is observed. Using conception and contraception failures as instrumental variables require that they were correlated with the stock of children and not correlated with the unobservables of the working decision.

Regarding conception failures, it is important to note that there is a consensus in that fertility is heterogeneous across populations and declines with a woman's age.[55] But, medical literature is not in agreement about what other factors influence infertility (Dunson and Weinberg (2000)). On the one hand, some of these studies show a correlation between infertility and smoking (Baird and Wilcox (1985) and Dunson and Zhou (2000)), alcohol, caffeine, exercise, BMI, drug use (Buck et al. (1997)) and poor health such as sexually transmitted diseases and miscarriages (Grodstein et al. (1994)). However, the design of these studies seems to be contaminated. For instance, if smoking is a sign of risk love, women who smoke take more risks than women who do not smoke. Then smokers with higher fecundity may have had their desired number of children quickly, leaving only the infertile smokers in the sample (Dunson and Weinberg (2000)). On the other hand, there is some evidence which claims that there is no statistically significant correlation between infertility and the abovementioned variables, mother's background characteristics, father's social class and parity (Joffe and Barnes (2000)). Moreover, Bongaarts and Menken (1983) argue that fecundity is not greatly affected by contemporary socioeconomic conditions and that fecundity is essentially exogenous in a high income population such as that of the USA. Finally, Negro-Vilar (1993) reviews the role of stress and other environmental factors affecting infertility in men and women. He argues that four main problems appear in the estimation of the effect on fecundity: the difficulty to control for possible contributing factors, the poor design of the studies, the diversity of parameters evaluated and whether they measure outcomes (i.e., pregnancy rates) or intermediate events (i.e. semen values, ovulation, etc.). He concludes that consistent and systematic methods are needed to properly asses the environmental influences on human reproductive health. Until then, he argues, the causes of female (and male) infertility will remain unexplained. This discussion follows very closely Miller (2009, 2011).

Turning to some empirical evidence, using the US 1995 NSFG I estimate the probability of having an infertile episode when childless on some covariates. The result is that there is no evidence of correlation between conception failures when childless and background characteristics such as schooling, husband's schooling, labor force experience, age, age at marriage and smoking.

Regarding contraception failures, according to the Demographic and Health Surveys Report

[55] Women fertility declines earlier than men's. Moreover, it starts declining at 32, slowly, and faster at 37.

Table B1: Probability of having a conception failure episode when childless

Variable	Estimate	Std. Error
Wife's education	-.043	.142
Husband's education	-.068	.141
Labor experience	.146	.145
Wife's age	.017	.070
Age at marriage	-.007	.081
Smoking	.032	.126
Experience before marriage	.051	.039
Constant	-1.494	.822
Number of observartions	1734	
R2	.004	

Note: The sample includes childless continuously married white women older than 20 years old and younger than 41 years old. Sample was constructed with women which were not using contraception methods up to a birth or a conception failure.

(1997), demographic characteristics of women (age, number of living children, contraceptive intention, and the marital status) are generally associated with the risk of contraceptive failure while socioeconomic status, education, and area of residence are not. In particular, the risk of contraceptive failure declines with age, increases for women with no living children and for those with five or more living children (women with no living children may not be very motivated to avoid pregnancy while women with five or more living children may include poor contraceptive users). Moreover, women who are using contraception to prevent future births are less likely to experience contraceptive failure than women who are using to space births. Furthermore, contraception failures are not correlated with contraceptive use prior to first birth, type of contraception used, background factors that predict wages, such as age-adjusted AFQT scores, a woman's religious affiliation (at birth or in the present), nor her frequency of attendance at religious services, woman who lived in homes (at age 14) with magazines, newspapers or a library card. However, the statistically significant predictor for an unintended first pregnancy is having a father with more schooling (Miller (2009) and Miller (2011) using NLSY79). Finally, there is evidence that suggest that contraceptive failures are random among women with a college degree (Herr (2008) and Herr (2011) using PSID). However, Knowles (2007) argues that contraceptive failures are correlated with skilled jobs (alternatively with income and education) which reflects selection on ability to use birth control methods.

Turning to some empirical evidence, using the US 1995 NSFG I estimate the probability of having a contraception failure when childless on some covariates. The result is that there is no evidence of correlation between contraception failures and background characteristics such as schooling, husband's schooling labor force experience, age, age at marriage and smoking.

In addition to the evidence presented, there are two important issues related to family planning failures: pregnancy outcomes and assited reproductive technologies. Pregnancy outcomes affect

Table B2: Probability of having and contraception failure when childless

Variable	Estimate	Std. Error
Wife's education	.029	.163
Husband's education	-.083	.157
Labor experience	-.021	.030
Wife's age	.051	.050
Age at marriage	-.099	.104
Smoking	.024	.141
Experience before marriage	.066	.044
Constant	-2.471	.878
Number of observartions	5534	
R2	.004	

NOTE: The sample includes childless continuously married white women older than 20 years old and younger than 41 years old. Sample was constructed with women which were using contraception methods up to a birth.

measurement of failures. Suppose a contraception failure which ends in abortion or a non-failure pregnancy which ends in miscarriage. The former affects the measurement of a contraception failure whereas the latter affects the measurement of a conception failure.

The 1995 NSFG reports five possible outcomes: live births, induced abortions, miscarriages, stillbirths and ectopic pregnancies. A miscarriage is a death of the fetus prior the 20 weeks of gestation. A stillbirth is a death of the fetus after 20 weeks of gestation. An ectopic pregnancy is a complication in which the fetus is allocated outside the uterine cavity. Stillbirths (0.7%) and ectopic pregnancies (1.1%) accounts for almost 1.8% of pregnancies, abortions are 4% and miscarriages are 11.9%. For childless couples, stillbirths (0.6%) and ectopic pregnancies (1.4%) accounts for almost 2.0% of first pregnancies, abortions are 4.1% and miscarriages are 12.6%. Miscarriages and ectopic pregnancies are usually considered as random events (Farquhar (2005)). Stillbirth causes are not excatly identified but are very rare. Induced abortions are decisions made by the couple.

Regarding use of reproduction technologies, as soon as a couple experiences the first conception failure, they could choose to seek help to achieve a pregnancy. In my sample 9.42% (267) of couples have used infertility services (ovulation, tubes surgery, insemination and in vitro). Data is not precise about the date of use of the infertility services, so it is not possible to know if they were childless or not. Of these, 44% (118) have had failures. For these, the probability of using infertility services is not correlated with socioeconomic characteristics of the couple (age, education labor force experience, number of children and smoking). The other 56% (149) never had a failure. This is more troublesome because it is not possible to know whether they could have had at least an infertile period or not. So, within this group there are non-infertile and potentially infertile couples. The worst case would be if all of them would have been infertile. For this group, the probability of seeking infertility services is positively correlated with husband's education and negatively correlated with smoking and the number of children. However, none of these covariates is correlated with the likelihood of having a conception failure. Furthermore, there is evidence that in the period this study covers, fertility treatments were not very effective. In the worst case, assuming that all of them were infertile, the probability of a conception is approximately the same independently of seeking help (Collins et al. (1983) and Collins et al. (1993)). Finally, Cristia (2008) use the fact that pregnancy within women who have sough help is random to estimate the effect of the first born child on female labor supply using the 1995 US NSFG.

C Data Aggregation

The main feature of the 1995 NSFG is that it cotains monthly information on labor force participation and contraception decisions. For the purposes of this study, I will aggregate the information to have an annual database. Aggregation has been made carefully to avoid mismatch in participation and contraception decisions and birth outcomes between monthly and annual data.

Regarding labor force participation, aggregation has been made in order to have comparable figures with participation trends by year and age based on the Bureau of Labor Statistics and the Current Population Survey estimates. Thus, a woman is considered participating in the labor market in a given age if she has been working for at least six months in that age.

With respect to contraception decisions, aggregation takes into account events which are particularly observed in a monthly basis and not exactly observed in a yearly basis. Therefore, aggregation is as follows:

1. The base of the aggregation regarding conception failures is twelve consecutive months of not using any contraception method ($bc = 0$), following the standard measure in the medical literature. The following cases are considered:

   A Twelve consecutive months in a given year with $bc = 0$ and without a pregnancy is considered as a year with $bc = 0$.

   B The first part of the year with $bc = 1$, the second part with $bc = 0$ and without a pregnancy is considered as a year with $bc = 1$.

   C The first part of the year with $bc = 1$, the second part of the year with $bc = 0$ with a pregnancy is considered as a year with $bc = 0$.

   D The first part of the year with $bc = 0$ without a pregnancy, the second part of the year with $bc = 1$:

   - the second part of the previous year with $bc = 1$, is considered as a year with $bc = 1$.
   - the second part of the previous year with $bc = 0$ and the sum of the consecutive months with $bc = 0$ is equal to or larger than 12, is considered as a year with $bc = 0$.
   - the second part of the previous year with $bc = 0$ and the sum of the consecutive months with $bc = 0$ is less than 12, is considered as a year with $bc = 1$.
   - all the previous year with $bc = 0$ and the sum of consecutive months is not a multiple of 12, is considered as a year with $bc = 1$.
   - all the previous year with $bc = 0$ and the sum of consecutive months is a multiple of 12, is considered as a year with $bc = 0$.

   E The first part with $bc = 0$ and a pregnancy, the second part with $bc = 1$, is considered a year with $bc = 0$.

2. The base of the aggregation regarding contraception failures is observing what exactly was doing the couple when they got pregnant. The following cases are considered:

   - If in the month where the couple got pregnant $bc = 0$, is considered as a year with $bc = 0$.
   - If in the month where the couple got pregnant $bc = 1$, is considered as a year with $bc = 1$.

Other important aggregation is regarding births because of the lag between pregnancy and the delivery date. Thus, a birth is attached to pregnancy and the stock of children increase in the following period. With respect to esterilization, a couple is considered sterilized in a given year if they report twelve months of being sterilized. With less than twelve months is still possible to observe a pregnancy.

D Bayesian Updating

The model assumes that couples do not know their true joint fecundity level soon after marriage. However, they will learn about it in each period in which they do not use any birth control method and from births. I assume that each cycle has the same distribution of the probability of having a birth. It is plausible to think that much of the fecundity level is learnt in the absence of contraceptive methods, that is one of the reasons pre-marital relationships are not being taken into account, assuming that pre-marital couples do not desire children.[56] Therefore, couples make decisions based on their beliefs. After a period without using contraceptive methods or a birth, couples update their prior and make decisions based on this new belief.

Let the probability of having a birth in period t be $p_t = \gamma k_t$, where γ is the joint natural fecundity level $\gamma \in (0,1)$ and k_t is the natural decline of fecundity. Couples do not know their true γ soon after marriage. Let $\pi_t(p)$ be the prior distribution describing beliefs about natural fecundity in period t which is assumed to be a Generalized Beta distribution with support $(0, k_t)$ and shape parameters (α, β). Let us explore some relevant cases for the updating.

If a couple has a birth in the first period not using contraception methods (k_0), the conditional distribution of births (b) is:

$$f_t(b|p) = \gamma k_0 \tag{17}$$

The prior distribtion is

$$\pi_t(p) = \frac{1}{B(\alpha,\beta,k_t)}(pk_t)^{\alpha-1}(k_t - pk_t)^{\beta-1} \tag{18}$$

where $B(\alpha, \beta, k_t)$ is the Generalized Beta distribution with parameters α and β and support $[0, k_t]$:

$$B(\alpha,\beta,k_t) = \int_0^{k_t} (pk_t)^{\alpha-1}(k_t - pk_t)^{\beta-1}dp = k_t \int_0^1 (p)^{\alpha-1}(1-p)^{\beta-1}dp \tag{19}$$

the joint distribution is

$$\phi_t(p,b) = f_t(b|p)\pi_t(p) = \frac{1}{B(\alpha,\beta,k_t)} k_0 k_t (p)^{\alpha}(1-p)^{\beta-1} \tag{20}$$

where $b = [0, 1]$ depending on the occurence of a birth. The marginal distribution is

$$m_t(b) = \int_0^{k_t} \phi_t(b,p)dp = \frac{1}{B(\alpha,\beta,k_t)} k_0 \int_0^{k_t} k_t(p)^{\alpha}(1-p)^{\beta-1}dp \tag{21}$$

the posterior distribution is

$$\pi_t(p|b) = \frac{\phi(p,b)}{m(b)} \tag{22}$$

[56] The proportion of unmarried women having sexual intercourses using birth control methods is greater than the proportion of married women using birth control methods.

the mean of the posterior distribution is

$$E_t[m(b)] = \frac{\int_0^{k_t} \frac{1}{B(\alpha,\beta,k_t)} k_0 k_t(p)^{\alpha+1}(1-p)^{\beta-1}dp}{\frac{1}{B(\alpha,\beta,k_t)} k_0 \int_0^{k_t} k_t(p)^{\alpha}(1-p)^{\beta-1}dp} \tag{23}$$

$$E_t[m(b)] = \frac{B(\alpha+1,\beta)}{B(\alpha,\beta)} = \frac{\frac{\Gamma(\alpha+1)\Gamma(\beta)}{\Gamma(\alpha+\beta+1)}}{\frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha+\beta)}} = \frac{\alpha+1}{\alpha+\beta+1} \tag{24}$$

where Γ is the Gamma distribution. Other scenario is having a conception failure at t=1. In this case the conditional distribution for t>1 is:

$$f_t(b|p) = 1 - pk_1 \tag{25}$$

The prior distribution is

$$\pi_t(p) = \frac{1}{B(\alpha,\beta,k_t)}(pk_t)^{\alpha-1}(k_t - pk_t)^{\beta-1} \tag{26}$$

the joint distribution is

$$\phi_t(p,b) = f_t(b|p)\pi_t(p) = \frac{1}{B(\alpha,\beta,k_t)} k_t(p)^{\alpha-1}(1-p)^{\beta-1}(1-pk_1) \tag{27}$$

the marginal distribution is

$$m_t(b) = \int_0^{k_t} \phi_t(b,p)dp = \frac{1}{B(\alpha,\beta,k_t)} \int_0^{k_t} k_t(p)^{\alpha}(1-p)^{\beta-1}(1-pk_1)dp \tag{28}$$

the posterior distribution is

$$\pi_t(p|b) = \frac{\phi(p,b)}{m(b)} \tag{29}$$

the mean of the posterior distribution is

$$E_t[m(b)] = \frac{\int_0^{k_t} \frac{1}{B(\alpha,\beta,k_t)} k_t(p)^{\alpha}(1-p)^{\beta-1}(1-pk_1)dp}{\frac{1}{B(\alpha,\beta,k_t)} \int_0^{k_t} k_t(p)^{\alpha-1}(1-p)^{\beta-1}(1-pk_1)dp} \tag{30}$$

$$E_t[m(b)] = \frac{B(\alpha+1,\beta) - k_1 B(\alpha+2,\beta)}{B(\alpha,\beta) - k_1 B(\alpha+1,\beta)} \tag{31}$$

$$E_t[m(b)] = \frac{\mu_0 - k_1\mu_0\mu_1}{1 - k_1\mu_0} \tag{32}$$

where $\mu_n = \frac{\alpha+n}{\alpha+\beta+n}$. In case of two failures, the mean of the posterior distribution is:

$$E_t[m(b)] = \frac{\mu_0 - (k_1+k_2)\mu_0\mu_1 + k_1k_2\mu_0\mu_1\mu_2}{1 - (k_1+k_2)\mu_0 + k_1k_2\mu_0\mu_1} \tag{33}$$

and in case of three failures, the mean of the posterior distribution is:

$$E_t[m(b)] = \frac{\mu_0 - (k_1+k_2+k_3)\mu_0\mu_1 + (k_1k_2+k_1k_3+k_2k_3)\mu_0\mu_1\mu_2 - k_1k_2k_3\mu_0\mu_1\mu_2\mu_3}{1 - (k_1+k_2)\mu_0 + (k_1k_2+k_1k_3+k_2k_3)\mu_0\mu_1 - k_1k_2k_3\mu_0\mu_1\mu_2} \tag{34}$$

E Local Average Treatment Effects (LATE)

Before explaining the procedures to compute weights, let us define a treatment and a control node and the general formulation of weights. A treatment node is a collection of state variables characterized in particular by an exogenous increase of the number of children with respect to the previous period. A control node is a collection of state variables equal to a treatment node but characterized in particular by a changeless number of children with respect to the previous period. In other words, a treatment node is a women with an additional child whereas a control node is the same women with the same number of children as the previous period. Finally, weights are defined as follows[57]:

$$\begin{aligned}\omega_1 =& Prob(N_{t+1} = N_t + 1, \Omega'_{t+1}, N_t | Z_{t+1} = 1) - Prob(N_{t+1} = N_t, \Omega'_{t+1}, N_t | Z_{t+1} = 1) \\ \omega_0 =& Prob(N_{t+1} = N_t + 1, \Omega'_{t+1}, N_t | Z_{t+1} = 0) - Prob(N_{t+1} = N_t, \Omega'_{t+1}, N_t | Z_{t+1} = 0) \\ \omega =& \omega_1 - \omega_0\end{aligned} \tag{35}$$

where Z is the instrumental variable and Ω' is a collection of state variables, excluding information about the stock of children. Conceptually, ω_1 is the difference between the likelihood of having an additional child and the likelihood of continuing with the same number of children when $Z = 1$; ω_0 is the difference between the likelihood of having an additional child and the likelihood of continuing with the same number of children when $Z = 0$ and ω show the importance of a change in the instrument on the likelihood of having an additional child and the likelihood of continuing with the same number of children. This difference is the analog of $Prob(D_1 - D_0 = 1|X)$ in the LATE jargon.[58] These weights can be rewritten as follows:

$$\begin{aligned}\omega_1 =& Prob(\Omega'_{t+1}, N_t | Z_{t+1} = 1) \left[Prob(N_{t+1} = N_t + 1 | Z_{t+1} = 1, \Omega'_{t+1}, N_t) - Prob(N_{t+1} = N_t | Z_{t+1} = 1, \Omega'_{t+1}, N_t)\right] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t | Z_{t+1} = 0) \left[Prob(N_{t+1} = N_t + 1 | Z_{t+1} = 0, \Omega'_{t+1}, N_t) - Prob(N_{t+1} = N_t | Z_{t+1} = 0, \Omega'_{t+1}, N_t)\right]\end{aligned} \tag{36}$$

where $Prob(\Omega'_{t+1}, N_t)$ is the probability of arriving to a specific combination of state variables in $t+1$. Given exogeneity of the instrumental variable, this term is independent of the realization of the instrument. Therefore, $Prob(\Omega'_{t+1}, N_t | Z_{t+1} = 1) = Prob(\Omega'_{t+1}, N_t | Z_{t+1} = 0) = Prob(\Omega'_{t+1}, N_t)$.[59]

In the case of the first born child, family planning failures have been used as instrumental variables in the literature. In fact, family planning failures can be of two types: conception and contraception failures. Each of them are consequences of different processes, in particular of birth control decisions: a conception failure may appear when not using contraception methods and a

[57]In fact, this is the numerator of the weights. The denominator is a rescaling factor which is the same for all points of the distribution. This numerator is of the same sign for all points under monotonicity.

[58]This is the numerator in Heckman (2010) and Angrist and Fernandez-Val (2011).

[59]Let summarize Ω'_{t+1}, N_t in X. $P(X|Z) = \frac{P(Z|X)P(X)}{P(Z)}$. Exogeneity condition is $(Y_1, Y_0) \perp Z | X$. In empirical applications this is equivalent $P(Z|X) = P(Z)$. Therefore, $P(X|Z) = P(X)$.

contraception failure may appear when using contraception methods. Therefore, compliers may be different. That's why different weights are calculated for each of them.

For conception failures as instrumental variable weights are calculated as follows:

1. Take observations with $N_t = 0$ and $bc_t = 0$.

2. The weights are (all is conditioned on $bc_t = 0$):

$$\begin{aligned} \omega_1 =& Prob(\Omega'_{t+1}, N_t = 0|Z_{t+1} = 1)[Prob(N_{t+1} = 1|Z_{t+1} = 1, \Omega'_{t+1}, N_t = 0) \\ &- Prob(N_{t+1} = 0|Z_{t+1} = 1, \Omega'_{t+1}, N_t = 0)] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t = 0|Z_{t+1} = 0)[Prob(N_{t+1} = 1|Z_{t+1} = 0, \Omega'_{t+1}, N_t = 0) \\ &- Prob(N_{t+1} = 0|Z_{t+1} = 0, \Omega'_{t+1}, N_t = 0)] \end{aligned} \tag{37}$$

3. Since a conception failure means that a birth did not appear, weights can be rewritten in the following way (See Reproduction Function)[60]:

$$\begin{aligned} \omega_1 =& Prob(\Omega'_{t+1}, N_t = 0)\,[0 - 1] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t = 0)\,[\gamma k_t - (1 - \gamma k_t)] \end{aligned} \tag{38}$$

4. Finally:

$$\omega = Prob(\Omega'_{t+1}, N_t = 0)(-2\gamma k_t) \tag{39}$$

5. The negative coefficient is a mechanic result. A conception failure does not generate an additional child, therefore, the treatment effect is possitive.

6. Abstracting from conditions which take women to a given node ($Prob(\Omega'_{t+1}, N_t = 0)$), women with less conception failures (higher γ) and younger (higher k_t) matter more.

7. $Prob(\Omega'_{t+1}, N_t = 0)$ can be calculated from data. This is the contribution of each combination of state variables in the sample.

For contraception failures as instrumental variable weights are calculated as follows:

1. Take observations with $N_t = 0$ and $bc_t = 1$.

2. The weights are (all is conditioned on $bc_t = 1$):

$$\begin{aligned} \omega_1 =& Prob(\Omega'_{t+1}, N_t = 0|Z_{t+1} = 1)[Prob(N_{t+1} = 1|Z_{t+1} = 1, \Omega'_{t+1}, N_t = 0) \\ &- Prob(N_{t+1} = 0|Z_{t+1} = 1, \Omega'_{t+1}, N_t = 0)] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t = 0|Z_{t+1} = 0)[Prob(N_{t+1} = 1|Z_{t+1} = 0, \Omega'_{t+1}, N_t = 0) \\ &- Prob(N_{t+1} = 0|Z_{t+1} = 0, \Omega'_{t+1}, N_t = 0)] \end{aligned} \tag{40}$$

[60] The reproduction function is: $p_t = \gamma k_t(1 - e.bc_t)$

3. Since a contraception failure means that a birth appeared, weights can be rewritten in the following way:

$$\begin{aligned}\omega_1 =& Prob(\Omega'_{t+1}, N_t = 0)\,[1-0] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t = 0)\,[\gamma k_t(1-e) - (1-\gamma k_t(1-e))]\end{aligned} \tag{41}$$

4. Finally:

$$\omega = Prob(\Omega'_{t+1}, N_t = 0)(2\gamma k_t(1-e)) \tag{42}$$

5. Abstracting from conditions which take women to a given node ($Prob(\Omega'_{t+1}, N_t = 0)$), women with less conception failures (higher γ) and younger (higher k_t) matter more.

6. An interesting result is that independently of how women arrived to a given node, the distribution of compliers which conception and contraception failures generate is the same. However, this result holds as long as contraception efficiency is the same for all kind of contraception methods. If different contraception efficiency is taken into account, women using less efficient contraception methods will matter more.

7. $Prob(\Omega'_{t+1}, N_t = 0)$ can be calculated from data. This is the contribution of each combination of state variables in the sample.

For twins as instrumental variable, weights are calculated as follows:

1. Take observations with $N_t = 0$ and $birth_t = 1$.

2. The weights are:

$$\begin{aligned}\omega_1 =& Prob(\Omega'_{t+1}, N_t = 0|Z_{t+1} = 1)[Prob(N_{t+1} = 2|Z_{t+1} = 1, \Omega'_{t+1}, N_t = 1) \\ &- Prob(N_{t+1} = 1|Z_{t+1} = 1, \Omega'_{t+1}, N_t = 0)] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t = 0|Z_{t+1} = 0)[Prob(N_{t+1} = 2|Z_{t+1} = 0, \Omega'_{t+1}, N_t = 1) \\ &- Prob(N_{t+1} = 1|Z_{t+1} = 0, \Omega'_{t+1}, N_t = 0)]\end{aligned} \tag{43}$$

3. Since twins means that two births appeared, weights can be rewritten in the following way:

$$\begin{aligned}\omega_1 =& Prob(\Omega'_{t+1}, N_t = 0)\,[1-0] \\ \omega_0 =& Prob(\Omega'_{t+1}, N_t = 0)\,[0 - \gamma k_t(1-e.bc_t)]\end{aligned} \tag{44}$$

4. Finally:

$$\omega = Prob(\Omega'_{t+1}, N_t = 0)(1 + \gamma k_t(1-e.bc_t)) \tag{45}$$

5. Abstracting from conditions which take women to a given node ($Prob(\Omega'_{t+1}, N_t = 0)$), women with less conception faillures (higher γ) and younger (higher k_t) will matter more in the LATE estimation.

6. $Prob(\Omega'_{t+1}, N_t = 0)$ can be calculated from data.

For sex of the first two children as instrumental variable, weights are calculated as follows:

1. Take observations with $N_t = 1$ and $birth_t = 1$.

2. The realization of the sex of the first two children do not mean instantaneously a third birth. Thus, weights are calculated as follows:

$$\begin{aligned}\omega_1 =& Prob(\Omega'_{t+1+s+1}, N_t = 2, N_{t+1+s} = 2|Z_{t+1} = 1)[Prob(N_{t+1+s} = 3|Z_{t+1} = 1, \Omega'_{t+1+s+1}, N_t = 2)- \\ & Prob(N_{t+1+s} = 2|Z_{t+1} = 1, \Omega'_{t+1+s+1}, N_t = 2)] \\ \omega_0 =& Prob(\Omega'_{t+1+s+1}, N_t = 2, N_{t+1+s} = 2|Z_{t+1} = 0)[Prob(N_{t+1+s} = 3|Z_{t+1} = 0, \Omega'_{t+1+s+1}, N_t = 2)- \\ & Prob(N_{t+1+s} = 2|Z_{t+1} = 0, \Omega'_{t+1+s+1}, N_t = 2)]\end{aligned} \tag{46}$$

where s is the age of the second born child at which a third child appeared ($N_{t+1+s} = 3$).

3. Consider that $\Omega'_{t+1+s+1} = (\Omega'_{t+1}, \Omega'^{*}_{s+1})$, where Ω'_{t+1} is the collection of state variables at the moment when the second child appeared and Ω'^{*}_{s+1} is the collection of state variables $s + 1$ periods after the second child appeared. Therefore, the first term can be rewritten as follows:

$$Prob(\Omega'_{t+1+s+1}, N_t = 2, N_{t+1+s} = 2|Z_{t+1} = z) = Prob(\Omega'_{t+1}, N_t = 2)Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = z) \tag{47}$$

4. The first term of the rhs is not conditioned on Z_{t+1} due to exogeneity of the instrument (sex of the first two children). The second term takes into account the effect of the instrument over women's behavior. If exclusion restriction is not violated, then:

$$Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = 1) = Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = 0) = Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2) \tag{48}$$

5. However, in the estimated structural model, this is not the case (α_7) because having the two first children of the same sex increases marginal utility of leisure.

6. Considering that the probability of having an additional child in s is $\gamma k_s(1 - e.bc_s)$.

$$\begin{aligned}\omega_z =& Prob(\Omega'_{t+1}, N_t = 2)Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = z)\,[\gamma k_s(1 - e.bc_s) - (1 - \gamma k_s(1 - e.bc_s))] \\ \omega_z =& Prob(\Omega'_{t+1}, N_t = 2)Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = z)\,[2\gamma k_s(1 - e.bc_s) - 1] \\ \omega_z =& Prob(\Omega'_{t+1}, N_t = 2)[Prob(bc_s = 1)Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = z, bc_s = 1)(2\gamma k_s(1 - e) - 1)+ \\ & Prob(bc_s = 0)Prob(\Omega'^{*}_{s+1}, N_{t+1+s} = 2|Z_{t+1} = z, bc_s = 0)(2\gamma k_s - 1)]\end{aligned} \tag{49}$$

F Tables

Table F1: Summary Statistics

Variable	Ever Married	Always Married	21-40	Non sterilized
Women	3669	2970	2967	2880
Number of Observations	51620	41459	38160	35968
Average number of observations per women	8.41	8.36	8.51	8.43
	(5.19)	(5.17)	(4.90)	(4.87)
Age	29.06	29.14	29.46	29.40
	(5.78)	(5.72)	(5.01)	(4.99)
Age at marriage	20.97	21.13	21.29	21.39
	(3.43)	(3.45)	(3.41)	(3.41)
Experience previous marriage	2.54	2.66	2.78	2.86
	(2.96)	(3.01)	(3.02)	(3.04)
Education	.47	.49	.50	.50
	(.50)	(.50)	(.50)	(.50)
Husband's education	.50	.53	.54	.55
	(.50)	(.50)	(.50)	(.50)
Number of children	1.39	1.40	1.44	1.43
	(1.14)	(1.13)	(1.13)	(1.12)
Children under 6 years old	.55	.56	.58	.59
	(.69)	(.69)	(.70)	(.70)
Experience after marriage	5.68	5.62	5.79	5.72
	(4.97)	(4.93)	(4.77)	(4.73)
Periods out of labor force	2.83	2.81	2.79	2.70
	(4.04)	(4.05)	(3.97)	(3.92)
Period with conception failures	.23	.21	.23	.23
	(.74)	(.71)	(.73)	(.74)
Period with contraception failures	.04	.04	.04	.05
	(.20)	(.21)	(.20)	(.21)
Working	.75	.74	.75	.75
	(.43)	(.44)	(.43)	(.43)
Using birth control	.51	.51	.50	.52
	(.50)	(.50)	(.50)	(.50)
Sterilized	.26	.26	.26	.25
	(.44)	(.44)	(.44)	(.43)
Use of infertility services	.09	.10	0.10	.10
	(.28)	(.29)	(.30)	(.30)

NOTE: White women from 1995 US NSFG. Standard deviations in parenthesis.

Table F2: Literature Review: Structural dynamic models of labor force participation and birth control under imperfect control of fertility

Paper	Model	Objective	Data and Sample	Limitations
Rosenzweig and Schultz (1985) AER	Labor Supply Model 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 function without accounting for dynamics
Hotz and Miller (1988) Econometrica	Fertility and Female Labor Supply	Effect of child care cost on labor supply and birth spacing	PSID women with at at least one child	No information on contraception methods
Sylvester (2007) RED	Schooling, Marriage Birth Control, Labor Supply	Study the interdependecy of these decisions	NLSY 1979-1999	No unobserved heterogeneity No complete information Just 8 of 18 waves
Radhakrishnan (2009) Manuscript	Labor Supply and Birth Control	Effect of the expansion of of a family planning program on labor supply and birth control in India	Indonesia Family Life Survey	Estimation of probability of birth outside the model
Maheshwari (2009) Manuscript	Schooling, Marriage Birth Control, Labor Supply Occupational choice	Why women choose certain occupations	NLSY 1979	No complete information on contraception methods Just 8 of 18 waves
Knowles (2007) Manuscript	Birth Control, Fertility Work and Occupation	The role of birth control in female work	NSFG 1995	Do not use micro info

Table F3: Literature Review: Estimation of the effect of the first born child on female labor supply using family planning failures

Paper	Objective/Instrument	Data and Sample	Result	Limitations
Aguero and Marks (2008) AER P&P	Self-reported infertility: i) Women mention infertility or subfertility as their reason for not using contraception methods. ii) Non-sterilized women responded they are unable to have more children	Demographic Health Surveys Colombia (1995), Bolivia (1994 and 1998) Nicaragua (1998) Dominican Republic (1996)	No effect.	Dependent variable: working for paid in the week prior to the survey. Excluding women who were using contraception methods and sterilized women.
Miller (2009) AER P&P	Effect of age at first birth on cognitive abillity of first children. Instruments: i) Contraception failure of the first child ii) Time elapsed for first conception.	NLSY79 + Children Survey Women with at least one child between 21-33 years old (1979-2000)	Positive: 0.5 point per year delay	Contraception decisions not modelled. Incomplete info on contraceptions.
Miller (2011) JPopE	Effect of age at first birth on career outcomes. Instruments: i) Contraception failure of the first child ii) Time elapsed for first conception.	NLSY79 Women with at least one child between 21-33 years old (1979-2000)	Negative (Delay one year: 3% average wage rate 6% in hours worked 9% earnings)	Contraception decisions not modelled. Incomplete info on contraceptions.
Herr (2010) Manuscript	Effect of timing of first birth on wages Instrument: contraception failure of first child.	NLSY79 Married women with at least one year of college degree.	Negative (earnings) One year delay increase 3.5%	Contraception decisions not modelled Incomplete info on contraceptions
Rondinelli and Zizza (2010) Manuscript	Self reported infertility	Bank of Italy's Survey of Household Income	No effect at long-run	Women older than 39 Current employment
Schott (2010) Manuscript	Effect of motherhood on employment: Fecundity variable in Survey	2006-2008 NSFG	Negative (26%)	Excluding sterilized women. Employment week prior to survey.

Table F4: Choices

Variable	Ever Married	Always Married	20-40	Non sterilized
Working and using birth control	.38	.38	.38	.39
	(.48)	(.49)	(.48)	(.49)
Working and not using birth control	.16	.15	.16	.16
	(.36)	(.36)	(.36)	(.37)
Not working and using birth control	.12	.12	.11	.11
	(.32)	(.32)	(.31)	(.32)
Not working and not using birth control	.06	.06	.06	.06
	(.24)	(.24)	(.24)	(.24)
Working and choosing sterilization	.02	.02	.02	.02
	(.14)	(.14)	(.14)	(.14)
Not working and choosing sterilization	.01	.01	.01	.01
	(.11)	(.11)	(.11)	(.11)
Sterilized women working	.19	.19	.20	.18
	(.40)	(.39)	(.40)	(.39)
Sterilized women not working	.06	.07	.07	.06
	(.24)	(.25)	(.25)	(.24)

Note: White women from 1995 NSFG. Standard errors in parenthesis.

Table F5: Number of observations by year

Year	Frequency	Percent	Cumulative
1975	478	1.33	1.33
1976	615	1.71	3.04
1977	762	2.12	5.16
1978	907	2.52	7.68
1979	1,045	2.91	10.58
1980	1,214	3.38	13.96
1981	1,351	3.76	17.72
1982	1,520	4.23	21.94
1983	1,707	4.75	26.69
1984	1,874	5.21	31.9
1985	2,032	5.65	37.55
1986	2,197	6.11	43.66
1987	2,333	6.49	50.14
1988	2,473	6.88	57.02
1989	2,593	7.21	64.23
1990	2,762	7.68	71.91
1991	2,743	7.63	79.53
1992	2,619	7.28	86.81
1993	2,454	6.82	93.64
1994	2,289	6.36	100

Note: Continuously married white women older than 20 and younger than 41 years old (dropping sterilized women for non contraception reasons). Source: 1995 NSFG.

Table F6: Comparison with other Sources

Year	Working	Birth Control	Sterilized
1976	0.492	0.492	0.186
1982	0.561	0.401	0.278
1988	0.675	0.381	0.362
1995	0.729	0.394	0.370

NOTE: Birth Control and Sterlization Information: Statistics for currently married women between 15-44 yeas old. Contraceptive Utilization United States, 1976, Table 3, p. 19, Source NSFG 1976. For white women between 15-44 is 66.3 and 4 percent, respectively; Contraceptive Use United States, 1982, Table 12, p. 36, Source NSFG 1982. For women between 25 and 29 years old is 54 and 15 percent, respectively; Contraceptive Use in the United States 1973-1988, Table 3, p. 4, Source NSFG 1988. For women between 25 and 34 years old sterilization rate es 27.2 percent; Fertility, Family Planning and Women's Health, Table 42, p. 52, Source NSFG 1995. Working Information: For 1976, Working Women and Childbearing, 1982, p. 18, Source NSFG 1976. For 1982, Changes in Labor Force Participation in the US 2006, Married Women between 20 and 60 years old, Table 2, p. 33, Source CPS 1979; For 1988, Changes in Labor Force Participation in the US 2006, Table 2, p. 33, Source CPS 1989; For 1995, Evaluation of the 1995 NSFG 1997, Table 7, Source CPS 1995. Percentages in birth control use and sterilization are taking into account couples surgically sterile for non contraception reasons

Table F7: Means by year

Year	Working	Birth Control	Sterilized	Mean Age	Max. Age
1975	0.69	0.68	0.06	22.81	25
1976	0.69	0.67	0.08	23.34	26
1977	0.69	0.64	0.09	23.84	27
1978	0.69	0.61	0.10	24.37	28
1979	0.69	0.59	0.13	24.92	29
1980	0.72	0.60	0.15	25.44	30
1981	0.72	0.56	0.17	26.06	31
1982	0.71	0.56	0.19	26.60	32
1983	0.72	0.55	0.20	27.11	33
1984	0.74	0.54	0.22	27.66	34
1985	0.75	0.50	0.23	28.24	35
1986	0.76	0.51	0.25	28.80	36
1987	0.77	0.48	0.26	29.49	37
1988	0.77	0.49	0.27	30.16	38
1989	0.78	0.49	0.28	30.83	39
1990	0.79	0.48	0.29	31.34	40
1991	0.78	0.50	0.30	32.09	40
1992	0.77	0.49	0.31	32.54	40
1993	0.76	0.48	0.32	32.98	40
1994	0.77	0.50	0.34	33.47	40

NOTE: Continuously married white women older than 20 and younger than 41 years old (dropping sterilized women for non contraception reasons). Source: 1995 NSFG.

Table F8: Effect of a conception failure on children, participation and experience

Time after failure	Observations	Children	Participation	Experience
0	1710	0,000	0,033	-0,094
		(0)	(0,0164)	(0,0667)
1	1691	-1,000	0,141	0,060
		(1,22E-17)	(0,0193)	(0,0791)
2	1640	-0,951	0,230	0,298
		(0,0212)	(0,0214)	(0,0916)
3	1559	-1,130	0,225	0,548
		(0,0303)	(0,0226)	(0,0888)
4	1470	-1,300	0,174	0,733
		(0,0377)	(0,0259)	(0,107)
5	1328	-1,340	0,130	0,846
		(0,0477)	(0,0287)	(0,135)
6	1235	-1,370	0,115	0,944
		(0,0557)	(0,0307)	(0,16)
7	1141	-1,410	0,106	1,050
		(0,0641)	(0,032)	(0,193)
8	1022	-1,450	0,057	0,998
		(0,0722)	(0,0344)	(0,229)
9	902	-1,500	0,044	1,150
		(0,0793)	(0,0378)	(0,27)
10	778	-1,550	0,038	1,200
		(0,0888)	(0,0397)	(0,315)
11	676	-1,550	0,045	1,330
		(0,0974)	(0,0412)	(0,368)
12	567	-1,520	0,005	1,290
		(0,108)	(0,0456)	(0,431)
13	473	-1,620	0,025	1,540
		(0,121)	(0,0465)	(0,466)
14	378	-1,610	0,025	1,450
		(0,134)	(0,0523)	(0,569)
15	278	-1,710	0,003	1,840
		(0,144)	(0,0564)	(0,646)

Note: Coefficients of OLS regresions of Children, Participation and Experience on having a conception failure. Sample includes women who were not using contraception methods at 0. Standard errors in parenthesis.

Table F9: Effect of a contraception failure on children, participation and experience

Time after failure	Observations	Children	Participation	Experience
0	1760	0,000	-0,087	0,090
		(0)	(0,0301)	(0,0692)
1	1752	1,000	-0,227	-0,052
		(3,54E-18)	(0,0298)	(0,0798)
2	1749	0,907	-0,320	-0,333
		(0,0242)	(0,0329)	(0,0931)
3	1736	1,020	-0,261	-0,585
		(0,0375)	(0,0332)	(0,114)
4	1703	1,050	-0,176	-0,696
		(0,0435)	(0,0338)	(0,122)
5	1567	1,020	-0,144	-0,874
		(0,0497)	(0,0353)	(0,154)
6	1470	1,010	-0,110	-0,990
		(0,0529)	(0,0359)	(0,182)
7	1364	0,961	-0,076	-1,050
		(0,0602)	(0,037)	(0,217)
8	1266	0,882	-0,038	-0,994
		(0,0644)	(0,038)	(0,249)
9	1153	0,804	-0,050	-1,100
		(0,0685)	(0,0408)	(0,288)
10	1046	0,772	-0,031	-1,080
		(0,0746)	(0,0416)	(0,324)
11	939	0,715	-0,012	-1,100
		(0,0767)	(0,0414)	(0,366)
12	822	0,651	0,052	-0,915
		(0,0811)	(0,044)	(0,439)
13	714	0,673	0,027	-0,866
		(0,0867)	(0,0483)	(0,493)
14	630	0,626	-0,001	-1,040
		(0,0923)	(0,0512)	(0,571)
15	521	0,632	0,042	-1,050
		(0,104)	(0,0503)	(0,657)

Note: Coefficients of OLS regresions of Children, Participation and Experience on having a conception failure. Sample includes women who were not using contraception methods at 0. Standard errors in parenthesis.

Table F10: Wage Equations

Wive's Equation: Fixed effects panel data		
Estimates		**s.e.**
Experience	0.14	0.01
$Experience^2$	-0.003	0.0007
Interruptions	-0.02	0.01
Constant	5.68	0.05
Number of Observations		2805
R2		0.2086
Wive's Equation: Unobserved Heterogeneity (OLS)		
Estimates		**s.e.**
MorethanSecondary	0.27	0.04
Constant	-0.10	0.03
Number of Observations		642
R2		0.08
Husband's Equation		
Estimates		**s.e.**
Experience	0.04	0.005
$Experience^2$	-0.0009	0.0002
MorethanSecondary	0.41	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, estimated using 1995 US NSFG. This is an OLS estimation. This difference is because in the 1995 NSFG there is retrospective information for wives but not for husbands.

Table F11: Estimation of the parameters

Utility function		
Estimates		**s.e.**
Leisure (type 1)	0.14	0.01
Leisure (type 2)	0.09	0.01
$Leisure^2$	-0.0003	9e-5
Children (type 1)	2.15	0.11
Children (type 2)	1.03	0.05
$Children^2$	-0.10	0.03
Same	-7.01	0.64
Same*Leisure	0.01	0.02
Birth Control	-0.01	0.005
Sterilization	-0.62	0.05
Reproduction Function		
Estimates		**s.e.**
γ_1	0.60	0.25
γ_2	0.31	0.29
Geometric Trend	0.16	0.01
Contraception Efficiency	0.97	0.02
Probability of Type 1		
Estimates		**s.e.**
Previous Experience	-0.40	0.03
Married before 21	-0.26	0.07
Wife Education	-0.24	0.06
Husband Education	-0.25	0.05
Constant	-0.10	0.06

NOTE: Bootstrapped standard errors with 50 repetitions.

Table F12: Data vs. Model

Averages	Data	Model
Working	0.75 (0.43)	0.72 (0.38)
Use of birth control	0.51 (0.5)	0.45 (0.49)
Sterilized	0.25 (0.38)	0.24 (0.38)
Children	1.37 (1.13)	1.44 (0.98)
Experience	5.17 (4.8)	5.96 (4.62)
Failures	0.16 (0.3)	0.17 (0.38)
Interruptions	2.12 (3.48)	1.21 (1.82)

NOTE: Simulations are performed using as starting values the earliest observation for each women in the sample.

Table F13: **Female work proportions by number of children Data vs. Model**

Number of children	Data	Model
0	0.83	0.81
1	0.72	0.70
2	0.70	0.66
3	0.65	0.60
4	0.53	0.55

Table F14: Effect of fertility on female work by parity, education, preferences for leisure and children and horizon

Horizon	Age	Experience	Low Educated		High Educated	
			High Preferences	Low Preferences	High Preferences	Low Preferences
First born child						
Short Run	21	0	-0,158	-0,055	-0,045	-0,017
	25	0	-0,196	-0,073	-0,075	-0,026
	25	4	-0,125	-0,051	-0,041	-0,016
	30	0	-0,217	-0,091	-0,119	-0,037
	30	9	-0,109	-0,055	-0,045	-0,021
	35	0	-0,194	-0,112	-0,171	-0,057
	35	14	-0,124	-0,084	-0,072	-0,041
Long Run	21	0	-0,089	-0,037	-0,026	-0,015
	25	0	-0,131	-0,057	-0,039	-0,021
	25	4	-0,072	-0,047	-0,027	-0,021
	30	0	-0,165	-0,073	-0,073	-0,030
	30	9	-0,077	-0,054	-0,041	-0,028
Second born child						
Short Run	21	0	-0,128	-0,048	-0,045	-0,015
	25	0	-0,127	-0,058	-0,064	-0,022
	25	4	-0,093	-0,042	-0,032	-0,012
	30	0	-0,097	-0,067	-0,093	-0,033
	30	9	-0,078	-0,046	-0,036	-0,016
	35	0	-0,069	-0,050	-0,097	-0,029
	35	14	-0,065	-0,034	-0,046	-0,019
Long Run	21	0	-0,060	-0,019	-0,016	-0,007
	25	0	-0,071	-0,014	-0,024	-0,006
	25	4	-0,041	-0,008	-0,018	-0,004
	30	0	-0,052	-0,008	-0,035	-0,003
	30	9	-0,023	-0,001	-0,011	0,000
Third born child						
Short Run	25	0	-0,022	-0,013	-0,011	-0,005
	25	4	-0,015	-0,010	-0,006	-0,004
	30	0	-0,017	-0,016	-0,017	-0,008
	30	9	-0,014	-0,013	-0,006	-0,003
	35	0	-0,013	-0,013	-0,017	-0,005
	35	14	-0,012	-0,009	-0,010	-0,006
Long Run	25	0	-0,039	-0,013	-0,016	-0,003
	25	4	-0,024	-0,008	-0,013	-0,003
	30	0	-0,041	-0,023	-0,029	-0,010
	30	9	-0,029	-0,011	-0,017	-0,006

NOTE: Data are composed by the counterfactual analysis for the first born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old. Short run averages over the 5-year period soon after birth. Long run averages over the following years after short run period.

Table F15: Effect of fertility on (potential) wages by parity, education, preferences for leisure and children and horizon

Horizon	Age	Experience	Low Educated		High Educated	
			High Preferences	Low Preferences	High Preferences	Low Preferences
First born child						
Short Run	21	0	-0,041	-0,016	-0,010	-0,004
	25	0	-0,053	-0,025	-0,024	-0,003
	25	4	-0,033	-0,012	-0,008	-0,002
	30	0	-0,059	-0,022	-0,036	-0,014
	30	9	-0,018	-0,006	-0,007	-0,003
	35	0	-0,047	-0,024	-0,027	-0,009
	35	14	-0,002	-0,003	-0,001	-0,001
Long Run	21	0	-0,112	-0,032	-0,025	-0,009
	25	0	-0,159	-0,052	-0,049	-0,006
	25	4	-0,072	-0,022	-0,016	-0,006
	30	0	-0,130	-0,042	-0,076	-0,023
	30	9	-0,028	-0,009	-0,009	-0,004
Second born child						
Short Run	21	0	-0,031	-0,016	-0,016	-0,005
	25	0	-0,027	-0,004	-0,005	-0,008
	25	4	-0,003	-0,008	-0,009	-0,003
	30	0	-0,020	-0,017	-0,022	-0,005
	30	9	-0,009	-0,007	-0,005	-0,001
	35	0	-0,018	-0,022	-0,036	-0,009
	35	14	-0,006	-0,003	-0,002	-0,001
Long Run	21	0	-0,089	-0,034	-0,031	-0,005
	25	0	-0,078	-0,016	-0,021	-0,017
	25	4	-0,015	-0,014	-0,014	-0,004
	30	0	-0,067	-0,039	-0,049	-0,016
	30	9	-0,018	-0,013	-0,005	-0,002
Third born child						
Short Run	25	0	-0,005	-0,001	-0,004	-0,001
	25	4	-0,002	0,000	-0,001	-0,001
	30	0	-0,002	-0,003	-0,004	-0,002
	30	9	-0,001	-0,001	-0,001	0,000
	35	0	-0,001	-0,002	-0,004	-0,002
	35	14	0,000	0,000	0,000	0,000
Long Run	25	0	-0,028	-0,016	-0,012	-0,004
	25	4	-0,002	-0,004	-0,007	-0,005
	30	0	-0,010	-0,019	-0,011	-0,012
	30	9	-0,004	-0,005	-0,001	-0,002

NOTE: Data are composed by the counterfactual analysis for the first born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old. Short run averages over the 5-year period soon after birth. Long run averages over the following years after short run period.

Table F16: OLS estimates of treatment effects on female work by birth order

Variable	First	Second	Third
Time	0,0044	0,0083	-0,0035
	(0,001)	(0,001)	(0,001)
$Time^2$	-0,0002	0,0004	0,0002
	(0,000)	(0,000)	(0,000)
Age-21	-0,0053	-0,0005	0,0000
	(0,000)	(0,000)	(0,000)
Experience	0,0072	0,0038	0,0015
	(0,001)	(0,001)	(0,000)
$Experience^2$	-0,0002	-0,0002	-0,0001
	(0,000)	(0,000)	(0,000)
Low Ed - Low Pref	0,0670	0,0426	0,0116
	(0,004)	(0,003)	(0,002)
High Ed - High Pref	0,0719	0,0339	0,0097
	(0,004)	(0,003)	(0,002)
High Ed - Low Pref	0,1027	0,0593	0,0192
	(0,004)	(0,003)	(0,002)
Constant	-0,1271	-0,1047	-0,0191
	(0,005)	(0,004)	(0,002)

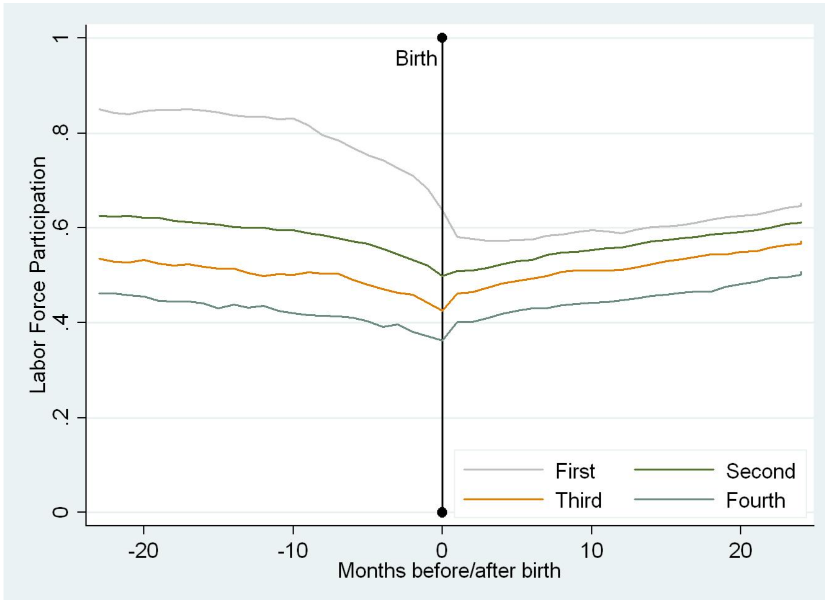
Note: OLS regresion of the treatment effect on time after birth and its square, age at birth (base category is 21 years old and it is normalized to zero), experience and its square, and interactions of education (high and low) with preferences for children and leisure (high and low, the base category is low education with high preferences).

Table F17: Counterfactual Experiments

Variable	Data	Model	Perfect Control of Fertility	Costly Contraception
Working	0.75	0.72	0.70	0.72
Use Birth Control	0.51	0.46	0.49	0.27
Sterilization	0.20	0.19	0.17	0.02
Children	1.43	1.63	1.85	2.07
Experience	5.72	5.74	5.65	5.80
Failures ≤ 31	0.15	0.15	0.00	0.17
Faillures > 30	0.01	0.02	0.00	0.03
Welfare	—	42.52	43.30	40.51

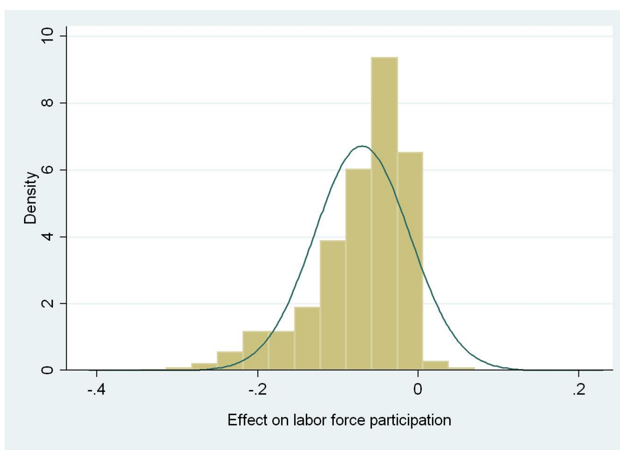
G Figures

Figure G1: Labor Force Participation of Married Women in US by age and stock of children before and after birth, 1970-1995



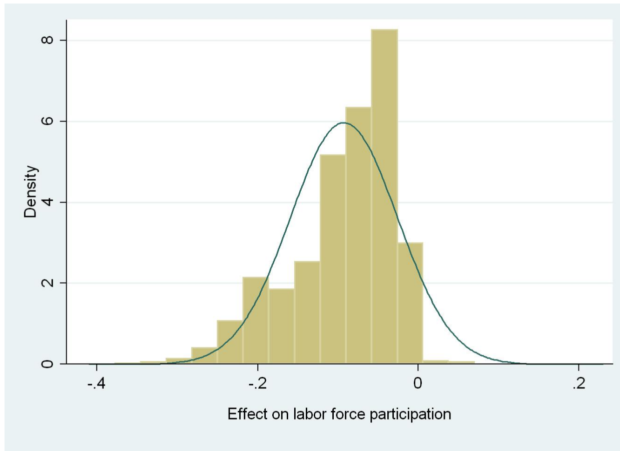
Note: Retrospective information on participation using 1995 US NSFG.

Figure G2: Distribution of the effect of the first born child on female labor supply



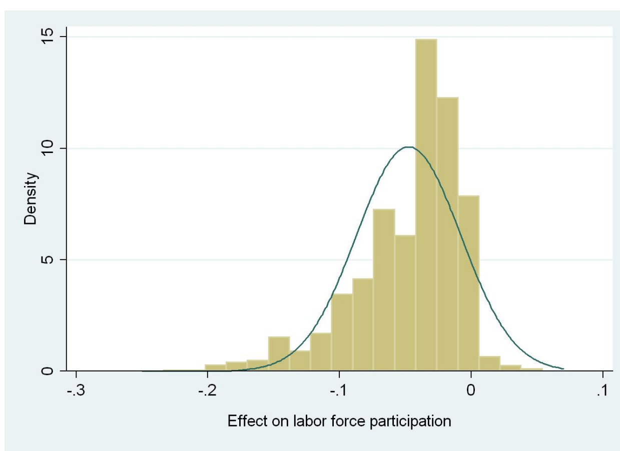
Note: Data are composed by the counterfactual analysis for the first born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G3: Distribution of the effect of the first born child on female labor supply for women with high preferences for leisure and children



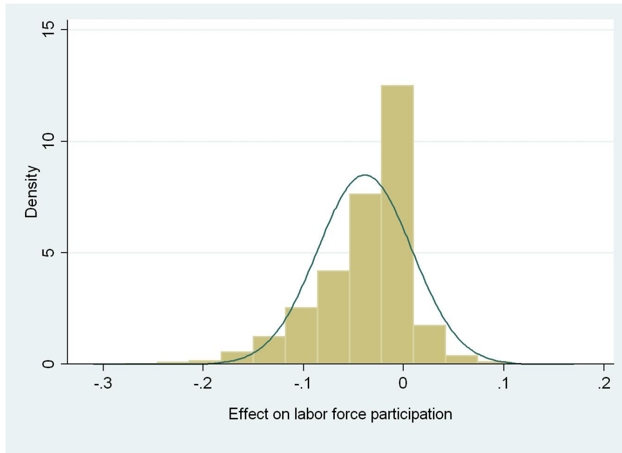
Note: Data are composed by the counterfactual analysis for the first born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G4: Distribution of the effect of the first born child on female labor supply for women with low preferences for leisure and children



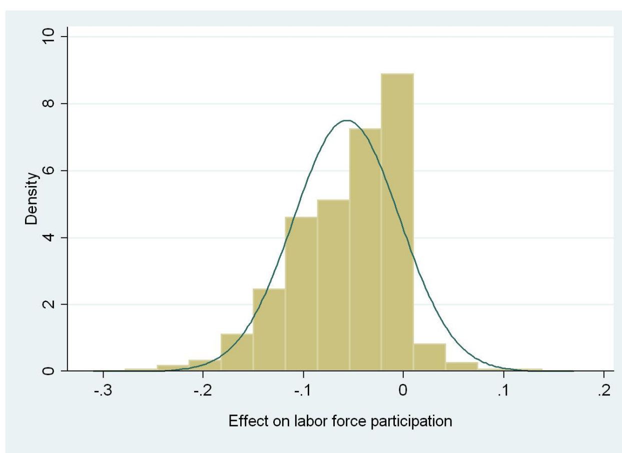
Note: Data are composed by the counterfactual analysis for the first born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G5: Distribution of the effect of the second born child on female labor supply



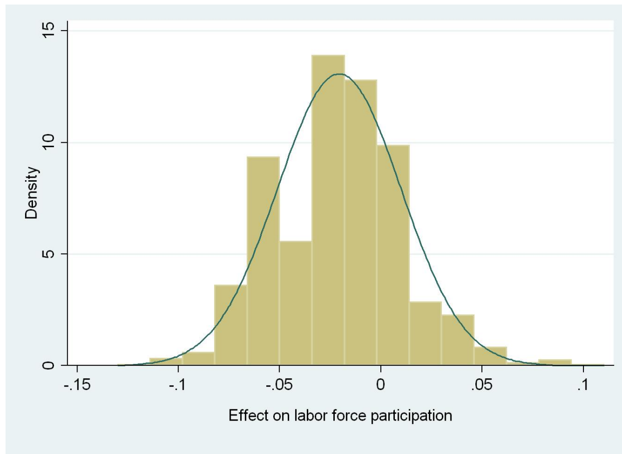
Note: Data are composed by the counterfactual analysis for the second born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G6: Distribution of the effect of the second born child on female labor supply for women with high preferences for leisure and children



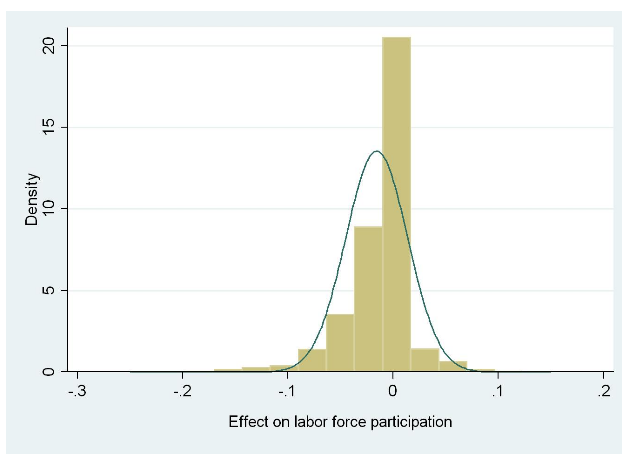
Note: Data are composed by the counterfactual analysis for the second born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G7: Distribution of the effect of the second born child on female labor supply for women with low preferences for leisure and children



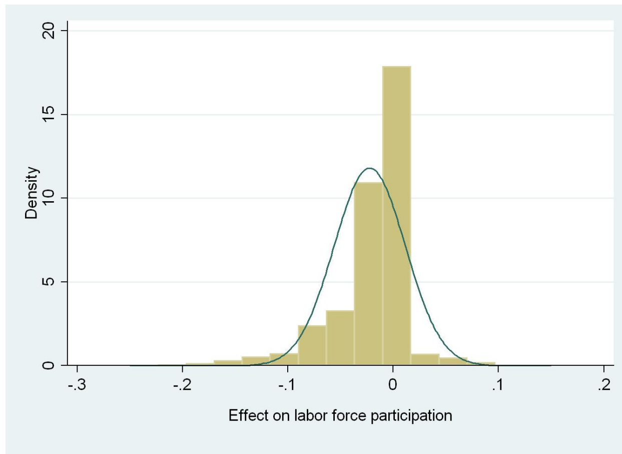
Note: Data are composed by the counterfactual analysis for the second born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G8: Distribution of the effect of the third born child on female labor supply



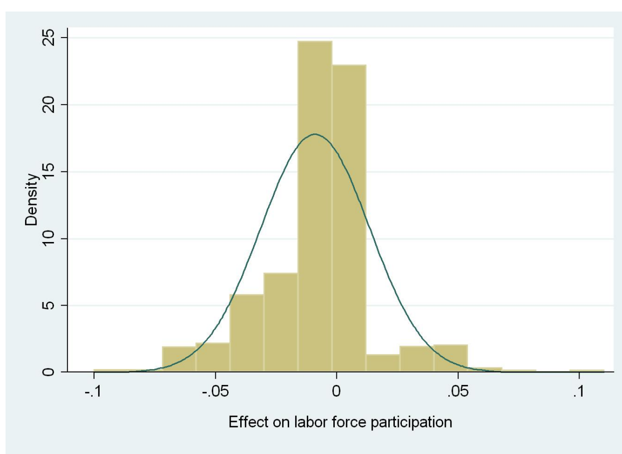
Note: Data are composed by the counterfactual analysis for the third born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 21, 25, 30 and 35 years old.

Figure G9: Distribution of the effect of the third born child on female labor supply with high preferences for leisure and children



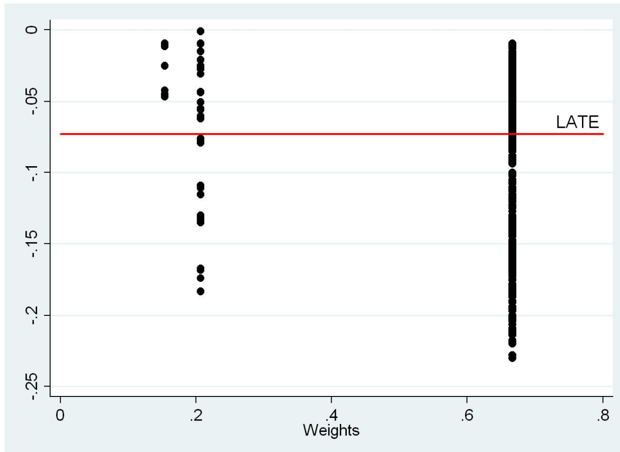
NOTE: Data are composed by the counterfactual analysis for the third born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 25, 30 and 35 years old.

Figure G10: Distribution of the effect of the third born child on female labor supply with low preferences for leisure and children



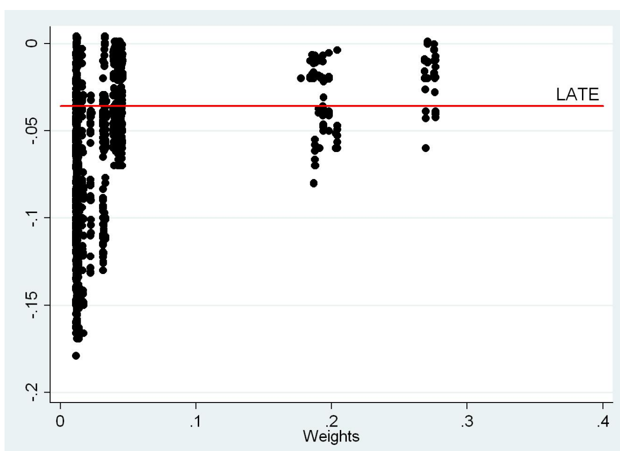
NOTE: Data are composed by the counterfactual analysis for the third born child; for each type of women based on initial conditions: previous experience, age at marriage, wife and husband schooling; for each type of preferences for children and leisure: high and low; for births at 25, 30 and 35 years old.

Figure G11: Local Average Treatment Effect (LATE) of the first born child on female labor supply using conception failures as IV



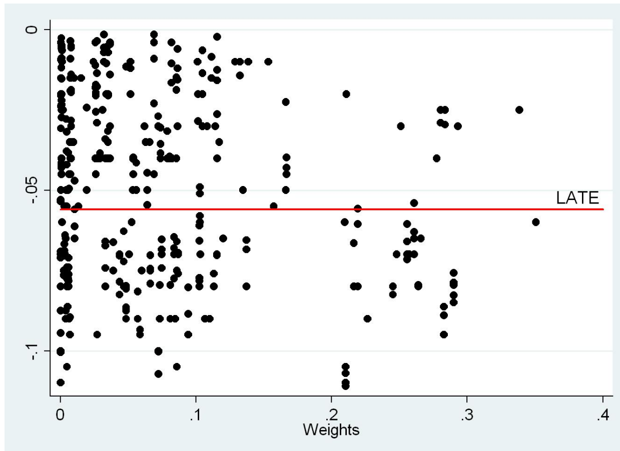
Note: Points are treatment effects associated to a weight related to their importance in the estimation of the LATE (i.e. the importance of their compliance).

Figure G12: Local Average Treatment Effect (LATE) of the second born child on female labor supply using twins as IV



Note: Points are treatment effects associated to a weight related to their importance in the estimation of the LATE (i.e. the importance of their compliance).

Figure G13: Local Average Treatment Effect (LATE) of the third born child on female labor supply using same-sex as IV



NOTE: Points are treatment effects associated to a weight related to their importance in the estimation of the LATE (i.e. the importance of their compliance).

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