

Socio-economic characteristics, completed fertility, and the transition from low to high order parities in Mexico

Alfonso Miranda*
Economics Department
University of Warwick
June 2003

Correspondence Address: Department of Economics, University of Warwick, Coventry, CV4 7AL, UK. E-mail: Alfonso.Miranda-Caso-Luengo@warwick.ac.uk

*I am grateful to Wiji Arulampalam and Mark Stewart for useful comments. I am also grateful to the National Council for Science and Technology (CONACYT) for its financial support.

Abstract

The present paper reports a study on the socio-economic determinants of completed fertility in Mexico. Special attention is given to how socio-economic factors such as religion and ethnic group affect the likelihood of transition from low to high order parities. This methodological approach allows the researcher to enquire about the role that such socio-economic characteristics have played in the process of adoption and diffusion of a low fertility norm in Mexico. Hurdle Poisson and Negative Binomial count data models are used as main econometric tools. Among other models, an endogenous treatment (or sample selection) count specification is estimated. The findings indicate that Catholicism is associated to reductions on the likelihood of transiting from low to high order parities in Mexico and that broad ethnic group does not affect such a probability. Hence, empirical results suggest that ethnic background does not constitute an obstacle for the diffusion of a low fertility norm (contraception use) in Mexico.

Keywords: Completed fertility, fertility change, hurdle count models, religion and ethnic group social network effects, sample selection count models.

JEL Classification No.: J13, J15, C25.

1. Introduction

The demographic transition in Mexico has gone through two main stages. The first stage, spanned approximately from the start of the 1930s to the first half of the 1960s, was characterised by significant reductions on infant mortality and increments on period fertility rates. The second stage, initiated at some point in the second half of the 1960s, has been characterised by further reductions on infant mortality that are accompanied by reductions on period fertility rates. In reference to the second phase, Juarez and Quilodran (1990) find evidence that women cutting off fertility at high parities have been the *pioneers* -and the leading force- of the change of fertility behaviour in Mexico. And Welti (1997), Zavala de Cosio (1992) and Mier and Rabell (1990) suggest that the main innovation introduced by those pioneers is the adoption of definite natal control once desired family size has been reached. In addition, Gomez (1996) indicates that women with less than four children use contraceptives much more intensively than women with larger families, and that most users of contraceptives in Mexico select female sterilization as their preferred method.

These tendencies are obviously reflected on lifetime fertility. Information for completed fertility from the National Survey of Demographic Dynamics 1997 (ENADID) indicates that a 53% of women with more than three children will transit to parities higher than five, and that a 25% of them will transit to parities higher than seven. Hence, it seems that pioneers of fertility change in Mexico are women who adopt definite contraception approximately before the arrival of a four child (Juarez and Quilodran, 1990). Women who cross that threshold appear to behave in a traditional fashion, as they tend to transit to high parities without taking measures to limit their fertility. Whether to cross such 'proximate' threshold is then an important decision that Mexican women appear to be taking in the past few decades.

From the point of view of economic theory the existence of 'proximate' behavioural thresholds such as the third child can be explained if the diffusion and adoption of contraceptives and low lifetime fertility standards are thought of as an innovation process. During this process, it is said, individuals decide whether to adopt a new 'fertility norm' or contraception technology on the basis of information transmitted

through their social network, taking into account that their actions might lead to social 'punishment' (Bongaarts and Watkins, 1996; Kohler, 1997; and Kohler, 2000.) In this context noisy signals and incomplete information flow through the social network might generate proximate coordination and 'gathering' strategies. The successful diffusion of such coordination or/and gathering strategies depends critically on the existence of early adopters -i.e., pioneers- of the new fertility standard (Gerosky, 2000.)

The present work presents a study on the determinants of completed fertility in Mexico that models explicitly the transition from low to high parities. Two main issues are addressed: (1) how do socio-economic characteristics such as religion, ethnic group, education and cohort of age affect the probability of transition from parities lower than four to parities of higher order? And (2) once the threshold of the third child has been crossed, what is the role of those variables on completed fertility? Other important factor that is likely to affect the probability of transition from low to high parities is that of sex preference. Ben-Porath and Welch (1976), and Angrist and Evans (1998) find that women who have either two girls or two boys in their first two pregnancies are more likely to have a third child than women who achieve instead mixed-sex offspring. Hence, it seems that parents prefer to have some mixture in the sex composition of their offspring. Moreover, empirical evidence suggests that they are willing to pay some cost to obtain it. In this line of thought, the present work enquires if the desire for an offspring 'sex-mixture' affects the probability a woman has of transiting from low to high parities in Mexico, and in particular, it is studied if such an effect differs across indigenous and non-indigenous individuals.

The rest of the present paper is organised as follows. Section two discusses briefly the existing economic literature on fertility behaviour, giving stress on what is known about fertility in developing societies that are in the middle of their demographic transition. Section three introduces the reader into the general stylised facts and institutional background on population issues in Mexico. Then section four describes the data used in the empirical trials reported in the present work. Section five discusses all relevant econometric issues and section six presents empirical results. Finally, section seven concludes.

2. Fertility change as an innovation process

Most economic demography in the last forty years has been orientated by three hypothesis on fertility behaviour that intend to offer an explanation of the main contemporary facts on population issues in developed societies. First there is the 'quantity-quality' trade-off of children hypothesis, firstly discussed by Becker (1960), and Becker and Lewis (1973). In this model children and their quality are both considered consumption goods and parents exchange them at some extend, depending on their opportunity costs. The main result shows that increments on family's income lead to an ambiguous effect on fertility. However, if income elasticity of quality is larger than income elasticity of quantity a substitution effect of quality against quantity is guaranteed. Becker and Lewis (1973) argue that this situation is a good description of reality in modern societies. The second hypothesis, proposed by Willis (1973), suggests that childbearing is a relatively time-intensive activity performed mainly by women. In a modified time-allocation model, the author shows that these ideas imply that the opportunity cost of children increases as female education and wage rise, inducing rational individuals (i.e., individuals that maximise their utility) to cut their demand for children. Finally, there is the 'relative income' hypothesis of Easterlin (1975, 1987). The argument is that individuals compare their current standard of living with an 'internalised' norm, and that such relative income determines behaviour. According to Easterlin, individuals form their preferences towards consumption and children during adolescence. Once in adulthood, they compare current standard of living with that experienced in the parental household. If a reduction on relative income is perceived, then a downward adjustment on lifetime fertility would be induced.

A widely recognised weak point of most neoclassic models of fertility behaviour is that perfect contraception is considered available at low or null cost for all individuals and at all times –no mistakes allowed. Sociologists and demographers, supported mainly on evidence from developing countries, have rejected these ideas as a valid description of the data (Boongaarts and Menken, 1983; Van de Walle, 1992). From their point of view contraception is a 'modern' need, required just after achievements in medicine and public health made possible significant reductions on mortality rates

–in all, general, infant and intrauterine mortality-, and natural mechanisms of regulation of human populations become weak. The transition from a regime of high mortality and high fertility to a regime of low mortality and low fertility is then thought of as a long-term process where contraception and health services become available in an imperfect and gradual way to different groups of people in the society. For this reasons, contraception cost and benefits differ across individuals and social groups (for more on these hypotheses see for instance Bongaarsts and Watkins, 1996).

Recent research suggests that adoption of contraceptives and reduction of family size may be thought of as an innovation process (See for example Freedman and Takeshita, 1969; Rogers and Kincaid, 1981; Retherford and Palmore, 1983; Montgomery and Casterline, 1993; Rosero-Bixby and Casterline, 1993; Bongaarsts and Watkins, 1996; Kohler, 1997; and Kohler, 2000). These ideas have contributed to bring closer the points of view of economists, sociologists and demographers. Under the new perspective the transition from a regime of high mortality and high fertility to a regime of low mortality and low fertility is a dynamic process of diffusion of knowledge and adoption of new techniques of contraception and fertility ‘norms.’ Following a microeconomic principle, heterogeneous individuals are recognised to be decision units that choose either to keep traditional fertility patterns or to adopt innovative behaviour on the basis of a utility maximization problem. Social-network effects are present so that an individual’s costs or/and benefits from innovation is a function of the number and identity of other innovators in his/her social network. By this means ‘contagion’ or diffusion of the new fertility standard is generated. The hypothesis has various advantages. First, It integrates in a natural way the notion that individuals are heterogeneous, this is, that they have individual-specific characteristics that affect the cost and benefits of innovation. This feature is capable of integrating the views of demographers and sociologist suggesting that, during a demographic transition, contraception technology becomes available in an imperfect and gradual way so that the cost of adoption differs across individuals and social groups. Second, it recognises the existence of ‘fertility standards’ and the importance of social influence and social-network effects in the diffusion of them. Finally, it accommodates a micro-founded mechanism of fertility decision-making into the analysis.

Various mechanisms justify the existence of social-network effects in the diffusion of new contraception technology and fertility 'norms'. One argument suggests that women are often uncertain about individual-specific suitability, effectiveness, and health implications of modern contraceptives (low fertility norm). In the presence of such uncertainty, it is said, women contraceptive choice commonly relies on information obtained from early adopters in casual word-of-the-mouth communications with friends and neighbours (Kholer, 1997; Montgomery and Casterline, 1993; Rogers and Kincaid 1981). Under these circumstances, the probability for an individual to adopt modern contraception (low fertility norm) depends on the experience on contraceptive use (advantages of low fertility) accumulated in her social-network. Social learning creates then a network effect, and with it, the possibility of information cascades or herding (Ellison and Fundenberg, 1995; Kapur, 1995; Kirman, 1993). In this context, a unique equilibrium is not always guaranteed. In fact, multiple equilibria will appear if enough 'noise' and/or limited information about contraceptives (advantages of low fertility) are transmitted through the network. Inefficient herding -convergence to the wrong equilibrium- is hence possible (Ellison and Fundenber, 1995; Kohler, 2000). Moreover, noise and limited information sharing could also contribute to accelerate or delay the adoption of new contraception methods (low fertility norm).

Direct social influence is other source of social-network effects that may affect the diffusion of innovative fertility behaviour. The intuition, which comes from sociology, is that individuals 'conform' rather than 'revolt' established social norms in order to avoid potential punishment for misbehaviour –punishment may have different levels of credibility. Given these incentives, network partners (neighbours, friends) communicate each other to generate a local knowledge that is then used to take individual participation decisions –i.e., whether to conform or to revolt. Local knowledge proportionate two bits of information to each individual: (1) information about the willingness to participate of their direct neighbours (those who have a direct link with her/him), and (2) information, transmitted by direct neighbours, about the willingness to participate of indirect neighbours. In this context, low fertility (revolt) is a best response strategy for a given individual depending on the number and identity of other individuals in her/his social network that are themselves willing to choose low fertility (contraception adoption) as their own strategy (Kohler, 2000).

This is, each individual ‘participates’ only if other individuals participate as well –the “I’ll go if you go” of Chwe (2000). The existence of such strategic complementarities creates the possibility of multiple and Pareto-rankable equilibria, inducing potential problems of coordination failure (Kohler, 2000). Under this theoretical perspective, change of social norms is understood as a process of diffusion and adoption of different patterns of behaviour among the members of a society. The framework accommodates easily the idea that social norms are ‘proximate’, this is, that they do not specify a specific rule but a range of rules that as a whole constitute the norm. For instance, a low fertility norm might be ‘lifetime fertility below or around three.’ This semi-open rule implies that some people with more than three children, but with completed fertility close enough to three, could be adopting a low fertility norm whereas other people with more than three children could be adopting a high fertility norm instead.

Regardless the argument, information flows or social influence, social-network structure is a key element that determines speed of diffusion and eventual adoption of innovative fertility behaviour. Form, size, and density of the network become central concepts for the analysis (see Jackson and Wolinsky, 1996; Dutta and Jackson, 2001; Galeotti and Goyal, 2002; Kohler, 1997 among others.) Quality (noisy versus non-noisy network) and nature of the links (unilateral versus multilateral, directed versus non-directed, self-sustaining versus non-self-sustaining bilateral relations) are also important (see for instance Bala and Goyal, 2000; Groh, 2002; Lippert and Spagnolo, 2002.) Heterogeneity among individuals is, however, one of the most important factors affecting speed of diffusion and eventual adoption of an innovative behaviour. Indeed, adoption of a new technology is likely to be more profitable and less costly to individuals with some ‘good’ characteristics, either observable or unobservable, than what it is to people with some ‘bad’ characteristics –individual characteristics could include social-network structure. Moreover, to some people innovative behaviour could be so well suited that adoption is a best strategy regardless imperfect information, uncertainty, and/or social pressure. They will be the ‘pioneers’ or early entrants described by Geroski (2000), Chwe (2000) or Zimmermann and Eguíluz (2001). The role of pioneers is critical, as they generate a mass of information or social influence needed for individuals with different characteristics to adopt the new

norm or technology. As described above, the process would lead eventually to an information cascade and herding towards the new fertility standard.

3. Institutional background

In the last forty years consistent and significant reductions on total fertility rate (TFR) in Mexico have been registered -it went from 6.5 children per woman in 1970 to less than 3 children per woman in 2000 (INEGI, 2000; INEGI, 2001a.) Among other factors the reduction on fertility is associated to an important decline on infant mortality, which in the period 1970-2000 passed from 68.5 to 17.5 deaths for each 1,000 births (INEGI, 2000; INEGI, 2001a.) Other development indicators witness as well important improvements on the living standard of Mexican citizens. In fact, between 1970 and 1999 average education increased from 3.4 to 7.6 years and life expectancy went from 61 to 75 years (INEGI, 2001b.) During the same period of time real GDP per capita increased 57% and urban population went from representing 60% to 75% of total population. Finally, female participation in the labour force (female workers /total women in age of work) increased from 11% to 27% (World Bank, 2001.) All these aspects of modernization are likely to have influenced fertility reduction in Mexico.

Improvement in development indicators, however, is not homogeneous across broad ethnic groups. For instance, in year 2000 infant mortality rate among Mexican Indians was 1.2 times higher than the corresponding figure for Mexico as a whole (CONAPO, 2002.) Similarly, in 1997 average education in indigenous population was reported to be three years lower than average education in non-indigenous population (ENADID, 1997.) Obviously, differences in standards of living are reflected in differences on fertility rates. In fact, CONAPO (2001) estimates that in year 1996 Total Fertility Rate (TFR) for indigenous individuals was a 67 percent higher than the corresponding figure for non-indigenous individuals –4.7 children per Indian woman compared to 2.8 children per non-Indian woman.

Public policies are other important factor explaining fertility decline. In 1973 the Mexican government initiated for the first time a public programme to offer free

contraceptives and to promote family reduction as a rational and responsible behaviour among Mexican citizens. Simultaneously, all previous legal restrictions for the sell of contraceptives were lifted. Between 1973 and 1979 these 'family planning' campaigns targeted potential users of contraception in urban and sub-urban zones. But at the onset of the 1980s decade rural zones were also integrated (Cabrera, 1994.) During the last 20 years geographical coverage of such campaigns increased significantly. However, universal access to modern contraceptives is still far from reality. Despite the failure of providing universal access to contraception, population policy in Mexico is widely considered a success, as the diffusion and adoption of modern contraceptives increased dramatically in the past few decades. In fact, while in 1976 thirty percent of all married women -or living in consensual union- were active users, in 1998 the figure was estimated to be seventy per cent (INEGI, 2001b.) Today, and since late 1970s, the public sector constitutes the main source of contraceptives in the country though private supply remains important (INEGI, 2001b.)

A dramatic change in the composition of the demand for contraceptives is one of the most significant stylised facts of the last twenty years. Indeed, at the end of the 1970s nearly 35% of all users adopted the pill, 19% IUD, and 9% permanent female sterilization (PFS). In contrast, in 1998 51% of users adopted PFS, 24% IUD, and 10% traditional methods. At this last date, the pill was selected by less than six per cent of all active users of contraception (INEGI, 2001b.) Gomez (1996) indicates that most young Mexican individuals do not adopt contraception before the arrival of a first or second child, and that many of them adopt PFS or IUD as their preferred method. In addition, the author finds that women with two or three children are responsible for most of the demand for contraceptives in Mexico. This is, that the prevalence in the use of contraceptives among women with more than four children is much lower. Because of this, he concludes, women with more than three children are 'selected' into a high-parity group, in contrast to women with less than four children who are selected into a low-parity group (i.e, pioneers versus non-pioneer of fertility reduction.)

Demographers explain the observed trends in the demand for contraceptives as the outcome of various factors. They mention that the public health system in Mexico has

done a deliberated effort to promote the adoption of definitive natal control (definite contraception) among women that have three or more children. In fact, most of the 'delivery effort' of contraceptives has been concentrated on reaching women *looking* to initiate natal control after they reach their *desired* family size. According to Zavala de Cosio (1990) this policy has contributed to generate and to disseminate a new 'norm' of fertility among Mexicans, but at the same time it has bias the demand for contraceptives towards PFS and IUD. Lindstrom (1998) finds that Mexican women fear -many times relying on unfounded grounds- undesired side effects of hormonal contraceptives (such as cancer) and unwanted pregnancy due to ineffectiveness. On the basis of these findings, the author suggest that fear to undesirable side effects of hormonal-based contraceptives is the main reason for the observed shift to PSF among Mexican women.

4. Data and variable definition

Data from the National Survey of Demographic Dynamics 1997 (ENADID from its acronym in Spanish) is used. The ENADID is micro-data-set containing detailed economic and demographic information for 88,022 Mexican women aged between 15 and 54 years. Since completed fertility is the main concern of this study, a total of 19,559 cases of women aged 40 or over at the time of survey (December 1997) are selected. Four cohorts of age can be defined: from women born in period 1940-1944 to women born in the period 1955-1957.

From a theoretical point of view it is not clear whether fertility decisions are taken in terms of lifetime number of pregnancies, lifetime number of live births, or lifetime number of surviving children. Obviously, lifetime number of pregnancies is the broadest concept as it is the cumulative sum of every conception a woman has during her fertile life. Number of live births excludes voluntary and involuntary miscarriages as well as stillbirths. Finally, number of surviving children takes out infant deaths up to a certain age, say, age five. Most economic models of fertility choice consider that individuals decide over the number of surviving children rather than over number of pregnancies or live births. This is, that individuals choose the number of children they would like have at the end of fertile life, without regard to the number of pregnancies

required to reach such a number of decedents (see for instance Becker and Lewis, 1973; and Willis, 1973.) Hence, the death of a child is thought to induce a new pregnancy (or a series of failed pregnancies) such that final family size remains constant. In the same line of thought, unwanted children would be neglected to death in the absence of better means of birth control. In applied work, in contrast, the common practise is to define lifetime fertility as the number of children ever born live to a woman at the end of her childbearing period (see for instance Santos and Covas, 2000; and Merkerson and Rooth, 2000.) The convention in applied work seems to be as arbitrary as the convention in theoretical work. Given that child mortality is not explicitly considered, the present work adopts the convention in theoretical literature. Therefore, completed fertility will be defined as total number of at-least-5-year-surviving children ever born to a woman during her lifetime, **children**. **Children** is the dependent variable. According to the descriptive statistics (see Table 1,) **children** has mean 4.42 and variance 2.75. The data is then over-dispersed.

Controls for women's religion, ethnic group, education at age 12, cohort of age, sibling sex composition, and place of birth are included as explanatory variables (see table 1.) The definition of those variables is as follows:

Catholic. Binary indicator that takes value one if the woman is catholic and zero otherwise. Defining two broad religious groups seems to be the finest sensible classification for Mexico given that nearly 90% of Mexicans are Catholics and a further 7% are Protestants.

Indspker. Dummy variable indicating whether an individual is able ($\text{indspker} = 1$) or unable ($\text{indspker} = 0$) to speak an indigenous language. **Indspker** proxies broad ethnic group (indigenous/mixed) rather than specific socio-cultural community. Clearly, neither indigenous nor mixed population are homogeneous socio-cultural entities in Mexico. However, a broad ethnic-group classification seems to be sensible because attitudes towards contraception, family size, and female work are mostly traditional across indigenous groups (i.e., against remunerated female work and modern contraception,) and contrast with modern attitudes commonly found among mixed individuals. **Indspker** presumes that indigenous individuals keep the ability of speaking their own language and declared so to the ENADID interviewer. Obviously,

in some cases an individual may have lost her indigenous-language skills but remain culturally indigenous. And some bilingual women may hide their language skills at the time of the ENADID survey. Therefore, **Indspker** is potentially recorded with measurement error. However, if present, such an error is likely to be small and non-correlated with unobservables that may affect fertility.

Edu12. Proxy variable for women's completed years of education at age 12. **Edu12** is an indicator of skills and human capital accumulated before the onset of reproductive life, and thus it is treated as an exogenous variable. Given that primary education in Mexico is composed by six compulsory grades and children initiate their instruction at age six, **Edu12** is bounded between zero and six. Because of lack of detailed information in the ENADID survey some assumptions have been done in the construction **Edu12**. Namely, it supposed that (a) all children start primary education at age 6, (b) all children assist continuously to school until the date of their definite dropout, and (c) none fails an attended course. Under these assumptions it is possible to infer women's completed years of education at age 12 from information on women's date of birth and their completed years of schooling at the time of the survey. These last two pieces of information are available in the ENADID survey. Notice that assumptions (a) through (c) imply that variations of **Edu12** across individuals are induced by potential heterogeneity in desertion ages before graduation. Clearly some children may start education after age 6, dropout temporally, and repeat some courses. As a consequence, **Edu12** might contain some measurement error. The important point here is that such a measurement error is unlikely to be correlated with factors other than family background and skills because primary education is compulsory in Mexico since 1934 and, consequently, children enter it almost universally at age six. Moreover, temporary dropouts are rare in either rural or urban zones and completion of primary education is commonly achieved unless children find limited supply of education services in the local community –some schools in rural and marginal zones do not offer all the six grades that integrate primary education-, suffer from financial difficulties, or fail courses respectively. In very few cases course repetition is extended long beyond the age of menarche. Hence, measurement error in **Edu12** is unlikely to be correlated with unobservables affecting fertility.

Cohort of age. Using information on women's date of birth five cohorts can be defined, from 1940-1944 to 1955-1957. Four binary dummy variables indicating cohort of age are then generated (=1 if born on the corresponding 5-year period): **c4044**, **c4549**, **c5054** and **c5559**. The first cohort is taken as reference group.

Ssex3. Dummy variable that takes the value of one if the first three children are all either boys or girls. In other words, **Ssex3** = 1 if all siblings have the same sex. Otherwise, **Ssex3** = 0. This variable is likely to have a significant role in the transition from low to high parities. In fact, Ben-Porath and Welch (1976) and Angrist and Evans (1998) find that women who have either two girls or two boys in their first two pregnancies are more likely to have a third child than women who achieve instead mixed-sex offspring. The intuition is that parents prefer to have some mixture in the sex composition of their offspring and that they are willing to pay some cost to obtain it. Since children's sex 'allocation' is largely a random process, realisations of **Ssex3** are unlikely to be uncorrelated with any possible observed or unobserved individual characteristic of the mother.

Place of birth. 32 geographic dummies that correspond to each of the 32 federal entities that integrate Mexico. Mexico City (D.F.) is used as reference group.

5. Econometric issues

The starting point is a Poisson count model with hurdle at three (previous use of Hurdle models include, among others, Arulampalam and Booth, 1997; Santos Silva and Covas, 2000.) To fix ideas let individual's i completed fertility be y_i . The objective is estimating a model for the probability that a count j would be observed for i from a random sample $Y = \{y_1, \dots, y_n\}$. The model is written as:

$$P(y_i) = \begin{cases} P(y_i \leq 3) \\ [1 - P(y_i \leq 3)]P(y_i | y_i > 3). \end{cases} \quad (1)$$

The probability of observing counts larger than three is modelled as a Poisson distribution truncated at three,

$$P(y_i | y_i > 3) = \Pr[y_i = j] = \left\{ \frac{1}{1 - \frac{\exp[-\mathbf{m}_i] \mathbf{m}_i^3}{3!}} \right\} \frac{\exp[-\mathbf{m}_i] \{\mathbf{m}_i\}^{y_i}}{y_i!}, \quad j = 4, 5, \dots \quad (2)$$

where the parameter \mathbf{m}_i has a deterministic log-linear relationship with a set of explanatory variables x_i ,

$$\mathbf{m}_i = \exp[x_i \mathbf{b}]. \quad (3)$$

x_i represents a $1 \times k$ vector of explanatory variables and \mathbf{b} is its $k \times 1$ vector of associated coefficients (including the constant). The exponential form of \mathbf{m}_i in the parent process –i.e., the non truncated Poisson- ensures that that $\mathbf{m}_i = E[y_i|x_i]$ will be non-negative so that $P(y)$ is a well behaved probability. No unobserved individual heterogeneity is allowed and $E[y_i|x_i] = \text{Var}[y_i|x_i]$. Notice that the vector of coefficients \mathbf{b} cannot be interpreted as marginal effects. Instead, one should say the a unit change in x_{ik} leads to a proportional change of \mathbf{b}_k in $E[y_i|x_i]$.

The probability of observing counts smaller or equal three will be modelled as a standard Logit model,

$$P(y_i | y_i \leq 3) = \frac{1}{1 + \exp[z_i \mathbf{d}]} \quad (4)$$

As before, z_i is a $1 \times k$ vector of explanatory variables and \mathbf{d} is its $k \times 1$ vector of associated coefficients. Vectors x_i and z_i might contain common variables. The model is estimated by maximum likelihood and if H represents the Hessian matrix, at convergence, $-H^{-1}$ can be used to estimate the covariance matrix. Usual hypothesis test can be performed on the basis of t, LR and Wald statistics.

Using a Poisson function for the parent process has two main drawbacks: it assumes equi-dispersion, $E[y_i|x_i]=\text{Var}[y_i|x_i]$, and it does not accommodate for the presence of unobserved individual heterogeneity.

The assumption of equi-dispersion is rather restrictive and in practice over-dispersion $\text{Var}[y_i|x_i]>E[y_i|x_i]$ or under-dispersion $\text{Var}[y_i|x_i]<E[y_i|x_i]$ are commonly detected. Since violations to the equi-dispersion assumption might result in loss of efficiency, more flexible models have been used in applied work (Winkelmann and Zimmermann, 1995; and Winkelmann 2000 provide an excellent survey of the count data literature.) However, an important advantage of this simple model is that if the mean function is correctly specified the Poisson regression produces consistent estimators even in the presence of over-dispersion/under-dispersion (see Gourieroux, Monfort and Trognon 1984, and Cameron and Trivedi 1986.) For this reason the Poisson regression is widely used as a benchmark for comparison with more sophisticated models. In the field of population economics the Poisson regression has been used by Nguyen and Dinh H (1997) and Melkersson and Rooth (2000), among others.

After estimating an initial hurdle model with a Poisson parent process, the study proceeds to extend the model in order to accommodate unobserved individual heterogeneity and over-dispersion in the count process. In particular, a Negative Binomial specification for the parent process is considered. Firstly, it is supposed that conditional on an unobserved heterogeneity term, v_i , the count y_i has a Poisson distribution

$$P(y_i | x_i, v_i) = f(y_i | x_i, \mathbf{e}_i) = \frac{\exp[-\mathbf{m}_i(\mathbf{e}_i)]\{\mathbf{m}_i(\mathbf{e}_i)\}^{y_i}}{y_i!}. \quad (5)$$

Therefore, the mean of y varies across individuals not only due to variations on the vector of observed characteristics, x_i , but also due to variations in an unobserved heterogeneity term, \mathbf{e}_i . Following the common practice we parameterise $\mathbf{m}_i(\mathbf{e}_i)$ as

$$\mathbf{m}_i(v_i) = \exp[x_i \mathbf{b} + \mathbf{e}_i] = \exp[x_i \mathbf{b}]v_i, \quad (6)$$

and suppose that v_i is uncorrelated with x_i . Notice that the random term v_i scales $E[y_i]$, and that v_i might be interpreted as a synthetic variable that collects all effects associated to omitted explanatory variables. Unobserved heterogeneity may also collect some measurement error in the explanatory variables. Given this structure, the unconditional probability of the count can be written as

$$P(y_i) = \int_{v_i} f(y_i | x_i, v_i) g(v_i) dv_i. \quad (7)$$

The model is closed once a distribution function for the unobserved heterogeneity term, $g(v_i)$, is specified. If v_i is distributed as Gamma with mean 1 and variance α , the heterogeneity term in (5) can be integrated out and, after some algebra, $P(y_i)$ becomes a Negative Binomial,

$$P(y_i) = \frac{\Gamma(\mathbf{a}^{-1} + y_i)}{\Gamma(\mathbf{a}^{-1})\Gamma(y_i + 1)} \{1 + \mathbf{a}\mathbf{m}_i\}^{-(\mathbf{a}^{-1} + y_i)} \{\mathbf{a}\mathbf{m}_i\}^{y_i}. \quad (8)$$

Mean count remains $\mathbf{m}_i = E[y_i|x_i]$ but the variance is now $\text{Var}[y_i|x_i] = \mu_i + \alpha\mu_i^2$. Hence, the model exhibits over-dispersion whenever α is different from zero. In the case of $\alpha=0$ the distribution for the unobservables collapses into a single mass point at $v_i=1$ and a simple Poisson with no heterogeneity is obtained.

Having this model in mind it is always possible to specify $P(y_i | y_i \geq 3)$ as a Negative Binomial truncated at three,

$$P(y_i | y_i \geq 3) = \left\{ \frac{\Gamma(\mathbf{a}^{-1} + y_i) \{1 + \mathbf{a}\mathbf{m}_i\}^{-(\mathbf{a}^{-1} + y_i)} \{\mathbf{a}\mathbf{m}_i\}^{y_i}}{\left[1 - \frac{\Gamma(\mathbf{a}^{-1} + 3)}{\Gamma(\mathbf{a}^{-1})\Gamma(4)} \{1 + \mathbf{a}\mathbf{m}_i\}^{-(\mathbf{a}^{-1} + 3)} \{\mathbf{a}\mathbf{m}_i\}^3 \right] \Gamma(\mathbf{a}^{-1})\Gamma(y_i + 1)} \right\}, \quad (9)$$

and keep the hurdle as before, this is, specified as a standard Logit. The adequacy of this extended model can be tested against a simple one with Poisson parent process by testing $\alpha=0$. If the null $\alpha=0$ may not be rejected, then unobserved heterogeneity will be unimportant and the simple model will be preferred. The test for $\alpha=0$ can be

performed on the basis of a likelihood ratio test. It only needs to be noted that the null lies on the boundary of the parameter space for α . Consequently, the LR ratio will be distributed as a 50:50 mixture of a point mass at zero and a chi-square variable with 1 degree of freedom. In the fashion of the Poisson hurdle, The Negative Binomial hurdle model is estimated by maximum likelihood.

As in the case of the count process, an unobserved individual heterogeneity term τ_i may be present in the hurdle. And if the random terms t_i and e_i were correlated, then neglecting individual heterogeneity in the hurdle would lead to sample selection bias in the post-hurdle count process. Hence, a final extension should consider an endogenous treatment or sample selection model as suggested by Greene (1997) and Terza (1998).¹

The model is modified as follows. Let individuals choose between two different fertility norms: low (L) or high (H). Represent utility for the i -th woman from choosing H as $U_i(H_i)$ and utility for the i -th woman from choosing L as $U_i(L_i)$. A rational individual chooses a high fertility norm if

$$d_i^* = U_i(H) - U_i(L) = z_i' \mathbf{d} + t_i > 0 \quad (10)$$

where d_i^* is a latent or unobserved variable. As before, z_i represents a vector of explanatory variables and δ its vector of associated coefficients. Finally, τ_i denotes a random term that contains all potential unobserved individual heterogeneity. Let d_i be an observed dummy taking one if a high fertility norm has been chosen and zero otherwise. Then, a dummy dependent variable model for the hurdle can be proposed in the usual way

$$d_i = \begin{cases} 1 & \text{if } z_i' \mathbf{a} + t_i > 0 \\ 0 & \text{otherwise.} \end{cases} \quad (11)$$

Suppose further that if the hurdle is crossed, i.e. if a high fertility norm is chosen, count y_i is governed by a truncated at three Poisson process

$$f(y_i | \mathbf{e}_i, x_i, d=1) = \left[\frac{1}{1 - \frac{\exp[-\mathbf{m}(\mathbf{e}_i)][\mathbf{m}(\mathbf{e}_i)]^3}{3!}} \right] \frac{\exp[-\mathbf{m}(\mathbf{e}_i)][\mathbf{m}(\mathbf{e}_i)]^{y_i}}{y_i!}, \quad (12)$$

where $\mathbf{m}(\mathbf{e}_i)$ defined as in (6). Vectors x_i and z_i might have some common elements. To close the model, let \mathbf{t}_i and \mathbf{e}_i be jointly normally distributed with mean vector zero and covariance matrix,²

$$\Sigma = \begin{pmatrix} \mathbf{s}^2 & \mathbf{s}\mathbf{r} \\ \mathbf{s}\mathbf{r} & 1 \end{pmatrix} \quad (13)$$

Conditional on \mathbf{e}_i , d_i and y_i are independent. Hence we can write

$$P(y_i | x_i, z_i, d=1) = \int_{-\infty}^{\infty} P(y_i | x_i, \mathbf{e}_i, d_i=1) P(d_i=1 | \mathbf{e}_i, z_i) g(\mathbf{e}_i) d\mathbf{e}_i. \quad (14)$$

Notice that function $g(\mathbf{e}_i)$ in equation (14) denotes the pdf for the random term \mathbf{e}_i .

Consider now a change of variable

$$\mathbf{h}_i = \frac{\mathbf{e}_i}{\mathbf{s}\sqrt{2}}.$$

Finally, exploiting the fact that $g(\mathbf{e}_i | x_i, z_i)$ is normal with mean zero and variance σ^2 , the joint conditional pdf of y_i and d_i given x_i and z_i may be written as:

$$f(y_i, d_i | w_i) = \frac{1}{\sqrt{\mathbf{p}}} \int_{-\infty}^{\infty} \left\{ f(y_i | d_i=1, x_i, \mathbf{s}\mathbf{h}_i\sqrt{2}) \Phi_i^*(\mathbf{s}\mathbf{h}_i\sqrt{2}) d_i \right. \\ \left. + (1 - d_i) \Phi_i^*(-\mathbf{s}\mathbf{h}_i\sqrt{2}) \right\} \exp(-\mathbf{h}_i^2) d\mathbf{h}_i, \quad (15)$$

where,

$$\Phi_i^*(sh\sqrt{2}) = \Phi\left(\frac{z_i'd + rh_i\sqrt{2}}{\sqrt{1-r^2}}\right)$$

The integral in (15) does not accept a close-form solution. However, Gauss-Hermite quadrature can be used to approximate it. The model is estimated by maximum likelihood. At convergence $-H^{-1}$ estimates the covariance matrix and usual hypothesis tests can be performed. Endogenous sample selection is present if ρ and σ^2 are both significantly different from zero.

6. Empirical Results

In this section empirical results for a study on the socio-economic determinants of completed fertility in Mexico are presented. The study puts special emphasis on how socio-economic factors such as religion and ethnic group affect the probability of transition from low to high parities. This is an attempt of understanding the role that such characteristics have played in the process of adoption and diffusion of a low fertility norm in Mexico in the last few decades. The paper is based on the analysis of data from the National Survey of Demographic Dynamics 1997 (ENADID) and hurdle count models are implemented.

As discussed in the last section the models estimated here are composed by two parts: (i) a hurdle governing the likelihood that a woman will have more than three children during her complete fertile period of life, and (b) a Poisson truncated at three process governing the likelihood of observing any particular count over three children. As explanatory variables the Poisson process will include **Catholic**, **Indspker**, **Edu12**, Cohort of age dummies, and Birthplace dummies. For the hurdle we seek a parsimonious specification. Therefore, the 32 birthplace dummies will be excluded and the variable **Ssex3** will be introduced along an interaction term between **Ssex3** and **Indspker**.

Table 2 presents empirical results. Besides the hurdle models, and for comparison purposes, Table 2 contains as well results from standard Poisson and Negative regressions. Obviously, coefficients for the count process from Hurdle and standard

models are not directly comparable as they estimate parameters for qualitatively different and non-nested statistical models. However, inspecting results from Hurdle and standard models is a valuable exercise to assess if the effect of explanatory variables on completed fertility varies importantly as different econometric models are formulated. In particular, a comparison of columns (1) and (3) -or (2) and (4)- of Table 2 gives an idea how the effect of explanatory variables such as religion changes when, instead of modelling a Poisson process for all counts, only parities higher than three are considered. To offer a complete picture, Table 2 contains as well results for a sample selection hurdle model in column (5).

Results for standard models are discussed first. Column (1) in Table 2 presents regressions results from a basic Poisson model. Counts higher than four are treated in the same manner than counts lower than four.

A negative and significant coefficient on **Catholic** indicates that individuals professing Catholicism have fewer children than individuals with other -or non-religious background. This result is interesting given the traditional policy of the Catholic Church against contraception, attitude that in many occasions is thought to be an important barrier to family reduction. Various factors are likely to be behind a negative coefficient on **Catholic**. First, there is the fact that, despite being in principle against the use of contraceptives, the Catholic Church has been rather tolerant with the increase of contraception use among its members in the last few decades. In fact, beyond some largely insignificant discredit campaigns launched by radical catholic associations -which are not directly related to the Church- no efforts to fight against the use of contraceptives in Mexico has been undertaken by the Catholic Church (Cabrera, 1994.) Beyond the attitude of the Catholic Church, a relatively large base of contraception users within the catholic community -in relation to the non-catholic community- might generate important social-network effects via information flow and social influence. As we said on section 2, such network-effects might contribute to create information cascades and herding that benefit the diffusion of a low fertility social norm. And differences on the intensity of social-network effects across religious groups may explain a negative coefficient on **Catholic**. A Final explanation of the negative coefficient on **Catholic** may stress the fact that Catholic principles prohibit sexual activity before marriage. Since in the last few decades many young

Mexicans have tended to delay marriage in reference to previous generations, it is arguable that delay of marriage and sexual abstinence imply reductions on women's exposure to the risk of pregnancy at some extent. Holding other things constant, such a reduction on 'exposure time' should lead to some reduction on family size. All these hypotheses are consistent with a negative coefficient on **Catholic** and the econometric methodology being used here cannot discriminate among them. However, it is very likely that all these mechanisms are simultaneously at work.

As expected, the proxy for broad ethnic group **Indspker** has a positive coefficient attached, implying that indigenous women have significantly more children than non-indigenous women. Besides differences on culture and genetic makeup, it is likely that the coefficient on **Indspker** reflects the well-known differences on standards of living and economic opportunities between indigenous and non-indigenous population in Mexico. In fact, most indigenous individuals remain in small rural communities that are far from the industrial centres and its labour markets. In such localities health and education services are very limited and most individuals are involved on activities for self-consumption on agriculture, livestock or fishing. In a few words, they live with a high degree of marginality (CONAPO, 2001b.)

According to the results included on column (1) of Table 2, education at age 12 has a negative and significant effect on completed fertility. This supports economic theory suggesting that investment on human capital increases the opportunity cost of children (Willis, 1973.) A negative coefficient on **Edu12** is also consistent with recent literature stressing the idea that education might increase the bargaining power of women in their households (see for instance Klawon and Tiefenthaler, 2001; Eswaran, 2002; Hindin, 2000.)

All coefficients on the cohort-of-age dummies are negative and significant (the base group is composed by women who born between 1940 and 1944.) These results are clearly in line with the general trend that the Mexican period fertility rates, including the total fertility rate TFR, have showed in the last forty years. Pair-wise tests for the equality of the cohort-of-age coefficients -i.e., for instance, the equality between coefficients on c5559 and c5054- reject the null at any standard confidence level. More importantly, results in column (1) indicate that younger cohorts of women have

larger coefficients on their age-specific dummy. Hence, there is strong evidence that young cohorts of Mexican women are reducing their lifetime fertility in reference to the experience of older cohorts.

Column (2) contains regressions results for a Negative Binomial model. As discussed before, this model controls explicitly for the potential presence of unobserved individual heterogeneity. A likelihood ratio test for the significance of a indicates that unobserved heterogeneity is indeed present. Hence, a Negative Binomial model is preferred over the Poisson specification. Notice that this LR test is performed on the boundary of the parameter space for alpha and that the likelihood ratio statistic is then distributed as a 50:50 mixture of a mass point at zero and a chi-square variable with one degree of freedom. Since a is positive there is empirical evidence that the data is over-dispersed. All coefficients on explanatory variables are significant and maintain the same signs as those estimated for the simple Poisson model. The interpretation of the coefficients remains the same and thus no further discussion on the issue is required.³

Standard models are non satisfactory on various respects. On one hand, they do not allow for extra probability on zero and two counts. A characteristic of fertility data that previous studies on the field have commonly found (for an excellent discussion on these issues see Winkelmann, 2000; Santos and Covas, 2000; Merkerson and Rooth, 2000.) More importantly, standard models do not consider that the decision on having a 'small' family in opposition to having a 'large' family is potentially different from the decision on the desired number of children once a low or high fertility norm has been adopted. The present work enquires about this last issue and puts emphasis on determining how socio-economic factors affect the likelihood of transition from parities lower than four to parities of higher order.

Results for a Hurdle at three Poisson are contained in column (3) of Table 2. There are two sets of estimates, a logit process that governs the probability of crossing the hurdle and a Poisson process that governs the outcome of the post-hurdle count variable. According to Akaike and consistent Akaike information criteria, Poisson Hurdle is preferred over a simple Poisson model (see bottom of Table 2, column 3.)

While coefficients on explanatory variables for the count process in column (3) refer to a Poisson model fitted for counts larger than three, the corresponding coefficients in column (1) refer to a Poisson model fitted for all possible counts. Therefore, coefficients are not directly comparable. However, results from both models seem to be consistent in the sense that all coefficients on explanatory variables at the top of columns (1) and (3) have common signs and are significant. In other words, **Catholic** is associated with relative reductions on lifetime fertility and **Indspker** with a larger expected count. Similarly, **Edu12** is reported to induce reductions on lifetime family size. In other issues, negative coefficients on cohort-of-age dummies in column (3) indicate that, conditional on having more than three children, young cohorts of women have on average fewer children in reference to older cohorts of women –just as the corresponding coefficients in column (1) suggest.

Moving to the hurdle section at the bottom of column (3) it is found that being a Catholic implies a reduction on the likelihood of transiting from low to high parities – i.e., a significant negative coefficient on **Catholic** is estimated. This result is consistent with the idea that the diffusion of a low fertility norm (and/or contraception use) among Catholic individuals proceeds at a faster pace than it does among non-Catholic individuals. Aside from cultural disparities, the differential on diffusion speed might be associated with the presence of relatively strong social-network effects within the Catholic community -which clearly dominates the picture- that benefit the transmission of information and influence about fertility behaviour and contraception use among individuals belonging to it. A large and diverse community is likely to be a key factor determining the emergence of ‘pioneers’ of the fertility change (low fertility norm and use of contraception) among Catholics. And, as we said in section 2, a large social-network is also important to accumulate a minimum ‘stock’ of innovators so that an information cascade is created and herding around the low fertility norm can be induced. Hence, a relative small social network might be behind a relatively high likelihood of crossing the hurdle among non-Catholic individuals. Obviously, other stories are possible and the present study cannot discriminate two or more alternative hypothesis explaining the reasons for a negative coefficient on **Catholic** for the hurdle part of the model. There is thus need for further research. The important point here is that religion is found to be an important factor determining the likelihood of transition from low to high parities in Mexico.

A negative but largely insignificant coefficient on **Indspker** is estimated for the hurdle part of the model –see the bottom part of column (3) of Table 2. This is a rather interesting result given the positive and significant coefficient on **Indspker** for the post-hurdle count process. It says that broad ethnic group does not influence the likelihood of transiting from parity three or lower to high order parities. However, given that the three-children threshold has been crossed, an Indian-language speaker is expected to have on average a larger completed fertility than a non-Indian-language speaker. This is a mixture of good and bad news. It is good news because ethnic background does not constitute an obstacle for the diffusion of the low fertility norm (contraception adoption) among indigenous individuals in Mexico. It is bad news because results indicate indigenous individuals that follow a high fertility norm are expected to have rather large families in relation to those non-Indian individuals that also follow a high fertility norm.

As it is witnessed by a negative coefficient on **Edu12**, reaching age 12 with a better education reduces the likelihood of crossing the three-children threshold. Since high education is commonly associated with a high cost of children, the result is consistent with the predictions that economic models such as those outlined by Becker (1960), Becker and Lewis (1973), and Willis (1973) assert. In other issues, and in accordance with the general trends of Mexican period fertility rates in the last three decades, young cohorts are found to be increasingly less likely to cross the hurdle.

The single most important variable influencing the likelihood of transition from low to high parities is **Ssex3**. As expected the coefficient on **Ssex3** is positive and highly significant, indicating that women prefer mixed-sexed offspring to single-sexed offspring and that they are willing to pay a cost for satisfying this desire (Ben-Porath and Welch, 1976; Angrist and Evans, 1998.) More interestingly, the interaction between indigenous language dummy **Inspker** and the three-same-sexed-children dummy **Ssex3** is found significant. A positive coefficient is estimated. Hence, if two otherwise similar women have three girls (or three boys) in a row in their first three pregnancies, the indigenous individual is more likely to cross the hurdle than the non-indigenous individual.

Introducing Gamma unobserved individual heterogeneity into the framework does not result in huge parameter changes (see column 4, table 2.) In fact, signs remain stable in both hurdle and post-hurdle process. Two previously significant variables become non-significant after Gamma unobserved heterogeneity is allowed. In particular, **Catholic** is no longer significant in the post-hurdle Poisson count process and the interaction dummy **Ssex3xIndspker** becomes insignificant in the hurdle.

Though a simple t-test concludes that parameter α is significantly different from zero -suggesting that the data is over-dispersed-, a $\chi^2(01)$ statistic for the significance of α is practically zero. Thus, the null $\alpha = 0$ cannot be rejected at any standard confidence level. Information selection criteria support this conclusion as Akaike, Consistent Akaike and Lamer-Schwarz metric conclude all that a Poisson Hurdle should be preferred to a Negative Binomial Hurdle. In a few words, unobserved individual heterogeneity does not appear to be present in the post-hurdle count process.

A final extension considers an endogenous treatment (or sample selection) Poisson Hurdle model. This specification includes an unobserved individual heterogeneity term in the hurdle in addition to the already integrated heterogeneity term in the post-hurdle count. Correlation between these the two unobserved characteristics is explicitly allowed and for simplicity it is assumed that they are jointly normal distributed. As a consequence, the hurdle is parameterised as Probit instead of Logit. Results are included in column (5) of Table 2.

Coefficients on explanatory variables in hurdle and post-hurdle processes in column (5) share signs with their corresponding entries in columns (4) and (3). Thus, there is a general consistency of the results draw from different statistical models. Moreover, coefficients for the post-hurdle Poisson count in columns (5) and (3) are fairly close. In the case of the hurdle, obviously, estimates are not directly comparable as different functional forms are being used. However, if the coefficient transformation rule $0.625\text{logit} = \text{Probit}$ is used results turn to be very similar. Take for instance the case of **Catholic**. From column (3) the Logit coefficient on Catholic is -0.3328 . Thus, its

equivalent Probit would be calculated as $(0.655)(-0.2228) = -0.083$. A figure that is very close to the coefficient on **Catholic** in the hurdle part of column (5), -0.0814.

There is still the issue of the adequacy of the sample selection Poisson Hurdle model. At the bottom of column (5) of table 2 estimates for σ^2 and ρ are reported. There it can be confirmed that a negative and significant correlation coefficient between unobserved heterogeneity terms in hurdle and post-hurdle processes is estimated. However, a t-test shows that the null $\sigma^2 = 0$ cannot be rejected at any standard confidence level. Hence, empirical evidence indicates that unobserved individual heterogeneity in the post-hurdle count process is not present; suggesting that a sample selection Poisson Hurdle does not describe adequately the data. Using Akaike information criteria to select models (5) and (3) leads to choose the simple Poisson Hurdle. Therefore, the best fitting model is the Poisson Hurdle regression reported in column (3).

Table 3 presents marginal effects for the Poisson Hurdle model. Marginal effects for the post-hurdle process are expressed in terms of unit changes in the expected number of children given that the hurdle has been crossed. Similarly, marginal effects in the Hurdle process are expressed in terms of unit changes on the likelihood of crossing the three-children threshold.

According to the results presented in table 3, *ceteris paribus*, a Catholic woman that has more than three children is expected to have on average 0.18 children fewer children than a non-Catholic woman that has also crossed the three-children threshold. Similarly, conditional on crossing the hurdle, an additional year of formal education at age 12 reduces expected family size by 0.2912 children, other things held constant. Finally, indigenous women are on average expected to have 0.2823 more children than a non-indigenous women. Generation effects seem to be the most important factors explaining a reduction of completed fertility given that a 'high fertility norm' has been chosen. In fact, women born in the 1955-1959 cohort is estimated to have 1.18 fewer children than the base age group 1940-1944 *ceteris paribus*.

In the case of the hurdle it is found that the single most 'important' variable affecting the likelihood of crossing the three-children threshold is **Ssex3** –see column (2) of

table 3. In fact, a woman that unlucky has three boys or three girls in her first pregnancies is 26% more likely to cross the hurdle than a woman that has instead a combination of girls and boys. In the case of indigenous individuals such a differential increases nearly to 36%. Generation dummies come second in importance as long as the `size' of the marginal effect concerns. As it can be seen in column (2) of Table 3, people born between 1955 and 1959 is 14% less likely of having more than three children than people in the reference group 1940-1944. Marginal effects for **Catholic** and **Indspker** are much less `importat.' In fact **Indspker** has a statistically insignificant marginal effect attached.

7. Conclusions

The present paper reports a study on the socio-economic determinants of completed fertility in Mexico. Special attention is given to how socio-economic factors such as religion and ethnic group affect the likelihood of transition from low to high parities -here represented by a hurdle at three children. This methodological approach allows the researcher to enquiry about the role that religion and ethnic group have played in the process of adoption and diffusion of a low fertility norm and contraception in the last few decades in Mexico. The paper is based on the analysis of data from the National Survey of Demographic Dynamics 1997 (ENADID.) A series of alternative count models are implemented, including hurdle Poisson and Negative Binomial models. Also, to complete the picture, an endogenous treatment (or sample selection) count data model is estimated. Under this last econometric specification unobserved characteristics affecting the decision of crossing the three-children threshold can be correlated with unobserved characteristics entering the post-hurdle count process. Thus, any potential sample selection bias is explicitly controlled.

Catholicism is found to be associated to reductions on the likelihood of transiting from low to high parities in Mexico. This result is consistent with the hypothesis that the diffusion of a low fertility norm (and contraception use) proceeds at a faster speed among Catholic than among non-Catholic individuals. The differential on diffusion speed might be induced, among other things, by the presence of social-network effects

within the Catholic community that tend to benefit the diffusion of a low fertility norm.

In other issues, empirical evidence suggests that broad ethnic group does not affect the likelihood of transiting from low to high parities. Thus, it seems that ethnic background does not constitute an obstacle for the diffusion of a low fertility norm in Mexico –which is a bit of good news for the southern States of Mexico such as Chiapas and Oaxaca. Good news is also implied by the fact that better education at age 12 was found to reduce women’s odds of choosing (or following) a high fertility lifestyle.

Conditional on having more than three children, Catholic women are expected to give birth fewer children than non-Catholic women over their entire lifetime. This differential amounts on average 0.18 children per woman. In the same token, indigenous background is found to be associated with an increase on completed fertility of around 0.28 children per woman. In other words, given that the three-children threshold has been crossed, indigenous background increases significantly expected count. Finally, as suggested by economic theory, higher education at age 12 is found to decrease women’s number of children at the end of fertile life.

EndNotes

1. There are available various econometric strategies for estimating endogenous treatment count models. Firstly, Terza (1998) and Green (1997) suggest a two-stage method of moments (TSM) just in the spirit of Heckman’s sample selection model –see Heckman, 1979. A second strategy, considered by Terza (1998), is based on a non-linear weighted least squares (NWLS) estimator for a Poisson model. Finally, Terza (1998) introduces a Full Information Maximum likelihood procedure (FIML.) The present work uses this last strategy.
2. For technical reasons a sample selection count model requires unobserved individual heterogeneity be distributed as a lognormal variable. Other

distributional assumptions, such as Gamma heterogeneity, simply do not allow enough flexibility. For a further discussion of this issues see Green (1997).

3. Provided that a constant is present, the mean of the heterogeneity term v_i is one. Hence in both models Poisson and Negative binomial $E[y_i | x_i] = \mathbf{m}_i = \exp[x_i' \mathbf{b}]$ and the marginal effect of a continuous variable x_k can be estimated as $E[y_i | x_i] \mathbf{b}_k$. In the case of a dummy variable x_q the marginal effect may be calculated simple as $E[y_i | x_q=1] - E[y_i | x_q=0]$. Standard errors are calculated using the delta method.

References

1. Angrist, J; Evans, W. (1998) Children and Their Parents Labour Supply: Evidence from Exogenous Variation on Family Size. *American Economic Review* **88** (3), 450-77.
2. Arulampalam, W; Booth, A. (1997) Who gets over the training hurdle? A study of The training experiences of young men and women in Britain. *Journal of Population Economics* 10, 197-217.
3. Bala, V.; Goyal, S. (2000) A Noncooperative Model of Network Formation. *Econometrica* 68 (5), 1181-1229.
4. Becker, G. (1960) An Economic Analysis of Fertility in Demographic Change in Developed Countries. Princeton University Press and NBER.
5. Becker, G; Lewis, G. (1973) On the interaction between the quantity and quality of children. *Journal of Political Economy* **81**, suppl., s279-s288.
6. Ben-Porath, Y; Welch, F. (1976) Do Sex Preferences Really Matter? *Quarterly Journal of Economics* **90** (2), 285-307.
7. Bongaarts, J.; Menken, J. (1983) The Supply of Children: A critical essay. In Rodolfo A. Bulatao and Ronad D. Lee (ed.), *Determinants of Fertility in Developing Countries: A summary of Knowledge*, Vol. 1, 27-60. New York, Academic Press.
8. Bongaarts, J; Walkins, S. (1996) Social Interactions and Contemporary Fertility Transitions. *Population and Development Review* **22** (4), 639-82.
9. Cabrera, G. (1994) Demographic Dynamics and Development: The Role of Population Policy in Mexico. *Population and Development Review* **20** (0), suppl. 1994, 105-20.

10. Cameron, A.; Trivedi, P. (1986) Econometric Models based on Count Data: Comparison and Applications of some Estimators and Test. *Journal of Applied Econometrics* 1, 29-53.
11. Chwe, S. (2000) Communication and Coordination in Social Networks. *Review of Economic Studies* 67, 1-16.
12. CONAPO (2001) El Comportamiento Reproductivo de la Población indígena.
13. CONAPO (2002) National Population Development Plan 2001-2006.
14. Dutta, B.; Jackson, O. (2001) On the Formation of Networks and Groups. Manuscript.
15. Easterlin, R. (1975) An Economic Framework for Fertility Analysis. *Studies in Family Planning* 6 (3), 54-63.
16. Easterlin, R. (1987) Birth and Fortune: The Impact of Numbers on Personal Welfare, 2nd. edn. University of Chicago Press, Chicago.
17. Ellison, G.; Fudenberg, D. (1995) Word-of-Mouth Communication and Social Learning. *Quarterly Journal of Economics* 110 (1), 93-125.
18. Eswaran, M. (2002) The employment of women, fertility, and child mortality: Towards a theoretical analysis. *Journal of Population Economics* 15, 433-454.
19. Freedman, R.; Takeshita, J. (1969) Family Planning in Taiwan: An Experiment in Social Change. Princeton University Press.
20. Galeotti, A.; Goyal, S. (2002) Network Formation with Heterogeneous Players. Manuscript.
21. Gerosky, P. (2000) Models of Technology Diffusion. *Research Policy* 29, 603-625.
22. Gomez, L. (1996) La fecundidad y el crecimiento de la descendencia. *Demos* 9, 12-13.
23. Gourieroux, C.; Monfort, A.; Trognon, A. (1984) Pseudo Maximum Likelihood Methods: Applications to Poisson Models. *Econometrica* 52, 701-721.
24. Greene, W. (1997) FIML Estimation of Sample Selection Models for Count Data. *Stern School of Business*, Manuscript.
25. Groh, C. (2002) Communication Networks and Cooperation. Manuscript.
26. Heckman, J. (1979) Sample Selection Bias as a Specification Error. *Econometrica* 47 (1), 153-162.

27. Hindin, M. (2000) Women's autonomy, women's status and fertility-related behavior in Zimbabwe. *Population Research and Policy Review* **19**, 255-82.
28. INEGI (2000) Estadísticas Históricas de México.
29. INEGI (2001a) Censo de Población 2000.
30. INEGI (2001b) Sistema de indicadores para el seguimiento de la situación de la mujer en México.
31. Jackson, M.; Wolinsky, A. (1996) A Strategic Model of Social and Economic Networks. *Journal of Economic Theory* **71**, 44-74.
32. Juárez, F.; Quilodrán, J. Mujeres Pioneras del Cambio Reproductivo en México. *Revista Mexicana de Sociología* **52** (1), 33-49.
33. Kapur, S. (1995) Technological Diffusion with Social Learning. *The Journal of Industrial Economics* **XLIII** (2), 173-95.
34. Klawon, E.; Tiefenthaler, J. (2001) Bargaining over family size: The determinants of fertility in Brazil. *Population Research and Policy Review* **20** (5), 423-40.
35. Kirman, A. (1993) Ants, Rationality and Recruitment. *The Quarterly Journal of Economics* **108** (1), 137-156.
36. Kohler, H. (1997) Learning in Social Networks and Contraception Choice. *Demography* **34** (3), 369-83.
37. Kohler, H. (2000) Fertility Decline as a Coordination Problem. *Journal of Development Economics* **63**, 231-63.
38. Lippert, S.; Spagnolo, G. (2002) Networks of Relations. Manuscript.
39. Linstrom, D. (1998) The Role of Contraceptive Supply and Demand in Mexican Fertility Decline: Evidence from a Microdemographic Study. *Population Studies* **52**, 255-274.
40. Macunovich, D. (1997) A Conversation with Richard Easterlin. *Journal of Population Economics* **10**, 119-136.
41. Mier, T; Rabel, C (1990) Introducción: la transición demográfica en la década de los ochenta. *Revista Mexicana de Sociología* **52** (1), 1-32.
42. Melkersson, M; Rooth, D. (2000) Modeling Female Fertility Using Inflated Cuont Data Models. *Journal of Population Economics* **13** (2), 189-203.

43. Montgomery, M.; Casterline, J. (1993) The Diffusion of Fertility Control in Taiwan: Evidence from Pooled cross-section time-series models. *Population Studies* **47**, 457-79.
44. Nguyen-Dinh, H. (1997) A Socioeconomic Analysis of the Determinants of Fertility: The case of Vietnam. *Journal of Population Economics* **10**, 251-271.
45. Rogers, E.; Kincaid, D. (1981) *Communication Networks: Toward a New Paradigm for Research*. New York, Free Press.
46. Rosero-Bixby, L.; Csterline, J. (1993) Modelling Diffusion Effects in Fertility Transition. *Population Studies* **47** (1), 147-67.
47. Santos Silva, J.; Covas, F. (2000) A Modified Hurdle Model for Completed Fertility. *Journal of Population Economics* **13** (2), 173-88.
48. Terza, J. (1998) Estimating count data models with endogenous switching: Sample selection and endogenous treatment effects. *Journal of econometrics* **84**, 129-154.
49. Van de Walle, E. (1992) Fertility Transition, conscious choice and numeracy. *Demography* **29** (4), 487-502.
50. Welti, C (1997) Cambios en la fecundidad. *Demos* **10**, pp. 16-18.
51. Willis (1973) A New Approach to the Economic Theory of Fertility. *Journal of Political Economy* **81**, s14-s63.
52. Winkelmann, R; Zimmermann, K. (1995) Recent Developments in Count Data Modelling: Theory and Application. *Journal of Economic Surveys* **9** (1), 1-24.
53. Winkelmann, R. (2000) *Econometric Analysis of Count Data*. Srpinger, Berlin.
54. World Bank (2001) World development indicators.
55. Zimmermann, M.; Eguíluz, V. (2001) Cooperation, Social Networks and the Emergence of Leadership in a Prisoner Dilemma with Adaptive Local Interactions. Manuscript.

Table 1. Descriptive Statistics

Variable	Description	Mean	Std. Dev.	Min	Max
Age	age in years	45.93	4.21	40.00	54.00
Children	number of children ever born alive	4.42	2.75	0.00	18.00
Edu12	Completed years of schooling at age 12	4.07	2.33	0.00	6.00
Religion and Ethnic group					
Catholic	=1 if Catholic; 0 otherwise	0.89	-	-	-
indspkr	=1 if indian language speaker; 0 otherwise	0.09	-	-	-
Cohort					
c4044	=1 if born within 1940-1944; 0 otherwise	0.09	-	-	-
c4549	=1 if born within 1951-1955; 0 otherwise	0.29	-	-	-
c5054	=1 if born within 1956-1960; 0 otherwise	0.36	-	-	-
c5559	=1 if born within 1961-1965; 0 otherwise	0.25	-	-	-
Offspring sex composition					
Ssex3	=1 if first three children are of the same sex; 0 otherwise	0.20			
+ 32 birth place dummies					
Number of observations				19,559	

Table 2
Regression Results
Coefficient [Std. Err.]

	Standard Models		Hurdle Models		Sample Selection Hurdle
	(1) Poisson	(2) Negative Binomial	(3) Poisson	(4) Negative Binomial	(5) Poisson
Count Process					
Constant	1.7852 [0.0236]**	1.7919 [0.0277]**	1.9484 [0.0304]**	1.9966 [0.0302]**	1.9490 [0.0304]**
Education, Religion and Ethnic group					
Catholic	-0.0672 [0.0110]**	-0.0673 [0.0133]**	-0.0301 [0.0127]*	-0.0228 [0.0128]	-0.0300 [0.0127]*
Indspker	0.0560 [0.0128]**	0.0599 [0.0156]**	0.0461 [0.0144]**	0.0433 [0.0145]*	0.0461 [0.0144]**
Edu12	-0.0898 [0.0015]**	-0.0911 [0.0019]**	-0.0479 [0.0018]**	-0.0401 [0.0018]**	-0.0475 [0.0019]**
Cohort (base 1940-1944)					
c4549	-0.0752 [0.0119]**	-0.0779 [0.0146]**	-0.0699 [0.0133]**	-0.0693 [0.0134]**	-0.0697 [0.0133]**
c5054	-0.1701 [0.0118]**	-0.1729 [0.0144]**	-0.1421 [0.0133]**	-0.1374 [0.0134]**	0.1416 [0.0133]**
c5559	-0.2404 [0.0127]**	-0.2427 [0.0153]**	-0.1971 [0.0144]**	-0.1889 [0.0146]**	-0.1963 [0.0145]**
+ 31 birthplace dummies (base Mexico City)					
Hurdle at three					
Constant	-	-	1.8728 [0.0799]**	1.8164 [0.0793]**	1.1174 [0.0471]**
Education, Religion and Ethnic group					
Catholic	-	-	-0.1328 [0.0524]*	-0.1278 [0.0521]*	-0.0814 [0.0315]**
Indspker	-	-	-0.0227 [0.0645]	-0.0153 [0.0642]	-0.0116 [0.0382]
Edu12	-	-	-0.3093 [0.0077]**	-0.3012 [0.0077]**	-0.1855 [0.0045]**
Offspring sex composition					
Ssex3	-	-	1.2305 [0.0464]**	1.1965 [0.0460]**	0.7448 [0.0272]**
Ssex3xIndspker	-	-	0.4345 [0.1893]*	0.3538 [0.1822]	0.2030 [0.1012]*
Cohort (base 1940-1944)					
c4549	-	-	-0.1623 [0.0628]**	-0.1550 [0.0625]*	-0.0932 [0.0374]*
c5054	-	-	-0.4342 [0.0611]**	-0.4206 [0.0607]**	-0.2576 [0.0364]**
c5559	-	-	-0.5911 [0.0634]*	-0.5748 [0.0630]**	-0.3541 [0.0379]**
Alpha	-	0.0924 [0.0034]**	-	0.0069 [0.0008]**	-
sigma	-	-	-	-	0.0049 [0.0088]
rho	-	-	-	-	-0.8457 [0.1791]**
chi2(01) for alpha	-	1193.48	-	0.0000	-
Prob >chi2(01)	-	0.0000	-	1.0000	-
Log-likelihood	-45,142.99	-44,546.25	-34,375.83	-34,525.39	-34,382.586
chi2	6,232.91	1,552.94	1,552.94	1,196.05	1,310.75
Prob >chi2	0.0000	0.0000	0.0000	0.0000	0.0000
AIC	90,361.98	89,170.50	68,845.66	69,146.00	68,863.16
CIAC	90,699.47	89,516.87	69,263.08	69,573.08	69,298.34
LM	-45,330.73	-45,738.93	-34,608.04	-34,757.60	-33,624.67
Number of observations	19,559	19,559	19,559	19,559	19,559

Note: ** significant at 1% ; * significant at 5%.

Table 3
Hurdle at Three Poisson Regression
Marginal Effect [Std. Err.]

	(1) Post-Hurdle Process	(2) Hurdle
Education, Religion and Ethnic group		
Catholic	-0.1840 [0.0779]*	-0.0315 [0.0123]**
Indspker	0.2823 [0.0891]**	-0.0055 [0.0156]
Edu12	-0.2912 [0.0110]**	-0.0742 [0.0018]**
Offspring sex composition		
Ssex3	-	0.2602 [0.0082]**
Ssex3xIndspker	-	0.0987 [0.0400]*
Cohort (base 1940-1944)		
c4549	-0.4231 [0.0801]**	-0.0392 [0.0153]*
c5054	-0.8590 [0.0801]**	-0.1050 [0.0148]**
c5559	-1.1811 [0.0860]**	-0.1443 [0.0155]**

Note: ** significant at 1% ; * significant at 5%. Marginal effect of variable x in (1) represents the unit change of expected number of children induced by a unit increase on x given that the hurdle has been crossed. Marginal effect of variable x in (2) represent the unit change of the likelihood of crossing the hurdle induced by a unit change on x.