A dynamic model of contraceptive choice of Spanish couples

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Abstract

In this paper we propose a simple dynamic stochastic model of sterilization and contraceptive use and we estimate its structural parameters using a sample of married couples from the 1995 Spanish Family and Fertility Survey. The estimated structural model improves on previous studies in terms of its ability to rationalize observed behavior. The large proportion of women contracepting at parity 0 is interpreted as evidence of 'precautionary' contraceptive behavior. Allowing for simple forms of permanent unobserved heterogeneity across couples in their ability to conceive has important implications for estimates of utility and cost parameters. Our estimates of child valuation parameters imply that most Spanish couples would have two children, but significant deviations from this goal are brought about by imperfect and costly fertility control. Our simulations suggest that the introduction of sterilization has reduced fertility by an average of 0.2 children per couple, and that the availability of more effective reversible contraceptive methods would reduce expected fertility by up to 0.4 children per couple.

JEL classification: C35, C61, J13.
Keywords: structural dynamic model, discrete choice, fertility.

1 Introduction

The analysis of fertility within the framework of modern economic theory goes back to Becker (1960, 1991). Since then, the literature known as the 'New Family Economics' has developed considerably. During the last 15 years researchers have developed new methods for the estimation of structural dynamic models of discrete choice.[1] These models are an atractive framework for the analysis of fertility decisions since they can explicitely accomodate several important features which were neglected in earlier static models, such as: 1) The dynamic dimension of fertility choices which are made in a life-cycle context. 2) The stochastic nature of human reproduction, whereby parents make contraceptive choices and respond to the (irreversible) realizations of the birth process. Furthermore, structural methods allow us to obtain estimates of parameters which can be interpreted directly in the context of the maintained behavioral model. The large computational burden of empirical work has constrained the number of applications in economic demography. Wolpin (1984), Montgomery (1988), Hotz and Miller (1993) and Ahn (1995) are a few examples. In this paper we propose a simple model of sterilization and contraceptive use over the life-cycle and we estimate its structural parameters using data from the 1995 Spanish Family and Fertility Survey. During the last two decades there was a large and rapid decline in fertility rates in Spain. In 1975 the Total Fertility Rate was still 2.4 but by 1994 it was only 1.2, the lowest in the world.[2] During this period there was an increase in the availability of contraceptive methods and sterilization became legal in 1983. We are not suggesting that these changes were the

[1] See Eckstein and Wolpin (1989) and Rust (1994) for surveys of this field.

[2] The Total Fertility Rate is the average number of children per woman in a synthetic cohort obtained from cross sectional age-specific fertility rates. In a stationary environment 2.1 is the replacement level.

main cause of the rapid fertility decline but we believe the analysis of the contraceptive behavior and the consequences of imperfect fertility control is of interest. Our main goal is to investigate whether the main features of the data can be rationalized in a dynamic stochastic optimization framework.

Dynamic models of contraceptive behavior were first studied in Heckman and Willis (1975) and Newman (1988). To our knowledge Montgomery's (1988) and Hotz and Miller's (1993) are the only earlier attempts to implement structural econometric versions, and our work shares several features with each of them. Children are modelled as an irreversible durable good, and the 'stock' of children is a controlled discrete-state stochastic process with transition probabilities determined by contraceptive choices. Montgomery used a sample of American households from the CASH dataset to estimate a model in which women choose between 4 different contraceptive options, including no use of contraceptives, and have preferences defined in terms of a 'target' number of children. His model fit the data reasonably well. However, it overpredicted the use of contraceptives in the early stages of the life-cycle and its treatment of sterilization -an important aspect of US data- was not very successful. Our model is very similar to Hotz and Miller's. However, unlike ours their NFS survey of U.S. households included income information. This allowed them to identify a richer structure but many of their parameter estimates were highly implausible and all 3 of their specifications were strongly rejected by the data. Hotz and Miller's study illustrated the use of the Conditional Choice Probability (CCP) estimator, an innovative method which does not require repeated solutions of the dynamic programming problem and thus significantly reduces the computational burden of estimation. Unfortunately, the CCP estimator is hard to implement in models with permanent sources of unobserved heterogeneity. In our empirical work allowing for permanent unobserved heterogeneity in fecundability across couples has turned out to be important. The estimated structural model fits the Spanish FFS data quite well and offers a more plausible rationalization of observed behavior. The use of contraceptives produces disutility but 'precautionary' behavior can help explain the large fraction of couples using them at parity 0. We perform counterfactual exercises which simulate the effect of sterilization and of improvements in reversible contraceptive methods.

The paper is organized as follows: in Section 2 we present the model of sterilization and contraceptive use of married couples and in Section 3 its econometric implementation. In Section 4 we describe and summarize the data. In Section 5 we present structural parameter estimates, we analyze how the estimated model rationalizes the data and we show the results of counterfactual exercises. Section 6 summarizes and concludes.

2 A model of contraceptive choice

We analyze a couple's decisions regarding the use of contraceptives and sterilization within the framework of a dynamic stochastic discrete choice model as in Hotz and Miller (1993). We assume that couples face no uncertainty about the maximum potential duration of their fertile life (T) and that they ignore the risks of their own and their children's mortality.[3] The timing of marriage is exogenous; couples who marry at different ages are identical except for the length of the decision horizon. We abstract from divorce, separation and adoption decisions and from fertility outside marriage.[4]

Every period from the time of marriage ($t = 1$) to the stopping period

[3] Given low mortality rates in Spain from birth to age 44, this seems a reasonable assumption.

[4] Divorce and separation rates and fertility rates outside marriage are still very low in Spain.

($t = \tau$) the couple chooses one of three mutually exclusive actions: not to contracept ($j = 1$), to use temporary contraceptive methods ($j = 2$), or to sterilize ($j = 3$). Define $d_{tj} = 1$ if action j is chosen in period t, and 0 otherwise. Then, $\sum_{j=1}^{3} d_{tj} = 1$. Let b_t denote an indicator variable for a period t birth, and S_t the state vector which contains all variables known to the couple at t which have an impact on their current and future choices. For instance, the state vector may include current parity and the recent history of contraceptive choices. Let $F_j\left(b_{t+1} = 1 \mid S_t\right)$ or F_{jt} denote the probability that a birth will occur at $t + 1$ conditional on the state and on the choice of action j in period t. We assume that $0 < F_{jt} < 1$ for $j = 1, 2$, i.e., fertility control is imperfect if either of the first two actions are chosen. If $d_{t3} = 1$ then $F_{3t} = 0$ and t is the stopping period. That is, sterilization is irreversible. Couples know the probabilities F_{jt} and they become infecund after the stopping period. For couples who never sterilize, the stopping period is T, the moment when menopause occurs.[5]

Period t contraceptive plans are chosen to maximize the intertemporal utility function

$$E_t\left(\sum_{s=t}^{\tau} \beta^{s-t} \sum_{j=1}^{3} d_{sj} u_{sj}(S_s)\right) + \beta^{\tau+1-t} E_t(W(\tau, S_{\tau+1})) \tag{1}$$

subject to the laws of motion of the state and, in particular, to birth control 'technology' $\{F_{jt}\}$. In (1) β is the discount factor, $W()$ is the terminal value function, E_t is the expectation operator conditional on the state and $u_{tj}()$ is the period-by-period utility function which aggregates utility flows from the stock of children and the cost or disutility of the current contraceptive action. Thus children in the model are an irreversible durable good. The stock of this durable is controlled through contraceptive choices but control is costly

[5] We take age 44 as the end of a woman's fertile life.

and imperfect. The detailed specification of $u()$ and $W()$ is found in section 4, and a discussion of its behavioral implications is deferred to Section 5.

3 Econometric implementation

Likelihood: Following Rust (1988), we assume the state vector can be partitioned as follows: $S_t = (X_t, \varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t})$, where ε_{jt} is a random variable which determines the utility of action j in period t. It is known to the couple at t but it is not observed by the econometrician, whereas X_t is observed by the econometrician. The ε_{tj}'s satisfy the Conditional Independence assumption, i.e., they are independent across choices, couples and periods with distribution $G()$. The utility function is additively separable in observables and unobservables:

$$u_{tj} = \widetilde{u}_{tj}(X_t) + \varepsilon_{tj}$$

Let $d^*_{tj}(S_t)$ denote the choice indicators when optimal actions are chosen and τ^* the optimal stopping period. Then $d^*_{tk}(S_t) = 1$ if and only if

$$k = \text{argmax}_{j \in \{1,2,3\}} \left[v_{tj}(X_t) + \varepsilon_{tj} \right] \tag{2}$$

and

$$P_{kt}(X_t) = \int I \left(k = \arg\max_j \left[v_{tj}(X_t) + \varepsilon_{tj} \right] \right) dG(\varepsilon_{tj}) \tag{3}$$

where $P_k(X_t)$ is the probability of choosing action k at t conditional on X_t and $v_{jt}(X_t)$ is a valuation function giving the expected flow of current and future utilities conditional on the choice of j at t and on optimal choices in the future. The valuation function satisfies the following Bellman equation:

$$v_{jt}(X_t) = \widetilde{u}_{tj}(X_t) + \beta E \left[\max_k \left\{ v_{t+1k}(X_{t+1}) + \varepsilon_{t+1,k} \right\} \mid X_t, d_{tj} = 1 \right] \tag{4}$$

for $j = 1, 2$ and $t \leq T - 1$, and $v_{jt}(X_t) = \widetilde{u}_{tj}(X_t) + \beta E \left[W(t+1, X_{t+1}) \mid X_t, d_{tj} = 1 \right]$ if $j = 3$ or $t = T$. Note that the Conditional Independence assumption implies that in order to compute valuation functions and the conditional choice probabilities it is not necessary to perform multiple integration over lagged values of the unobservables. In our specification below the birth outcome is the only source of uncertainty about X_{t+1} so the expectation on the right hand side of (4) is taken over conditional distributions of the birth outcome and of next period's values of the unobservables.

Suppose $u^*_{sj}()$, $W()$, $F_j()$ and $G()$ are known up to a vector of parameters θ. In order to allow for permanent unobserved heterogeneity we assume that some of the parameters in θ may vary across a finite number of 'types' in the population. Let θ_k denote the value of the parameters for type k and π_k the proportion of the population of that type. A couple's type is known to the couple but it is not observed by the econometrician. Since sterilization was not legal before 1983 we decided to drop all couple-year observations corresponding to that period. Our data consists of an unbalanced panel $\{d_{itj}, X_{it}, b_{it}\}_{i=1,\dots,n}^{t=\underline{t}_i,\dots,\bar{t}_i}$. A household's history may be right-censored ($\bar{t}_i < \tau^*_i$) if the woman was under 45 at the time of the interview, or left-censored ($\underline{t}_i > 1$) if the couple married before 1983, or both. Therefore, although the distribution of types $\{\pi_k\}$ is assumed independent of the couple's observable characteristics at the time of marriage X_{i1}, we have to consider the possibility that initial conditions $X_{\underline{t}_i}$ might be correlated with the unobservable type for couples with left-censored observations. We deal with this problem by allowing the probability that those couples are of each type to vary with initial conditions. A couple's contribution to the likelihood conditional on the unobserved type combines conditional choice probabilities and the probabilities of birth outcomes conditional on contraceptive actions:

$$\mathcal{L}_i(\theta_k) = \prod_t \prod_j \{P_j(X_{it};\theta)\ [b_{it+1}F_{jt}(\theta) + (1-b_{it+1})(1-F_{jt}(\theta))]\}^{d_{itj}}$$

The sample log-likelihood is then $L(\theta) = \sum_i \ln \sum_k \mathcal{L}_i(\theta_k) \Pr(k \mid X_{\underline{t}_i})$. In order to evaluate the likelihood we need the valuation functions v_{jt}. A full solution of the model is required to compute v_{jt} for $j = 1, 2$. Solving the model by backward induction for each θ is straightforward but computationally expensive. Under the asumption that the unobserved state variables ε_{tj} are drawn from an extreme value distribution, the conditional choice probabilities and the recursions in (3) and (4) have convenient (logistic) closed forms.[6]

Specification: The per-period utility function is

$$\begin{aligned} u_{itj}() \;=\; & \eta_1 I_{1t} + \eta_2 N_t + \eta_3 N_t^2 + \\ & + (\gamma_1 E_1 + \alpha_1 E_2) I_{1t} + (\gamma_2 E_1 + \alpha_2 E_2) I_{2t} + (\gamma_3 E_1 + \alpha_3 E_2) \sum_{i>2} I_{it} + \\ & + \mu_0 d_{t-1,1} d_{t2} + \mu_{j1} + \mu_{j2} R + \\ & + \psi (t-35) 1(t \geq 36) b_t + (\theta_1 dur_{t1} + \theta_2 dur_{t2} + \theta_3 dur_{t3}) b_t \end{aligned} \tag{5a}$$

The terms in the first two lines determine the utility of children as a function of parity, the couple's schooling and the parameters (η, γ, α). N_t is parity at the end of period t, the indicator I_{kt} is 1 if the wife has reached parity k or greater and E_1 and E_2 are the wife's and the husband's education. Our specification combines a quadratic-in-children baseline utility, parity-specific effects of the mother's and the father's education and an additional utility of leaving the state of childlessness. Thus the marginal value of the first child is $\eta_1 + \eta_2 + \eta_3 + \gamma_1 E_1 + \alpha_1 E_2$, the marginal value of the second child is $\eta_2 + 3\eta_3 + \gamma_2 E_1 + \alpha_2 E_2$ and the marginal value of the N -th child for $N > 2$ is $\eta_2 + (2N-1)\eta_3 + \gamma_3 E_1 + \alpha_3 E_2$. In the third line parameters (μ_{j1}, μ_{j2}) for $j = 1, 2, 3$ characterize the couple's preferences over contraceptive actions

[6] See Appendix for more details.

which depend on their religious beliefs. R is an indicator equal to 1 if the couple attends religious services every week. Since only utility differences are identified we use $\mu_{11} = \mu_{12} = 0$ as an identifying restriction; i.e., the disutility of taking no contraceptive action is set to zero. Note that separate identification of child valuation and contraceptive cost parameters relies on variation in the probabilities of conception.[7] The parameter μ_0 measures a cost which is incurred the first period a couple decides to contracept following a spell of no contraceptive use. This "switching cost" may also be interpreted in terms of habit formation and it will help us fit the persistence in the use of contraceptives which is a feature of the data. The terms in the last line capture birth timing and birth spacing effects. We assume that every year beyond the age of 35 the cost of giving birth increases by ψ. The indicators dur_{th} for $h = 1, 2, 3$ describe the duration of the current birth interval. Specifically, $dur_{th} = 1$ if the last birth occurred h periods ago. Positive values of the parameters $\theta_1, \theta_2, \theta_3$ reflect a couple's preference for spacing births.

We set the discount factor to 0.95 and in line with our treatment of children as an irreversible durable we assume that the terminal value function is the discounted sum of utility flows from the stock of children between the stopping period and the end of life at age 76.[8],[9]

[7] A couple's choice determines the current period's contraceptive costs with certainty, while the utility flow from children is uncertain because it depends on whether another occurs. Therefore contraceptive cost parameters μ enter utility differences directly whereas child valuation parameters are multiplied by differences in conditional birth probabilities.

[8] In preliminary estimation rounds the model was also estimated with a discount factor of 0.90 and 0.99, resulting in a smaller value of the maximized likelihood.

[9] If a couple sterilizes and the stopping period is less than age 45, we include in the terminal value function the expected discounted value of the unobservable components of contraceptive costs between the stopping period and age 45. We do this because unobservables have non-zero means and their variances may be large relative to the choice-specific valuation functions and we do not want the comparison between sterilization and the other choices to be dominated by the absence of unobservables.

The conditional birth probabilities F_{jt} are logistic functions of the couple's unobserved type, education and age as well as of the current period birth indicator b_t. That is, $F_{jt} = \exp(z_{jt}) / [1 + \exp(z_{jt})]$ with

$$
\begin{aligned}
z_{jt} = \theta_{j0} + \theta_2 1(\text{type } 2) + \theta_{j8} b_t + \\
+ \theta_{j1} 1(t \in [26, 30]) + \theta_{j2} 1(t \in [31, 35]) + \theta_{j3} 1(t \geq 36) + \\
+ \theta_{j4} 1(E_1 = 2) + \theta_{j5} 1(E_1 = 3) + \theta_{j6} 1(E_1 = 4) + \theta_{j7} 1(E_1 > 4)
\end{aligned}
$$

The number of unobserved types is fixed at two; if θ_2 is positive, type 2 is the 'more fecund' type.[10] Furthermore, based on our analysis of the raw data we set $\theta_{24} = \theta_{25} = \theta_{26} = \theta_{27} = \theta_{28} = 0$; i.e., the effects of education and lagged births on the probability of conception are negligible whenever contraceptives are used. Finally, we make the probability that a couple with left-censored history is of (unobserved) type 2 a logistic function of the couple's characteristics; if t_i^m is the wife's age when couple i married, then

$$
\Pr\left(\text{type } 2 \,|\, X_{\underline{t}_i}\right) = \frac{\exp\left\{\chi_{20} + \left[\chi_{21} * N_{\underline{t}_i} + \chi_{22} * (\underline{t}_i - t_i^m) + \chi_{23} E_{1i} + \chi_{24} E_{2i} + \chi_{25} R_i\right]\right\}}{1 + \exp\{.\}}
$$

where χ_{20} also determines the probability of drawing from each type at the time of marriage.

4 Data

Our data are drawn from the Spanish Fertility and Family Survey which was carried out by the Centro de Investigaciones Sociológicas (CIS). The survey interviewed 1992 men and 4021 women who were Spanish citizens between

[10] We explored specifications with more than two unobserved types and / or differences across types in utility parameters but the additional parameters were not significant.

the ages of 18 and 49 in 1994-95. The information obtained for each interview refers to the household's current characteristics, partnership history, current partner characteristics, pregnancies and children, contraceptive history, views on having children, values and beliefs, education and occupational history.

In order to make the empirical model more tractable we make no distinction between different reversible contraceptive methods and aggregate all of them into a single choice alternative. Panel A of Table 12 shows that at the time of the interview 84% of all couples using contraceptives were using 'safe' methods (pill, IUD and condom) so our approximation seems quite reasonable. Panel B gives sample means of birth and contraceptive use indicators by year. Notice the sharp decline in sample birth rates which dropped from 13% in 1984-5 to 8% in 1992-3. There was a slight upward trend in the choice of contraception; by 1993 more than 75% of the couples in the sample were contracepting. Note that these patterns may reflect changes in the sample distribution of ages and parities as much as an actual trend in behavior.

We screened out couples with missing information and couples facing situations which did not conform to the stylized model described in Section 2. Our sample consists of observations from 2923 couples in unbroken first marriages.[11] For each couple we included observations for every (calendar) year that the couple was married and the wife was under age 45, beginning in 1983 which is when sterilization became legal in Spain. This resulted in 21254 couple-year observations. For each observation we obtain values of the model's birth and contraceptive action indicators as follows.[12] We set the length of a period to one year.[13] The birth indicator b_t was set to

[11] Also excluded were couples who adopted a child or experienced the death of a child and those who sterilized for medical or other reasons unrelated to the choice of family size.

[12] Our criteria are similar to Hotz and Miller's.

[13] Given the information available in the survey it would be possible to construct indica-

1 if any births occured during calendar year t. If a birth occured during year $t+1$ information about the couple's behavior at the time of conception was used to assign the year t action. This information included answers to a question on the reasons why the couple stopped using contraceptive methods. Respondents were asked to be specific about contraceptive failures which resulted in conceptions and about decisions to stop contracepting in order to conceive. If $b_{t+1} = 0$ a couple was classified as 'contracepting' at t if they used any contraceptive methods for more than half the year. If a birth occured during year t we applied the same criterion to the interval beginning one month after the birth and ending in December of that year. We do the same in the year they got married. Sterilization is the year t action if any one of the spouses underwent at any time during the year.

We constructed categorical variables for the wife's and the husband's education and for the couple's religious beliefs. Definitions of these variables as well as their sample means and cross tabulations can be found in the Appendix. On average men have slightly more schooling than women in this sample, but the modal education category is 'secondary' (with less than a high school degree) for both men and women and the education of husbands and wives is highly correlated. The mean age at marriage is 23 years and it increases with the woman's education. Of the 2923 women in the sample, we have complete histories for 629 and 1285 are observed through age 36 or sterilization. Table 10 shows the distribution of final parity for these subsamples. Few births occur beyond age 36. Approximately one half of women stay at parity 2, at least a third move to parities 3 or higher and only 1-2 percent stay at parity 0. On average completed parity is lower for couples with more educated wives.

tors for shorter time intervals, but the computational burden of estimation increases with the number of periods. A year seems a reasonable compromise.

Table 3 tabulates birth outcomes conditional on the previous year's action and other covariates. The frequency of births conditional on no use of contraceptives is around 40% but it falls to 8.9% if another birth has just occurred.[14] There are significant differences across age and education categories; the birth hazard decreases monotonically with the mother's age and it is higher for more educated women. The frequency of births conditional on using contraceptives (i.e., 'failure' rates) is between 2 and 4 % on average. It also declines with age but there are no significant education effects.

Table 1 shows the couple's choices by parity and wife's age. The essential patterns of contraceptive behavior are the following. The use of contraceptives increases as couples move from parity 0 to parity 2, but it declines slightly for women in parities 3 and higher. Overall, the proportion of women choosing to contracept is very high, around 50% at parity 0 and higher than 70% at every other parity. At parity 0 the proportion using contraceptives is clearly decreasing in the mother's age, but not at higher parities. Sterilization almost never occurs at parities 0 and 1 but it is not uncommon at parities 2 and higher. The age profile of sterilization rates is hump-shaped with its peak around 30. Couples are a lot more likely to sterilize immediately after a birth: 8.5% choose to do so when their second child is born as well as 20% of those who experience a birth at higher parities (see Table 8).[15]

An important feature of the data is the persistence in the couples' choices. This is illustrated in Panel A of Table 2 which shows transition probabilities between actions within a birth interval. For instance, 81% of couples in parity 0 who choose not to contracept in any given year will choose the

[14] A lower birth hazard in the period following a birth is the consequence of post-partum amenorrhea and a shorter time to conceive.

[15] Sterilization rates are even higher when a birth follows contraceptive failure, but sample sizes are small and these differences are only marginally significant.

same action the following year, provided a birth has not occurred. The degree of persistence is larger at higher parities, reaching 96 % for couples who are contracepting in parities 2 and higher. Panel B shows, for the population of couples who attain a given parity, the proportion who are still contracepting at each duration of the subsequent birth interval. Duration 0 is the period that initiates the interval. With the exception of durations 0 to 1, the proportion keeps falling as couples switch to no contraception and/or experience a birth and move to the next parity.[16] That is, the proportion of couples contracepting is at a relative low immediately after a birth, increases sharply the following year and then declines monotonically. The decline is steeper at lower parities reflecting the smaller degree of persistence of those who are contracepting as seen in Panel A. As a result the proportion contracepting three years into the interval is only 15% at parity 0, still over a half at parity 1 and more than 80% at parity 2.

In summary, a large fraction of couples are contracepting right after marriage but the transition to no use of contraceptives and the first birth tends to be short. Most couples contracept for at least two years after the first birth and then gradually switch to no contraception and a second birth. A non-negligible number of couples choose to sterilize immediately after reaching parities 2 or higher. Almost all other couples at those parities contracept continuously; exits occur slowly and are the result of contraceptive failures and the decision by a few couples to stop contracepting.

Finally, the main difference in contraceptive behavior across education categories is that more educated women are more likely to contracept at parity 0 (see Table 9). Furthermore, educated couples are more likely to sterilize

[16] Some couples move from 'not contracepting' to 'contracepting' and thus partly offset the flow out of the pool of contracepting couples. However, this offsetting flow is very small first because the birth hazard is high and second because of the persistence in contraceptive behavior.

at parities 2 and higher and religious couples are less likely to contracept and to sterilize.

5 Results

Parameter estimates: Table 4 shows full information maximum likelihood estimates of the model's structural parameters. The (quadratic) baseline utility is concave in the number of children. Most education effects are significant. Of these the largest is the negative effect of the mother's schooling on the marginal utility of the first child. Furthermore the marginal utility of the second child increases with the father's education, while increases in both the mother's and the father's schooling reduce the marginal utility of the third and all subsequent children.

As we might expect given the low rates of sterilization, the estimates of cost parameters μ imply that the disutility of sterilization relative to the reference action (no contraception) is very large. Using contraceptives also produces disutility, although this disutility is significant only for religious couples. Two of the birth spacing parameters are significant and induce a preference for birth intervals of at least 3 years. The "switching cost" of initiating a spell of contraception and the disutility of giving birth beyond age 35 are strongly significant and have the expected signs. All contraceptive cost and birth spacing parameters are very large when compared to the point estimate of the lifetime utility from the first child which is 1.57 for a couple with modal education.

Table 7 contains estimates of conditional birth probabilities by education and age for the 90% of women who are of unobserved type 2.[17] For women

[17]Estimates of the parameters which determine type proportions for couples with left-censored histories can be found in Table 15.

under age 35 who are not using contraceptives the probability of giving birth in a year is high, ranging between 70% and 78%. A small fraction of the population is of unobserved 'type 1' which has much lower birth probabilities. A comparison with the raw data in Table 3 reveals that a model with no unobserved heterogeneity would grossly underpredict the birth probability for most women who are not using contraceptives. If birth hazards were so much lower there would be less use for precautionary contraception, and the only way the model could rationalize the high proportion of women contracepting at low parities would be by assigning a positive utility to the use of contraceptives. Thus, allowing for permanent unobserved heterogeneity had very important implications for estimates of utility parameters.[18] Furthermore, our estimates also suggest that the large education and age effects in the raw data are mostly spurious. For instance, the probability of a birth appears to decline between ages 25 and 35 because the proportion of type 1 women among those that are still 'stuck' at parity 0 and not contracepting increases with age. Table 4 still shows sharp declines in birth probabilities for women older than 35 and for those who have just given birth. Failure rates (i.e., the probability of a birth when contraceptives are used) range between 2% and 7% with a U-shaped age profile.

Fit - discussion: The model's within-sample predictions of contraceptive actions by parity and age, and the transition probabilities between actions, are in Tables 5 and 6 respectively.[19] A comparison with the corresponding sample statistics in Tables 1 and 2 reveals that the model succeeds in replicating the main patterns of behavior described in Section 2. We now discuss how the model rationalizes the main features of the data and we comment

[18]A conjecture that this would be the case can be found in Heckman and Willis (1976).

[19]A description of the computation of predicted probabilities can be found in the Appendix.

on the remaining discrepancies between model predictions and data.

Estimates of the utility function can be used to partition the distribution of couples' education in terms of the value of the marginal utility of children. Within-couple schooling levels are highly correlated, so most observations correspond to couples in which the husband's schooling is the same as the wife's or slightly higher. For almost all couples the marginal utility of the first two children is positive and the third and all subsequent children have negative value. If fertility control were perfect and costless, couples would stop at parity 2. However, for the less educated couples the marginal utility of children is monotonically decreasing whereas the second child actually has higher value than the first for the more educated couples. This pattern of marginal utilities rationalizes the observation that while the use of contraceptive methods increases between parities 0 and 2, the increase is much less marked for the more educated couples.

Given that couples value two children, why is the proportion of them using contraceptives so high at parities 0 and 1? Why does a sizable proportion move on to parity 3 and why is the proportion of women contracepting at parity 3 slightly smaller than at parity 2? At parity 0 the model's explanation is based on 'precautionary contraception'. Since fertility control is imperfect, a couple who reaches parity 1 early is at high risk of 'overshooting'; for instance, the cumulated failure rate for a woman who is continuously using contraceptives between ages 26 and 35 is 21 %. It may therefore be rational for many couples at low parities to contracept and delay births.[20] At parity 1 the precautionary motive is also present but, more importantly, for some couples the benefit of not contracepting (i.e., a second child) is small relative to the switching cost that will have to be borne once contraception

[20] The notion of precautionary contraception was introduced in Heckman and Willis (1976).

is resumed at parity 2. The reasons why many couples move to parity 3 are contraceptive failures which result in unplanned births combined with a large variance in contraceptive costs. In some decision periods, the random component of contraceptive costs can make the disutility of too many births smaller than the cost of preventing them. Finally, the small decline in the use of contraceptives at parity 3 is explained by the higher proportion of women with religious beliefs among those who attain that parity.

An implication of the precautionary motive for contraception is that at every parity the age profile of contraceptive use should be decreasing. On the other hand, there is a large disutility of late births and increasing the mother's age for fixed parity produces selected samples (by religion and education) of couples who are more likely to use contraceptives. It is the interaction of these opposing effects that enables the model to fit the sample age profiles by parity. However, note that we overpredict the use of contraceptives in parity 0 for the oldest women in the sample.

The model predicts the marked increase in sterilization rates at parities 2 and higher and their decline beyond age 35 at any given parity. The decline in the hazard of conception and the reduced number of periods at risk beyond age 35 explain the lower rates of sterilization predicted in that age group. However, we seriously overpredict sterilization rates for very young couples and we fail to match the hum-shaped age profile of sterilization rates. One reason for this may be the lack of uncertainty about future child valuations in our specification which basically eliminates the risk that couples will be unable to adjust to future changes in optimal family size. Furthermore, the model also rationalizes the observation that sterilization is a lot more likely immediately after a birth (see Table 8). When a birth occurs which makes the marginal utility of the next child negative, sterilization or contraception are needed in order to avoid another birth. If sterilization is optimal, a forward-looking couple would rather do it now rather than in the future since postponing it involves additional switching and contraceptive costs and temporary exposure to the hazard of conception.[21]

In order to assess the contribution of forward-looking behavior to the model's ability to rationalize the data we estimated a restricted version of the model with $\beta = 0$. The restricted model does not match the patterns of sterilization rates by parity, age and birth indicator. Because the precautionary motive is absent, it also fails to predict the decreasing age profile of the probability of contracepting at parity zero. Furthermore, point estimates are different and overall they seem less plausible: using contraceptives yields higher utility than not using them and the marginal value of the third child is positive for most education types.

Finally, the model matches a large part of observed persistence in contraceptive actions. Endogenous sample selection in the couple's observable and unobservable characteristics contributes to persistence in both actions at all parities. For instance, if a couple is contracepting this period it is more likely to have characteristics which make contracepting the optimal choice both this period and the next. At parities 0 and 1 preferences for spacing and precautionary contraception contribute to persistence in the use of contraceptives, whereas the positive marginal utility of the next child contributes to persistence in 'not contracepting'. At parities 2 and higher no more children are wanted which explains the very high degree of persistence in the use of contraceptives. A behavioral mechanism operating in the model that could explain persistence in 'no use of contraceptives' is the large value of the 'ad-hoc' switching cost introduced in our specification. Furthermore, only

[21] Notice that we underpredict sterilzation rates immediately after births in the 35-44 age group.

couples who did not contracept and did not have a birth are used to compute transition probabilities. Therefore, the relevant subsample is selected to include more of the less fecund 'type 1' couples and this should generate some persistence in that action. In spite of this, the model falls short in its predictions of the degree of persistence in no use of contraceptives.

Counterfactual experiments: Table 11 shows summary statistics for simulations which illustrate the importance of imperfect fertility control. The simulations are obtained from a model with the estimated parameter values. We first compute the distribution of final parity for a population of identical couples with the modal characteristics in the sample (the baseline population). We then repeat the calculations for alternative hypothetical scenarios. In the first one we assume that a new contraceptive method is introduced which has the same utility cost as the existing one but never fails; couples know that the failure rate is zero but the population is otherwise identical to the baseline case. In the baseline population the expected number of births is 2.6 and 45% of the population attains parity 3 or higher. In the zero failure rate scenario the precautionary motive which induces couples to use contraceptives at parity zero is not present. For instance, the fraction of couples using contraceptives the first period after marriage is 25% as opposed to 31% in the baseline population.[22] As a result, couples build their 'stock' of children faster but the proportion moving to parity 3 drops from 45% to only 25% and the expected number of births per married couple from 2.6 to 2.2. This experiment suggests that the estimated contraceptive failure rates of just 2-4% per year increase the average number of births per couple by 20% in spite of the fact that couples engage in precautionary contraception and

[22] We also simulated the effect of the introduction of a costless contraceptive method with the same failure rate as the current (costly) method. In this case there is a lot more precautionary contraception: the proportion of couples contracepting at marriage would reach 64%.

sterilization to offset the risk of failures. In another experiment we assume that sterilization is not available. The probability of moving to parity 3 increases by more than 10% relative to the baseline and expected final parity rises to 2.8. In spite of its high perceived costs and apparently low incidence, sterilization has a non-negligible impact on completed fertility.

Other simulations reported in Table 11 show the predicted effect on the number of births of variations in the couple's characteristics. Particularly noteworthy is the large impact of increases in the age at marriage. An increase from age 23 to ages 27 or 30 reduces the expected number of births from 2.6 to 2.3 and 1.9 respectively.

6 Conclusions

In this paper we proposed a simple dynamic stochastic model of sterilization and contraceptive use and we estimated its structural parameters using the 1995 Spanish Family and Fertility Survey. The estimated structural model improves on previous studies of US data in terms of its ability to rationalize observed behavior. Allowing for simple forms of permanent unobserved heterogeneity across couples in their ability to conceive has important implications for estimates of utility and cost parameters. The fit of the model improved when we introduced preferences for birth spacing and a 'switching cost' of intiating a spell of contraception. The large proportion of women contracepting at parity 0 is interpreted as evidence of 'precautionary' contraceptive behavior. Estimates of the utility function parameters imply that the couples in our sample value the first two children, but significant deviations from this goal are brought about by imperfect and costly fertility control. Our simulations suggest that the introduction of sterilization has reduced fertility by an average of 0.2 children per couple, and that the availability of more effective reversible contraceptive methods would reduce expected fertility by up to 0.4 children per couple.

Appendix

Expressions for emaxes and CCP's:

$>$From (4), the value function for $t < T$ and $j = 1, 2$ is:

$$
\begin{gathered}
v_{jt}(X_t) = \widetilde{u}_{tj}(X_t) + \\
+\beta F_{jt}(X_t) E_\varepsilon \left[\max_k \left\{ v_{t+1k}(X_{t+1}) + \varepsilon_{t+1,k} \right\} \mid X_t, b_{t+1} = 1, d_{tj} = 1 \right] + \\
+\beta (1 - F_{jt}(X_t)) E_\varepsilon \left[\max_k \left\{ v_{t+1k}(X_{t+1}) + \varepsilon_{t+1,k} \right\} \mid X_t, b_{t+1} = 0, d_{tj} = 1 \right]
\end{gathered}
$$

The expectations on the right hand side are taken over the conditional distributions of next periods's unobservable utility shocks. Given the assumptions that $\varepsilon_{t+1,k}$ is drawn from an extreme value distribution and conditional independence:

$$
E_\varepsilon \left[\max_k \left\{ v_{t+1k}(X_{t+1}) + \varepsilon_{t+1,k} \right\} \mid X_{t+1} \right] = \gamma + \ln \left(\sum_{k=1}^{3} v_{kt+1}(X_{t+1}) \right)
$$

where $X_{t+1} = (X_t, b_{t+1}, d_{tj} = 1)$, and γ is the Euler constant (0.577216).

If $t = T$, there is no more future uncertainty and the value function is:

$$
\begin{aligned}
v_{jT}(X_T) &= \widetilde{u}_{Tj}(X_T) + \beta F_{jT}(X_T) W\left(T+1, (X_T, b_{T+1} = 1)\right) + \\
&\quad + \beta (1 - F_{jT}(X_T)) W\left(T+1, (X_T, b_{T+1} = 0)\right)
\end{aligned}
$$

where $W(T+1, X_{T+1}) = \sum_{t=45}^{76} \beta^{t-45} \widetilde{u}_{t.}(X_{T+1})$ and $\widetilde{u}_{t.}()$ is $\widetilde{u}_{tj}()$ without any contraceptive action cost. The value functions for each t are calculated recursively from period $t = T$, backwards.

If $j = 3$, $F_{3t} = 0$ and

$$
v_{jt}(X_t) = \widetilde{u}_{tj}(X_t) + \beta E_\varepsilon \left[W(t+1, X_{t+1}) \mid X_t, b_{t+1} = 0 \right]
$$

where

$$E_{\varepsilon}\left[W\left(t+1,X_{t+1}\right) \mid X_t, b_{t+1}=0\right] =$$

$$= \sum_{h=t+1}^{T} \beta^{h-(t+1)} \left(\widetilde{u}_{h.}(X_{t+1}) + E_{\varepsilon}\left[\max_k \left\{\varepsilon_{h,k}\right\} \mid X_{t+1}\right]\right) +$$

$$+\beta^{T+1-(t+1)} W\left(T+1, X_{t+1}\right)$$

Conditional choice probabilities in 3 take the form:

$$P_{kt}(X_t) = \frac{\exp\left(v_{jt}(X_t)\right)}{\sum_{k=1}^{3} \exp\left(v_{kt}(X_t)\right)}$$

Analytical derivatives with respect to the parameters are computed in a straightforward manner from these expressions.

Sample and Variable definitions:

We select our sample among the 6013 people (1992 men and 4021women) interviewed in the Survey. We drop interviews with incomplete information about the variables we require for estimation. Out of 6013 individuals, 3549 were in unbroken first marriages and living with their spouse at the time of the interview. Our sample includes 2923 of those 3549 couples. The rest were excluded for any of the reasons listed here and in the Data section. Each interview contains information about both members of the couple, the interviewed person and his or her spouse. For each couple we construct the following variables:

- Wife's and husband's education are categorical variables that take values between 0 and 6. Each category has its conterpart in the International Standard Classification of Education. The categories are:

  0.- No Schooling or less than Primary

  1.- Primary School, starting around the age of 6 and lasting for five years

2.- Secondary School, lasting for about three years after Primary

3.- High School or Professional education, lasting for about three years

4.- 3 years in College

5.- 4 or 5 years in College

6.- Graduate studies

- The binary variable R describing a couple's religious beliefs is set to 1 if both members of the couple attend religious services at least once a week. We refer to these couples as 'religious'.

For each couple we construct observations for every calendar year using retrospective information. Each couple-year observation or period has the following variables:

- Contraceptive action indicators, d_{jt}, $j = 1, 2, 3$. The values of these variables are obteined as described in the Data section. If a birth occured during the last two months of a calendar year that year is not considered a decision period since the action that originated the birth is assigned to the previous year and there is no time left in the (birth) calendar year.for any relevant contraceptives choices. Therefore, we account for the birth but we drop that couple-year observation.

- Current birth indicator: $b_t = 1$ if a birth occured during calendar year t.

- Next period birth indicator: $b_{t+1} = 1$ if a birth occured during calendar year $t + 1$. The probability of this birth is determined by the contraceptive choice made in period t (d_{jt}, $j = 1, 2, 3$). We exclude the last observation of all couples with right censored histories because for that year we observe the contraceptive choice they made but we do not observe b_{t+1}.

- The number of children N_t is the stock of children at the begining of decision period t. Therefore, it includes any birth occured at period t.

- Previous contraceptive action indicator: If marriage or a birth occurred during period t, the period t 'previous contraceptive action indicator' is set to 1, i.e. not contracepting. Otherwise, it is equal to d_{jt-1}. For couples whose histories are left censored in 1983, we drop the 1983 observation since the 'previous contraceptive action' indicator would correspond to1982 which is censored. We have 1469 couples with left-censored histories, with an average left censoring of 6.5 periods per couple.

- Periods from the last birth.

- Wife's age in years.

The histories of couples who have twins are right-censored at the period they have twins because that outcome is not considered in our model .

Computation of predicted probabilities

Predicted conditional choice probabilities for each couple-year observation are computed as the weighted average of conditional choice probabilities for each unobserved type, with weights given by the 'ex-post' probability that the couple is of each type conditional on the couple's full history. That is:

$$
\begin{aligned}
P_{itj} &= \sum_{k=1}^{2} P_{itjk} \Pr(k \mid X_i, X_{\underline{t}_i}) \\
\Pr(k \mid X_i, X_{\underline{t}_i}) &= \frac{\Pr(k, X_i \mid X_{\underline{t}_i})}{\Pr(X_i \mid X_{\underline{t}_i})}
\end{aligned}
$$

$$\Pr(k, X_i \mid X_{\underline{t}_i}) = \Pr(X_i \mid k, X_{\underline{t}_i}) \Pr(k \mid X_{\underline{t}_i}) =$$

$$= \left(\prod_{t=\underline{t}_i}^{\bar{t}_i} \sum_j d_{itj} P_{itjk} \left[b_{it+1} F_{ijtk} + (1 - b_{it+1})(1 - F_{ijtk}) \right] \right) \Pr(k \mid X_{\underline{t}_i})$$

$$\Pr(X_i \mid X_{\underline{t}_i}) = \sum_{k=1}^{2} \Pr(X_i \mid k, X_{\underline{t}_i}) \Pr(k \mid X_{\underline{t}_i})$$

where P_{itjk} is the probability that couple i chooses action j at period t if it is of unobserved type k, conditional on the state variables observed at t; F_{ijtk} is the probability that couple i experiences a birth at $t+1$ if it is of unobserved type k, conditional on the state and on the choice of action j at period t; $X_i = \{X_t\}_{t=\underline{t}_i,\ldots,\bar{t}_i}$ is the history of the couple's choices and parity transitions; P_{itjk}, F_{ijtk} and $\Pr(k \mid X_{\underline{t}_i})$ are obtained from the model given parameter estimates.

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Table 1: Sample contraceptive actions by age and parity

Parity	Age group	No contraception	Contracept	Sterilize
0	15-24	45.2	54.8	0
	25-29	47.7	52.3	0
	30-34	56.5	43.3	0.2
	35-39	71.7	27.6	0.7
	40-44*	75.0	25.0	0
1	15-24	29.5	70.5	0
	25-29	28.4	71.5	0.1
	30-34	30.2	69.4	0.4
	35-39	27.3	72.3	0.4
	40-44	25.5	74.2	0.3
2	15-24	21.6	76.8	1.6
	25-29	15.5	81.3	3.2
	30-34	13.2	83.0	3.8
	35-39	12.1	85.8	2.1
	40-44	15.3	83.5	1.2
3+	15-24*	28.3	69.8	1.9
	25-29	23.8	67.7	8.5
	30-34	16.3	75.5	8.2
	35-39	17.0	78.1	4.9
	40-44	20.1	78.2	1.7

* Cell with less than 100 observations

Table 2: Sample transitions between actions

A. Sample choices, transition matrices

Parity zero at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.8056	0.1905	0.0040
2	0.3328	0.6672	0

Parity one at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.9242	0.0720	0.0038
2	0.1604	0.8365	0.0031

Parity two at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.9128	0.0780	0.0092
2	0.0192	0.9573	0.0236

Parity three or more at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.9167	0.0500	0.0333
2	0.0204	0.9593	0.0204

Note: These sample statistics are calculated for couples whose education level is less than High School (both husband and wife); the couple has R=0 (not religious) and married when the wife was between 20 and 24 years old. Periods with $b_t = 1$ are excluded.

B. Sample proportion of couples still contracepting, by duration of birth interval

Parity	Periods 0	1	2	3	4	5	6	7	8
0	51.0	41.7	26.1	15.4	9.6	6.8	4.9	4.3	4.1
1	59.1	78.1	66.7	65.7	51.9	40.8	31.6	26.4	24.2
2	56.5	83.7	84.8	82.3	80.1	75.7	74.8	74.3	70.6

Table 3: Sample birth frequencies by wife's age and education (in %)

A. Conditional on no contraception

Age group	No Birth at $t-1$	Birth at $t-1$	Education	
≤ 25	60.42	10.79	Primary or less	28.94
26-30	56.30	9.24	Secondary	39.44
31-35	36.52	5.26	High School	43.64
36-44	6.92	2.78	College (3-yr.)	43.47
			College (5+ yr.)	44.62
All	43.75	8.90	All	38.02

B. Conditional on contraception

Age group		Education	
≤ 25	5.39	Primary or less	2.63
26-30	2.86	Secondary	2.41
31-35	2.08	High School	3.19
36-44	0.71	3-year College (3 yr.)	1.62
		College (5+ yr.)	4.51
All	2.61	All	2.61

Table 4: Estimates of structural parameters

Log-likelihood=-14960

Parameter and variables		Estimate	Standard error	z-ratio
Conditional birth probabilities				
Not contracepting				
θ_{10}		-2.1442	0.09927	-21.60
θ_{11}	$Age \in [26, 30]$	-0.0234	0.06157	-0.38
θ_{12}	$Age \in [31, 35]$	-0.1750	0.07045	-2.48
θ_{13}	$Age \in [36, 44]$	-2.7897	0.08655	-32.23
θ_{14}	Secondary Education	-0.0953	0.05082	-1.88
θ_{15}	High School	0.0327	0.07761	0.42
θ_{16}	3 years college	-0.0772	0.10357	-0.75
θ_{17}	5+ years college	-0.2797	0.10810	-2.59
θ_{18}	birth at t	-2.8603	0.10728	-26.66
Contracepting				
θ_{20}		-6.4360	0.11384	-56.54
θ_{21}	$Age \in [26, 30]$	-0.6588	0.11246	-5.86
θ_{22}	$Age \in [31, 35]$	-0.8469	0.12583	-6.73
θ_{23}	$Age \in [36, 44]$	0.3536	0.08868	3.99
θ_2	Unobserved type 2	3.4381	0.09268	37.10
Per-period utility function				
μ_0	$d_{t-1,1}d_{t2}$ switching cost	-2.1906	0.04358	-50.26
μ_{21}	Contraceptive cost	-0.0130	0.02158	-0.60
μ_{22}	$R = 1$ religious couple	-0.3759	0.05169	-7.27
μ_{31}	Sterilization cost	-26.5460	0.39702	-66.86
μ_{32}	$R = 1$ religious couple	-4.2213	0.54079	-7.81
η_1	$N_t \geq 1$ at least 1 child	0.0608	0.04482	1.36
η_2	N_t stock of children	0.1684	0.02133	7.90
η_3	N_t^2	-0.0342	0.00358	-9.57
Effect of wife's education on				
γ_1	Value of 1st child	-0.0530	0.01227	-4.32
γ_2	Value of 2nd child	0.0035	0.00686	0.51
γ_3	V. of 3d and successive	-0.0120	0.00464	-2.60
Effect of husband's education on				
α_1	Value of 1st child	-0.0023	0.01239	-0.18
α_2	Value of 2nd child	0.0243	0.00686	3.55
α_3	V. of 3d and successive	–0.0150	0.00454	-3.31
Birth spacing effects				
θ_1	one period	-7.5244	0.90789	-8.29
θ_2	two periods	-2.2963	0.14290	-16.07
θ_3	three periods	-0.1932	0.13483	-1.43
Birth timing effects				
ψ	birth cost beyond age 35	-5.7446	0.26085	-22.02

Table 5: Predicted contraceptive actions by age and parity

Parity	Age group	No contraception	Contracept	Sterilize
	15-24	52.4	47.4	0.2
	25-29	45.1	54.6	0.3
0	30-34	50.5	49.1	0.4
	35-39	49.2	50.3	0.5
	40-44*	57.6	42.4	0
	15-24	27.3	72.0	0.7
	25-29	27.1	72.5	0.4
1	30-34	33.3	66.3	0.4
	35-39	20.2	79.4	0.4
	40-44	21.6	78.4	0.0
	15-24	18.6	74.8	6.6
	25-29	14.8	81.1	4.1
2	30-34	14.0	82.7	3.3
	35-39	12.0	86.5	1.5
	40-44	12.9	87.1	0.0
	15-24*	20.2	67.5	12.3
	25-29	16.4	74.6	9.0
3+	30-34	14.5	77.8	7.7
	35-39	18.1	78.9	3.0
	40-44	18.2	81.8	0.0

* Group with less than 100 observations

Table 6: Predicted choices, transition probabilities

Parity zero at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.7539	0.2450	0.0011
2	0.2197	0.7795	0.0008

Parity one at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.7575	0.2412	0.0013
2	0.1610	0.8370	0.0020

Parity two at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.6840	0.3053	0.0107
2	0.0475	0.9397	0.0128

Parity three or more at t and $t+1$

d_t	d_{t+1} 1	2	3
1	0.6656	0.3118	0.0226
2	0.0312	0.9536	0.0152

Note: These predictions have been calculated for the same subsample used in Table 2

Table 7: Estimated conditional birth probabilities for unobserved type 2

		≤25	26-30	31-35	≥36
Not Contracepting					
Primary or less	bt=0	78.5	78.1	75.4	18.3
	bt=1	17.3	16.9	14.9	1.3
Secondary	bt=0	76.8	76.4	73.6	16.9
	bt=1	16.0	15.6	13.7	1.2
High School	bt=0	79.0	78.6	76.0	18.8
	bt=1	17.7	17.4	15.3	1.3
3 year College	bt=0	77.1	76.7	73.9	17.2
	bt=1	16.2	15.9	14.0	1.2
5+ year College	bt=0	73.4	72.9	69.8	14.5
	bt=1	13.6	13.4	11.7	1.0
Contracepting		4.8	2.5	2.1	6.6

Estimated unconditional probability of being of type 2: 90.1%

Table 8: Sterilization rates by age, parity and current birth outcome

Parity	1		2		3	
	$b_t = 0$	$b_t = 1$	$b_t = 0$	$b_t = 1$	$b_t = 0$	$b_t = 1$
Sample proportions						
15-25	0.1	0	1.1	2.8	2.0*	5.4**
26-30	0.1	0	2.5	8.1	4.6	17.9
31-35	0.5	0*	2.6	13.0	5.7	19.4
36-44	0.6	0**	1.5	15.8**	1.8	28.8*
Predicted probabilities						
15-25	0..3	1.4	3.3	11.8	7.2*	19.9**
26-30	0.2	1.3	2.3	10.8	5.2	16.6
31-35	0.4	2.2*	2.3	12.5	4.7	21.0
36-44	0.2	1.1**	0.6	3.2**	0.9	3.8*

** Group with less than 40 observations
* Group with less than 100 observations

Table 9: Contraceptive actions by parity and wife's education

Parity	Wife's education	No contraception		Contracept		Sterilize	
		Sample	Predicted	Sample	Predicted	Sample	Predicted
0	Primary or less	67.7	61.2	32.3	38.7	0.0	0.1
	Secundary	52.0	51.7	47.9	48.1	0.1	0.1
	High School	40.1	43.3	59.9	56.4	0.0	0.3
	College	40.4	40.9	59.5	58.3	0.1	0.8
1	Primary or less	27.9	26.1	72.0	73.5	0.1	0.4
	Secondary	29.3	27.7	70.4	71.9	0.2	0.5
	High School	26.9	28.8	72.8	70.7	0.3	0.5
	College	31.0	30.4	68.7	69.1	0.3	0.4
2	Primary or less	14.3	14.4	83.2	83.6	2.5	2.0
	Secondary	14.5	13.8	82.5	83.3	2.9	2.9
	High School	10.5	11.3	86.4	85.0	3.1	3.8
	College	15.2	14.4	81.8	81.1	3.0	4.5
3+	Primary or less	22.1	19.0	74.1	77.7	3.8	3.4
	Secondary	14.9	14.7	78.6	80.3	6.6	5.0
	High School	11.2	13.0	79.3	80.6	9.5	6.4
	College	22.9	20.5	70.9	72.7	6.3	6.8

Table 10: Sample distributions of parity

	Number of Children				
	0	1	2	3+	Average
Full sample >35	2.9	13.0	54.4	29.7	2.2
Full sample >39	2.4	10.3	52.4	34.9	2.4
Full sample >43	1.3	7.5	52.8	38.5	2.5
Non-religious	2.6	13.0	55.4	29.0	2.2
Religious	5.0	13.2	47.2	34.6	2.3
Primary or less	0.9	12.4	48.9	37.8	2.4
Secondary	3.1	11.0	57.9	28.0	2.2
High School	4.5	19.6	59.8	16.1	1.9
College	7.4	19.0	52.1	14.1	1.7

The first three rows show the distribution of parity at a couple's last observation for all women who are then older than 35, 39 and 43 respectively. In each case we also included those who had sterilized before that age since that is their stopping period. The other rows are calculated using the last oberservation of women who are older than 35 and those who have sterilized. Age and education levels refer to the wife.

Table 11: Predicted distributions of parity at the end of fertile life

	Number of Children				
	0	1	2	3+	Average
Modal Couple	0.4	6.3	47.4	45.9	2.6
Counterfactual experiments for modal couple:					
Zero failure rate in contraception	0.4	2.6	72.2	24.8	2.2
Sterilization not available	0.9	4.9	37.9	56.3	2.8
Couple characteristics different from modal values:					
Unobserved type 1 (low fecundity)	44.3	38.8	14.4	2.5	0.8
Ex-ante average unobserved type	4.8	9.5	44.2	41.5	2.4
Age at marriage: 27	0.8	14.3	49.7	35.2	2.3
Age at marriage 27, Religious	0.3	8.0	44.5	52.8	2.6
Age at marriage 27, 5+ years in College	6.5	11.7	53.0	28.8	2.1
Age at marriage 30	2.3	30.3	44.1	23.3	1.9
Age at marriage 34	22.1	45.4	25.2	7.3	1.2

Modal characteristics: Wife and husband have secondary education; they got married when the wife was 23 years old, they aren't religiuos and they are of unobserved type 2 (high fecundity)

Table 12:

PANEL A: Contraceptive methods used at the time of the interview

Contraceptive method	Proportion
Condom	42.35
Pill	27.94
IUD	13.34
Withdrawal	12.13
Rhythm	2.66
Others	1.58

PANEL B: Age, parity, birth rate and contraceptive use: Time series of sample means

Year	# Obs.	Age: mean(sd)	Parity: mean(sd)	Birth rate: Births/Obs.	Contracept	Sterilize
1983	325	24.84(4.62)	1.19(1.16)	0.662	53.54%	1.85%
1984	1618	28.58(5.11)	1.49(1.05)	0.124	67.86%	1.11%
1985	1788	28.96(5.34)	1.52(1.08)	0.130	69.30%	1.62%
1986	1891	29.48(5.46)	1.54(1.07)	0.123	72.13%	1.53%
1987	1997	30.00(5.60)	1.55(1.05)	0.105	72.25%	1.95%
1988	2102	30.44(5.82)	1.53(1.05)	0.098	72.74%	1.76%
1989	2209	30.90(6.02)	1.53(1.05)	0.102	73.11%	2.13%
1990	2314	31.32(6.21)	1.52(1.03)	0.095	74.29%	1.86%
1991	2329	31.67(6.13)	1.51(1.01)	0.082	74.97%	1.89%
1992	2343	31.92(5.98)	1.51(1.01)	0.082	74.47%	2.26%
1993	2338	32.30(5.97)	1.49(0.97)	0.098	76.26%	2.01%

Table 13: Descriptive summary statistics by categories

	Variable	Obs	Mean	Std. Dev.
All couples	Age at marriage	2923	22.8	3.52
	Religious	2923	0.088	0.284
	Year of birth	2923	59.4	6.61
Primary or less	Age at marriage	673	22.0	3.49
	Religious	673	0.113	0.317
	Year of birth	673	56.3	7.15
Secondary	Age at marriage	1479	22.5	3.41
	Religious	1479	0.066	0.248
	Year of birth	1479	60.1	6.47
High School	Age at marriage	400	23.2	3.18
	Religious	400	0.080	0.271
	Year of birth	400	61.4	5.61
College	Age at marriage	371	25.2	3.27
	Religious	371	0.143	0.350
	Year of birth	371	60.2	5.14
Non religious	Age at marriage	2665	22.7	3.48
	Year of birth	2665	59.7	6.48
Religious	Age at marriage	258	23.7	3.85
	Year of birth	258	56.2	7.02

All characteristics but 'religious' refer to the wife

Table 14: Sample joint and marginal distributions of the couple's education

	Husband's education level							
Wife's education level	(0)	(1)	(2)	(3)	(4)	(5)	(6)	Total
(0) No Schooling	1.16	0.27	3.08	0.21	0	0.1	0	4.82
(1) Primary	0.68	1.33	13.68	2.09	0.17	0.21	0.03	18.2
(2) Secondary	1.13	4.65	31.2	9.89	1.33	2.26	0.14	50.6
(3) High School	0.07	0.86	5.1	4.62	0.82	2.22	0	13.68
(4) 3 year College	0.03	0.14	1.51	1.4	1.3	2.33	0.07	6.77
(5) 5 year College	0	0.1	0.65	1.09	0.68	2.63	0.34	5.51
(6) Postgraduate	0	0	0	0.1	0.03	0.17	0.1	0.41
Total	3.08	7.36	55.22	19.4	4.34	9.92	0.68	100
N. of observations	90	215	1614	567	127	290	20	2923

Table 15: Parameters of type proportion model for left censored observations

Parameter	Estimate	Standard error	z-ratio
χ_{20}	2.2048	0.11983	18.40
χ_{21}	0.2814	0.08459	3.33
χ_{22}	-0.0834	0.02184	-3.82
χ_{23}	0.0580	0.08017	0.72
χ_{24}	0.0044	0.07260	0.06
χ_{25}	-0.4626	0.21169	-2.19