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A Multinomial Model of Fertility Choice and Offspring Sex-Ratios in India

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Abstract

Fertility decline in developing countries may have unexpected demographic consequences. Although lower fertility improves nutrition, health, and human capital investments for surviving children, little is known about the relationship between fertility outcomes and female-male offspring sex-ratios. Particularly in countries with a cultural preference for sons, like India and China, fertility decline may deteriorate the already imbalanced sex-ratios. We use the fertility histories of over 90,000 Indian women in the Second National Family and Health Survey to investigate the relationship between fertility choices and offspring sex-ratios in India. Both *within-* and *between-family-size* differences in offspring sex-ratios are examined. Our analysis reveals three main findings. First, within-family-size differences show that for our reference household (i.e. non-low-caste Hindus), parental education reduces anti-female bias in survival in large families (three or more children households) but plays no role in small families (one or two children households). While a higher standard of living worsens anti-female bias in survival in both large and small families, it does so to a greater extent in small families. Small families that own land also have lower offspring sex-ratios compared to landless households. Second, between-family-size differences indicate an 'intensification' effect, whereby small families have dramatically lower offspring sex-ratios than large families. The intensification effect is greatest for Sikh and non-low-caste Hindu households, followed by low-caste Hindu and Christian households, but does not exist for Muslims. Third, while maternal education and urban residence weaken the intensification effect, paternal education, a higher standard of living, and land ownership strengthen it. Our results suggest that fertility decline, together with economic growth, may worsen India's already imbalanced sex-ratios. Thus, much needed fertility control policies must be supplemented with programs that counter offspring sex-selection in favor of sons. Policies that seek to eradicate son preference by making daughters more economically attractive to parents as well as those that imbibe more gender-equal attitudes within individuals are critically needed as economic growth generates higher levels of education and wealth in India.

JEL Codes: J11, J16, O12
Keywords: Female Disadvantage, Mortality, Son Preference, Fertility, India

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1 Introduction

During the past half century, India has experienced two striking demographic features. First, fertility has declined rapidly, as evidenced by the total fertility rate falling from 6.0 in 1951 to 2.7 in 2005, as shown in Figure 1.[1] Second, as Figure 2 shows, female disadvantage in survival among children has worsened. Despite a significant increase in the availability of health care and improved nutrition, the relative number of girls under five has fallen dramatically, from 1010 in 1941 to 927 girls per 1000 boys in 2001. The stark inter-regional heterogeneity of sex-ratios at birth is particularly striking in this respect, with state-level rates varying from 0.78 and 0.79 in Haryana and Punjab to 1.00 and 0.99 in Arunachal Pradesh and Mizoram, respectively.[2] The map in figure 3 illustrates this geographic pattern and clearly shows a concentration of the missing women phenomenon in the Northwest part of the country.

In this paper, we explore the relationship between fertility choices and offspring sex-ratios in India using fertility histories of over 90,000 women aged 15-49 years. Both *within-* and *between-*family-size differences in offspring sex-ratios are examined by focusing on small and large families. We define small families as those with one or two children whereas large families are those with three or more children. We find three interesting results. First, focusing on the reference household – i.e. Hindu households who are *not* members of a scheduled caste, scheduled tribe, or other backward caste – within-family-size differences show that parental education reduces anti-female bias in survival in large families but *not* in small families. While a higher standard of living worsens anti-female bias in survival in both large and small families, it does so to a greater extent in small families. Small families that own land also have lower offspring sex-ratios compared to landless households. Second, between-family-size differences indicate an 'intensification' effect, whereby small families have dramatically lower offspring sex-ratios than large families. The intensification effect is greatest for Sikh and non-low-caste Hindu households, followed by Christian and low-caste

[1] The total fertility rate measures the number of children a woman would have during her reproductive years if in each five-year age interval from ages 15-49 she had the number of children that women of that age currently have in the population as a whole.

[2] The US reference rate is around 0.95.

Hindu households, but does not exist for Muslims. Third, while maternal education and urban residence weaken the intensification effect, paternal education, a higher standard of living, and land ownership are found to strengthen it.

Our results suggest that the financial burden of daughters may not be the primary reason why parents discriminate against girls. There is ample evidence that inadequate economic returns to investments in daughters' education and health, as a result of lower female work participation rates, as well as excessive dowry payments lower the economic value of daughters relative to sons in India. However, a relaxation of economic constraints, which are brought about by wealth and to some extent parental education, should raise the relative value of daughters compared to sons. Moreover, parents who choose to have small families will have fewer financial constraints in raising their children compared to those who have large families. Therefore, if sex-selection is driven primarily by economic constraints and a higher cost of raising daughters relative to sons, then parents with smaller families and especially those with education and greater wealth should face less incentives to discriminate against daughters. In this case, small families with educated parents and a higher standard of living should have more balanced offspring sex-ratios. Our results reveal that small families not only have *lower* female-male offspring sex-ratios – the intensification effect – but also that paternal education, a higher standard of living, and land ownership *worsen* anti-female bias in survival within small families. The preference for sons therefore appears to overpower the relaxation of economic constraints that may make daughters more attractive to parents.

The consequences of deteriorating sex-ratios in a country already experiencing a scarcity of women may be dire. Not only will more unwanted daughters be terminated, either before or after birth, but this may also result in social problems as more and more men remain unmarried. For example, Hudson & den Boer (2004) explain that a shortage of women for marriage may result in the majority of low-status men remaining unmarried or paying a bride price in order to obtain a wife. In India, the shortage of eligible women does not seem to have led to a general rise in their value and bargaining power both before and after marriage. A simple equilibrium argument would predict that the lack of women for marriage in the areas with the lowest sex-ratios would have been followed by a fall in dowries which, in turn, would induce parents to raise more girls. This does not seem to have happened. On the contrary, the severe lack of women in certain regions of India seems to have resulted in increased trade in "brides" between states, forced prostitution, and sexual abuse of women and children.[3]

Important policy conclusions can be drawn from our results. It is essential that India's much needed family planning programs are accompanied by policies that seek to create more balanced sex-ratios. More widespread education and increased wealth – both changes that India's rapidly growing economy will generate – may not improve offspring sex-ratios in a country dominated by son preference and daughter aversion. On the contrary, our results suggest that increases in education and wealth may deteriorate India's already skewed offspring sex-ratios, especially as fertility begins to decline. Education and wealth may *directly* lower offspring sex-ratios by increasing households' access to pre-natal sex-selection technology. However, these factors may also lower offspring sex-ratios *indirectly* by inducing fertility decline.

Thus, policies that seek to eradicate son preference by making daughters more economically attractive to parents are critically needed. These may include education, health, and food subsidies to families with only daughters, free college education and reservation of well-paid public sector jobs for women, as well as strict enforcement of the minimum age at marriage for women and anti-dowry legislation. Policies that target wealthier parents are even more necessary since greater wealth not only induces fertility decline but also increases access to pre-natal sex-selection technologies. Inculcating more gender-equal attitudes within individuals, either through education or the media, may play a role in diminishing son preference and daughter aversion. While family planning and lower fertility are critical for India's economic development, individuals' fundamental preference for sons must be acknowledged and addressed in order to avoid any unwanted consequences of fertility decline.

In the literature on imbalanced sex-ratios, few papers allow for fertility outcomes to influence

[3]BBC World News, 5 April 2006.

anti-female bias in birth and survival, even though fertility choices can play a significant role in altering offspring sex-ratios. As discussed in Das Gupta & Bhat (1997), fertility decline can have two potential effects on offspring sex-ratios – a 'parity' or an 'intensification' effect. Based on the observation that excess mortality of daughters in South Asia is concentrated among higher parities (Das Gupta 1987, Muhuri & Preston 1991, Pebley & Amin 1991), the parity effect predicts that fertility decline will improve offspring sex-ratios in favor of daughters. However, studies in China and South Korea (Hull 1990, Yi et al. 1993) show that anti-female bias in survival has intensified at each parity as fertility has declined. If the number of children desired by parents falls more rapidly than the number of sons they desire, female-male offspring sex-ratios will decline as fertility declines. Das Gupta & Bhat (1997) find that the intensification effect dominated the parity effect during the 1980s in India. Ding & Hesketh (2006) find that the one child policy in China introduced a sharp decline in the total birth rate and preferred family size while at the same time, the female-male birth ratio deteriorated considerably. More recently, Ebenstein (2007) simulates a model and finds that a subsidy paid to Chinese families without a son will not only lower fertility but will also create more balanced sex-ratios.

Our paper builds on the existing literature by examining the relationship between fertility choices and offspring sex-ratios using a multinomial model of fertility and sex-selection. We examine both between- and within-family-size differences in offspring sex-ratios and focus on household characteristics, such as parental education, standard of living, land ownership, and sector of residence, that may influence both fertility and sex-selection. We incorporate several methodological innovations in this paper. First, in contrast to the vast majority of the previous work that has relied for various reasons on aggregated data, our analysis employs *household* level data to examine household decisions about offspring sex-selection. Second, we include offspring sex-selection in a more general setting of fertility outcomes. Rather than examine the relative preference for boys and girls, women's choice sets are expanded to include the option not to have any (more) children. Embedding sex-selection into a broader fertility framework provides more precise empirical evidence for parental motivation. Third, in examining the relationship between fertility choices and offspring sex-ratios, we control for persistent mother-specific traits that may affect gender-specific mortality outcomes. Fourth, we allow for differences in the relationship between fertility choices and offspring sex-ratios by religion, caste, parental education, standard of living, land ownership, and sector of residence – all factors that may influence both fertility and sex-selection.

Even though we control for mother-specific unobservables which may affect both fertility choices as well as offspring sex-ratios, the possibility of reverse causation between the number of children parents have and the gender composition of those children still exists.[4] Although our coefficient estimates cannot be interpreted as *causal* due to the possibility of reverse causation, our analysis does provide evidence of a robust positive *correlation* between family size and female-male offspring sex-ratios. Moreover, this correlation exists even though we control for persistent genetic and environmental factors that may result in correlations in mortality outcomes among daughters or sons of the same mother.

Using fertility histories of women in the Second National Family Health Survey (1998-99), Figure 4 shows offspring sex-ratios that vary considerably with the number of children a woman has. Using the full sample of women in our data, i.e. women with both complete and potentially incomplete families, one-child families have on average 848 daughters for every 1000 sons.[5] There is a considerable fall in this figure to 755 daughters per 1000 sons in two-child families and 818 daughters per 1000 sons in three-child families. The offspring sex-ratio increases as the number of children increase beyond three and is over 1000 for families with five or more children. The difference in offspring sex-ratios by family size is even more dramatic for women with complete families with one-, two-, and three-child families having an average of 638, 612, and 738 daughters per 1000 sons with the bias reversing for families with five or more children. This figure suggests

[4]For example, if parents are willing and able to use pre- or post-natal sex-selection to achieve their desired gender composition of children, it is likely that fertility choice may determine offspring sex-ratios. On the other hand, for parents who are not willing or able to use sex-selection and are less concerned about having small families, their offspring sex-ratio may well determine how many children they ultimately have. These parents may stop having children only after they achieve their desired gender composition.

[5]Complete families are defined as those where the mother has undergone a permanent method of contraception, i.e. sterilization, or who claim to desire no more children.

that a massive fertility decline in India could have dire consequences for the birth and survival of daughters.

Figures 5 and 6 show differences in offspring sex-ratios and fertility by cohort for two groups of women. The first group consists of women who we define as having complete families – i.e. sterilized women as well as those who do not desire any more children. Since one can argue that women who simply desire no more children may still have more children in the future, we also show offspring sex-ratios and fertility by cohort for only sterilized women, i.e. women who have definitely completed their fertility. Both groups show decreasing offspring sex-ratios and fertility by cohort. Thus, younger women are not only choosing to have fewer children, they are also discriminating against daughters to a greater extent than older women. Together, Figures 1, 2, 5, and 6 are indicative of an intensification effect and also suggest that a massive fertility decline in India may have dire consequences for the birth and survival of daughters.

The paper is organized as follows. Section 2 develops the empirical model and the assumptions behind the estimation procedure, describes the data, and finally discusses two important empirical issues. The results are presented in Section 3 and policy implications discussed in Section 4.

2 The estimation procedure, data, and empirical issues

2.1 The model and estimation

Although it cannot be ruled out that parents have at least some influence over their children's fertility decisions, especially in the context of the Indian joint family system, we treat women as the basic decision making unit in our analysis. Since we do not have information on unmarried women, we assume that only women who are currently or have at some point been married are able to have children. Given the moral sentiment pervasive throughout Indian society, this is probably not a gross misrepresentation of reality. Parents then have the choice between not having any children, or, conditional on having a child, engaging in sex-selection or not. The process in which this choice is made is likely to be complex and highly non-linear and we take a reduced-form approach by specifying the probabilities directly without deriving them from a utility-maximization framework.

In order to specify the empirical model, we assume that in every year after she has been married, $i \in \{1, \ldots, I_h\}$, a woman in our sample, $h \in \{1, \ldots, H\}$, can either give birth to a boy, $\{b\}$, a girl, $\{g\}$, or not have any children at all, an outcome denoted by $\{n\}$. To account for the natural limit on fertility, the cut-off point I_h is determined as the maximum of years she has been married at either the time of the survey or when she reached age 45. Letting $c \in C = \{b, g, n\}$ stand for a particular fertility outcome, the number of boys, y_h^b, and girls y_h^g, a woman h has given birth to, as well as the number of years in which she has not had any children y_h^n then follows a multinomial distribution with probabilities $\mathbf{p}_h = (p_{ch})_{c \in C}$,

$$\binom{I_h}{y_h^b, y_h^g, y_h^n} {p_{bh}}^{y_h^b} {p_{gh}}^{y_h^g} {p_{nh}}^{y_h^n}$$

where $p_{nh} = 1 - p_{bh} - p_{gh}$ and $y_h^n = I_h - y_h^b - y_h^g$.

The probability vectors $\mathbf{p}_h$ are assumed to be constant and determined by a vector of covariates, $\mathbf{x}_h$, and unobservable woman level random effects, η_{ch}. This random effect specification models idiosyncratic differences in preferences or biological factors which cannot be accounted for by the covariates and which are not directly observable. We can then write the probability that a given woman h experiences a fertility outcome $c \in C$, conditional on η_{ch}, as

$$p_{ch}(\mathbf{x}_h, \eta_{ch}) = \frac{\exp(\mathbf{x}_h \beta_c + \eta_{ch})}{\sum_{c \in C} \exp(\mathbf{x}_h \beta_c + \eta_{ch})} \tag{1}$$

As in Guimarães & Lindrooth (2007) we assume that the random elements $\exp(\eta_{ch})$ follow independent gamma distributions $\Gamma(\varphi_{ch}, {\varphi_{ch}}^{-1})$ where, for convenience of notation, $\varphi_{ch} = \exp(\mathbf{x}_h \beta_c)$ denotes the deterministic part of the probabilities. While this imposes a fairly rigid structure on the random effects $\exp(\eta_{ch})$, in particular making their variances $\text{var}(\exp(\eta_{ch})) = {\varphi_{ch}}^{-1}$ a function of the covariates, it has the desirable property that the products $\varphi_{ch} \exp(\eta_{ch})$ follow a gamma distribution with shape and scale parameters φ_{ch} and 1, respectively. As a consequence, the probability vectors $\mathbf{p}_h$ are stochastic and, as shown by Mosiman (1962), have independent multivariate β-distributions

(Dirichlet distributions) with parameters $(\varphi_{bh}, \varphi_{gh}, \varphi_{nh})$, that is $\mathbf{p}_h \sim \beta(\varphi_{bh}, \varphi_{gh}, \varphi_{nh})$, or

$$f(p_{bh}, p_{gh}) = \frac{\Gamma(\sum_C \varphi_{ch})}{\prod_C \Gamma(\varphi_{ch})} {p_{bh}}^{\varphi_{bh}-1} {p_{gh}}^{\varphi_{gh}-1} {p_{nh}}^{\varphi_{nh}-1} \qquad (2)$$

where $p_{nh} = 1 - p_{bh} - p_{gh}$ and $\Gamma(\bullet)$ stands for the gamma function.

The unconditional probability that a woman has given birth to y_h^b boys and y_h^g girls in the I_h years since her wedding can then be written as

$$\binom{I_h}{y_h^b, y_h^g, y_h^n} \int_0^1 \int_0^1 {p_{bh}}^{y_h^b} {p_{gh}}^{y_h^g} {p_{nh}}^{n_h^g} f(p_{bh}, p_{gh}) dp_{bh} dp_{gh} \qquad (3)$$

where $p_{nh} = 1 - p_{bh} - p_{gh}$ and $y_h^n = I_h - y_h^b - y_h^g$.

Making use of a result by Mosiman (1962), a closed form solution for equation 3 with probability vectors from equation 2 can be found,

$$\binom{I_h}{y_h^b, y_h^g, y_h^n} \frac{\Gamma(\sum_C \varphi_{ch}) \prod_C \Gamma(\varphi_{ch} + y_h^c)}{\prod_C \Gamma(\varphi_{ch}) \Gamma(\sum_C \varphi_{ch} + I_h)}$$

where $\Gamma(\bullet)$ again represents the gamma function.

We can then write the likelihood function for our empirical model as

$$L = \prod_{h \in H} \binom{I_h}{y_h^b, y_h^g, y_h^n} \frac{\Gamma(\sum_C \varphi_{ch})}{\Gamma(\sum_C \varphi_{ch} + I_h)} \prod_{c \in C} \frac{\Gamma(\varphi_{ch} + y_h^c)}{\Gamma(\varphi_{ch})}. \qquad (4)$$

where $\varphi_{ch} = \exp(\mathbf{x}_h \beta_c)$ as defined above.

Guimarães (2005) points out that the maximum likelihood function in equation 4 is equivalent to that of a fixed effects negative binomial count data model and that the estimation of the parameter vector $\hat{\beta}_c$ is easily implemented. We therefore estimate a negative binomial count data model with mother-specific fixed effects to obtain the vector of coefficients $\hat{\beta}_c$. The coefficients are, however, not the object of interest in themselves. Rather, we would like to be able to find the probability that a woman with particular characteristics gives birth to a girl or a boy. Due to the stochastic specification of the probabilities (equation 1), the closest we can get to this is the expected probability vector $\mathrm{E}(\mathbf{p}_h)$, that is the vector of probabilities for a *typical* woman with characteristic vector $\mathbf{x}_h$. From the properties of the multivariate β-distribution we know that,

$$\mathrm{E}(p_{ch}) = \frac{\varphi_{ch}}{\sum_C \varphi_{ch}}$$

and therefore the estimated probabilities $\hat{p}_{ch}$ are

$$\hat{p}_{ch} = \frac{\exp(\mathbf{x}_h \hat{\beta}_c)}{\sum_C \exp(\mathbf{x}_h \hat{\beta}_c)} \tag{5}$$

Since the model allows for women not to have any children in a given year, the probability of observing the birth of a girl does not give enough information to make statements about sex-ratios or anti-female bias. It is, however, easy to calculate the estimated sex-ratios (SR) directly as a function of the individual characteristics of a woman.

$$\mathrm{SR}_{gb}(\mathbf{x}_h) = \frac{\hat{p}_{gh}}{\hat{p}_{bh}} = \exp\left[\mathbf{x}_h(\hat{\beta}_g - \hat{\beta}_b)\right] \tag{6}$$

Moreover, the functional form of the expected probabilities makes it easy to compare the sex-ratios of two typical women h and j with different characteristics vectors $\mathbf{x}_h$ and $\mathbf{x}_j$, respectively. From equation 6, it follows that the relative sex-ratio (RSR) can be calculated as

$$\mathrm{RSR}_{gb} = \frac{\mathrm{SR}_{gb}(\mathbf{x}_h)}{\mathrm{SR}_{gb}(\mathbf{x}_j)} = \exp\left[\hat{\beta}_g(\mathbf{x}_h - \mathbf{x}_j)\right] \exp\left[\hat{\beta}_b(\mathbf{x}_j - \mathbf{x}_h)\right] \tag{7}$$

The relative sex-ratio represents an appropriate measure of differences in the anti-female bias of women with different characteristics. Comparing the probability that two women give birth to a girl alone, in contrast, is not sufficient due to the possibility that women do not have any children in a given year. A low probability of having a daughter could thus be due to anti-female bias (if the probability of having a son is high) or to a small family size (if a woman is likely not to have a child in a given year).

2.2 Data

The fertility histories as well as individual characteristics used in the empirical analysis were obtained from the Second National Family Health Survey (NFHS-2) conducted during 1998-99 in 26 states in India.[6] The NFHS-2 is a nationally representative survey that includes a household sample with information about each household and an individual sample covering all ever-married

[6]The survey was carried out by the International Institute for Population Sciences, Mumbai, India, and ORC Macro, Calverton, Maryland.

15-49 year old women within those households. Besides reporting various socio-economic indicators, such as religion, caste, education, standard of living index, land ownership, and occupation of ever-married women and their partners, the entire birth history of each woman is provided. The entire sample consists of 90,303 women. Excluding women who have been married less than one year and have therefore not had any fertility outcome in our definition we are left with 90,287 observations.

The vector of covariates, $\mathbf{x}_h$, consists of several household characteristics which are expected to influence offspring sex-ratios as well as fertility choices. A description of the household characteristics included in the analysis can be found in Table 1. Indicators for religion, caste, parental education, standard of living, land ownership, and sector of residence are included. While the NFHS-2 does not include measures of income, it does have information on assets owned by a household, from which a standard of living index is calculated.[7]

In order to examine between- and within-family size differences, we include an indicator for families that have 1 or 2 children and interact this indicator with all the other covariates included in $\mathbf{x}_h$. The reference household therefore consists of Hindu families with 3 or more children, who do not belong to a scheduled caste, scheduled tribe, or other backward caste. Both parents in the household are uneducated and the household has a low standard of living. The household does not own any land and lives in the rural sector.

2.3 Empirical issues

Two empirical issues are worth discussing in the context of our model. The first is the inclusion of persistent mother-specific traits and the second relates to the sample of families that we choose to use for our analysis.

In estimating the relationship between fertility choices and offspring sex-ratios, we control for

[7]The standard of living index (SLI) is calculated from 11 indicators – i.e. house type, toilet facilities, source of lighting, main fuel for cooking, source of drinking water, separate room for cooking, ownership of house, ownership of agricultural land, ownership of irrigated land, ownership of livestock, and ownership of durable goods. An index score ranging from 0-14, 15-24, and 25-67 constitute a low, medium, and high standard of living, respectively.

persistent mother-specific traits, the absence of which may result in biased coefficients. Controlling for unobservable persistent mother-specific traits that may influence offspring sex-ratios allows for the fact that daughters or sons of the same mother may have correlated mortality risk because of shared genetic or environmental factors. For example, mothers infected with the Hepatitis-B virus (HBV) may be more likely to have sons than daughters (Drew et al. 1986, Oster 2005), resulting in skewed sex-ratios of women with this trait. Similarly, environmental factors – such as access to health clinics, medical facilities, clean water, and sanitation – may have gender-specific effects on mortality risk of children since parents may be more likely to discriminate against daughters if access to medical facilities is scarce (Oster 2007). That we find evidence of a systematic relationship between family size and offspring sex-ratios, even after controlling for persistent mother-specific unobservable characteristics suggests that the intensification effect exists despite genetic or environmental factors that may introduce gender-specific correlations in mortality risk.

In estimating the relationship between fertility outcomes and offspring sex-ratios, it may be more appropriate to focus solely on complete families and still better to restrict the sample to only those families where the mother has undergone sterilization. Even though the relationship between fertility and offspring sex-ratios may be biased in incomplete families, we use the full sample of fertility histories in order to conduct the present analysis. Our main reason for including both complete and potentially incomplete families in our analysis is to preserve a larger sample size which enables us to control for persistent mother-specific traits in our estimation, which is necessary in order to obtain meaningful results.

The second reason for using the full sample rather than only complete families is that at any given point in time, the population consists of both complete and incomplete families. Thus, the overall offspring sex-ratio of the population is always a combination of the offspring sex-ratio of complete and incomplete families. In this empirical analysis, we are ultimately interested in calculating relative sex-ratios as well as predicting future changes in offspring sex-ratios with fertility decline or economic growth among the *overall* population. Thus, the full sample is of relevance to this analysis rather than only complete families.

The third reason why we choose the full sample over complete families relates to the direction of bias of our coefficient estimates. It is important to understand *how* the inclusion of incomplete families in our sample may bias the estimated relationship between fertility outcomes and offspring sex-ratios since future children may substantially change the sex-ratio of a woman's offspring. For example, our finding that small families have worse offspring sex-ratios than large families – i.e. the intensification effect – may not hold if we restrict the sample to include only complete families. This is because women with incomplete families and especially those with only one child will most likely have more children in the future[8]. If daughters are more likely to survive at higher parities, then the offspring sex-ratios of these women may improve as they move from having one child to two children. In this case, we may find that small complete families have higher female-male offspring sex-ratios than small families in the full sample (i.e. both complete and incomplete families). This suggests that an analysis that uses the full sample may either wrongly find an intensification effect or *overestimate* the intensification effect compared to an analysis that uses only complete families. Even though restricting our analysis to complete families may provide a more realistic relationship between family size and offspring sex-ratios, we argue that using the full sample of women most likely *underestimates* the intensification effect. As shown in Figure 4, women with complete families have worse female-male offspring sex-ratios than the full sample at every parity until the sixth child. Moreover, the largest difference occurs for women with one or two children. This observation suggests that complete families may have a stronger intensification effect than the full sample, in which case our estimated relationship between family size and offspring sex-ratios using the full sample may be biased *downwards*, and our results most likely provide a lower limit for the intensification effect.

Given the need for a larger sample to include persistent mother-specific unobservable characteristics, that we are interested in predicting future offspring sex-ratios in the overall population, and the likelihood that using the full sample underestimates the relationship between fertility choices

[8] The average number of children per woman in our sample is 2.6.

and offspring sex-ratios, we use the full sample of women, which includes both complete and potentially incomplete families, rather than restrict the sample to only those women who have completed their fertility histories.

3 Results

Using the coefficient estimates of the model, we first calculate offspring sex-ratios among our two main groups – large families or households with 3 or more children and small families or households with 1 or 2 children. Among households with the reference group characteristics – i.e. Hindu, non-low-caste, uneducated parents, low standard of living, landless, and rural – we find that families with 3 or more children have 963 daughters per 1000 sons whereas families with 1 or 2 children have 823 daughters per 1000 sons. While offspring sex-ratios in both groups reveal anti-female bias in birth and survival, smaller families have worse offspring sex-ratios.

3.1 Within-Family-Size Differences in Offspring Sex-Ratios

We examine within-family-size differences by calculating relative offspring sex-ratios within large and small households separately, which we present in Tables 2 and 3. For each household size, we calculate offspring sex-ratios of the reference household relative to households with a given characteristic (and all other characteristics of the reference household).[9]

Table 2 provides relative sex-ratios for four social groups relative to our reference group – i.e. non-low-caste Hindus – in large and small families. Offspring sex-ratios in large families are about 4% lower in Muslim than in non-low-caste Hindu households. However, in small families, Muslims have offspring sex-ratios that are 19% higher than non-low-caste Hindus. This suggests that with respect to fertility decline, offspring sex-ratios among Muslims may not exhibit anti-female bias as

[9]For example, the offspring sex-ratio of large Muslim relative to large non-low-caste Hindu families with the reference group characteristics (presented in Table 2 (row 1, column 1)) is given by $exp(\hat{\beta}[muslim * female])/exp(\hat{\beta}[muslim * male])$, where $\hat{\beta}[c]$ represents the coefficient estimate of characteristic c. Similarly, $exp(\hat{\beta}[small * educatedmother * female])/exp(\hat{\beta}[small * educatedmother * male])$ gives the offspring sex-ratio of small families with educated mothers (and all other reference group characteristics) relative to small families with uneducated mothers (and all other the reference group characteristics) for non-low-caste Hindus (row 1, column 2 of Table 3).

more parents choose to have one or two children rather than three or more children. Among large families, Christians and Sikhs have similar offspring sex-ratios to non-low-caste Hindus. However, in small families, Christians and Sikhs have offspring sex-ratios that are 10% higher and 18% lower than non-low-caste Hindus, respectively. Low-caste Hindus – that is those who belong to a scheduled caste, a scheduled tribe, or other backward caste – have offpsring sex-ratios that are 3% lower than non-low-caste Hindus in large families. On the other hand, low-caste Hindus have 7% higher offspring sex-ratios than non-low-caste Hindus in small families.

These results reveal that among families with one or two children, Sikhs have the worst offspring sex-ratios, followed by non-low-caste Hindus and low-caste Hindus. Small Muslim families have offspring sex-ratios that are most favorable to daughters, followed by small Christian families. Even though skewed sex-ratios among the Sikh community in the northwest Indian states of Punjab and Haryana is well established in the literature (Das Gupta 1987), this community comprises only a small proportion of the Indian population – both large and small Sikh families represent 2.3% of our sample whereas small Sikh families are 1.1% of the full sample. What is more worrying is that small non-low-caste and low-caste Hindu families have among the lowest offspring sex-ratios in India. These groups constitute the majority of the population. Both large and small Hindu families who do not belong to a low-caste constitute 30% of our sample whereas those who belong to a low-caste represent 48% of the sample. Even though small Hindu non-low-caste and low-caste families constitute only 14% and 18% of our sample, these numbers are expected to increase as more families choose to have one or two children. Thus, fertility decline in India will likely worsen the already skewed offspring sex-ratios in the country.

Table 3 presents relative sex-ratios for large and small families within these five social groups by parental education, standard of living, land ownership, and sector of residence.

Among non-low-caste Hindus (columns (1) and (2)), parental education increases daughters' survival chances relative to sons in large families. In these families, offspring sex-ratios are approximately 5% and 4% higher if the mother and father are educated, respectively. However, in small families, neither an educated mother nor father improves the survival chances of daughters compared to families with uneducated parents. Compared to families with a low standard of living, those with a medium or high standard of living have offspring sex-ratios that are 2% and 8% lower in large and small families, respectively. While land ownership does not change the relative survival chances of daughters in large families, landed households with small families have 5% lower offspring sex-ratios compared to landless households. Finally, within this social group there do not appear to be significant differences in offspring sex-ratios by sector of residence.

Among low-caste Hindus (columns (3) and (4)), maternal education and urban residence improve daughters' relative survival chances in small families whereas a higher standard of living deteriorates offspring sex-ratios in large families.

Among Muslims (columns (5) and (6)), a higher standard of living, land ownership, and urban residence hurt daughters' survival chances relative to sons in large families. However, in small families, parental education, a higher standard of living, land ownership, and urban residence, all increase offspring sex-ratios substantially compared to families with uneducated parents, a low standard of living, no land, and those who reside in the rural sector, respectively. Among small families, maternal education and urban residence improve daughters relative survival chances the most. That education and wealth decrease female disadvantage in survival among small Muslim families is consistent with the hypothesis that gender differences in survival are constraint- rather than preference-driven. One should expect to see offspring sex-ratios rise as not only family size decreases but also as parental education and wealth relax financial constraints in raising daughters. Thus, for Muslims in India, anti-female disadvantage in survival appears to be driven mostly by financial constraints.

For Christians (columns (7) and (8)), maternal education increases daughters' survival chances relative to sons in both large and small families, though paternal education does so only in large families. A higher standard of living and land ownership do not change offspring sex-ratios in large or small families while urban daughters have higher relative survival chances than their rural counterparts in small families. Like small Muslim families, in small Christian families maternal education and urban residence have the largest impact on the survival of daughters.

In Sikh households (columns (9) and (10)), the survival of daughters in large families is not influenced by parental education, a higher standard of living, land ownership, or sector of residence. In small families, all these factors worsen the survival chances of daughters relative to sons. Small families with maternal education and those who live in urban areas have offspring sex-ratios that are 17% and 16% lower than those without maternal education and those who live in rural areas, respectively. Small Sikh families with paternal education, land, and a higher standard of living have offspring sex-ratios that are 21%, 23%, and 25% lower than their those without paternal education, those who are landless, and those with a low standard of living, respectively.

Within-family-size differences in offspring sex-ratios show that parental education, a higher standard of living, land ownership, and urban residence increase the survival chances of daughters relative to sons for some groups and decrease these chances for other groups. While education, wealth, and urban residence are generally expected to diminish son preference by generating more gender-equal and modern ideas and beliefs and by relaxing the financial constraints associated with raising daughters, our results show that these factors may not always work in this way. For some groups, parental education and wealth improve daughters' relative survival chances – for example, maternal education for low-caste Hindus with small families or a higher standard of living for Muslims with small families. In other groups, these factors have no influence on daughters' survival chances relative to sons, such as parental education in non-low-caste small Hindu families. What is dangerous to the future survival of girls, however, is that parental education and especially wealth increase female disadvantage in survival in several groups – for example, both maternal and paternal education in small Sikh families and a higher standard of living in small and large non-low-caste Hindu families, large Muslim families, small Sikh families, and large low-caste Hindu families. For these households, which constitute a large proportion of India's population, parental education and wealth appear to either intensify son preference or make it easier for parents to engage in (pre-natal) sex-selection, or both.

3.2 Between-Family-Size Differences in Offspring Sex-Ratios

In order to examine between-family-size differences, we calculate offspring sex-ratios of large relative to small families.[10] Table 4 presents these relative sex-ratios and their respective chi-square test statistics and significance levels in parentheses.[11]

The first row of Table 4 presents the sex-ratio of large relative to small families for households in the reference group – i.e. those with uneducated parents, a low standard of living, no land, and rural residence – for non-low-caste Hindus (column 1), low-caste Hindus (column (2)), Muslims (column 3), Christians (column 4), and Sikhs (column 5). Row 1 of Table 4 shows that families with 1 or 2 children have dramatically lower offspring sex-ratios compared to those with 3 or more children for all groups except Muslims. This result provides evidence of an intensification effect – i.e. rather than discriminate more against daughters at higher parities, anti-female bias in birth and survival exists at even lower parities when families choose to have fewer children.

For households with the reference group characteristics, the intensification effect is greatest for Sikhs, where large families have offspring sex-ratios that are 49% higher than in small families. Non-low-caste Hindu households also have a large intensification effect, with large families having 22% higher offspring sex-ratios than small ones. Low-caste Hindus and Christians have smaller intensification effects, with 13% and 11% higher offspring sex-ratios in large compared to small families, respectively. Thus, daughters face a survival disadvantage in small relative to large families in four of our five social groups.

[10]For example, the offspring sex-ratio of small relative to large Hindu families who do not belong to a low-caste and all other reference group characteristics is calculated as $exp(\hat{\beta}[small * female])/exp(\hat{\beta}[small * male])$, where $\hat{\beta}[c]$ represents the coefficient estimate of characteristic c. The reciprocal of this gives the offspring sex-ratio of large relative to small Hindu families, presented in Table 4 (row 1, column 1). Similarly, the reciprocal of $exp(\hat{\beta}[small*Sikh*female]+\hat{\beta}[small*urban*female]+\hat{\beta}[small*female])/exp(\hat{\beta}[small*Sikh*male]+\hat{\beta}[small*urban*male]+\hat{\beta}[small*male])$ provides the offspring sex-ratio of large relative to small Sikh families who live in urban areas but have all other reference group characteristics (row 6, column 5 of Table 4).

[11]For each relative sex-ratio, we conduct a chi-square test to test whether the relative sex-ratio is equal to 1 under the null hypothesis and not equal to 1 under the alternate hypothesis. Critical chi-square values with 1 degree of freedom are 6.63, 3.84, and 2.71 at the 1%, 5%, and 10% levels of significance, respectively.

Rows 2-6 of Table 4 present offspring sex-ratios of large relative to small families within these 5 groups for households with various socio-economic characteristics. For example, the figure in row 2 and column 1 presents the offspring sex-ratio of large relative to small families in non-low-caste Hindu households with all the reference group characteristics except that the mother in the household is educated.

Compared to the reference household (row 1), two characteristics lower the offspring sex-ratio of large relative to small families – i.e. maternal education and urban residence – but only for Hindus (both non-low-caste and low-caste) and Sikhs. Educated mothers have offspring sex-ratios that are approximately 46%, 19%, and 11% higher in large than in small families for Sikhs, non-low-caste Hindus, and low-caste Hindus, respectively. Intensification effects are similar for urban households, that have offspring sex-ratios which are 45%, 19%, and 11% higher in large than in small families for Sikhs, non-low-caste Hindus, and low-caste Hindus, respectively. Thus, daughters with educated mothers and those in urban areas continue to face a survival disadvantage in small relative to large families. However, this relative disadvantage is slightly lower than that faced by daughters with uneducated mothers and those in rural areas. Factors that strengthen the intensification effect compared to the reference household are paternal education, a medium or high standard of living, and land ownership. Educated fathers have offspring sex-ratios that are approximately 55%, 26%, 18%, and 15% higher in large than in small families for Sikhs, non-low-caste Hindus, low-caste Hindus, and Christians respectively. Intensification effects are stronger for households with a medium or high standard of living – offspring sex-ratios are 62%, 32%, 23%, and 11% higher in large than in small families for Sikhs, non-low-caste Hindus, low-caste Hindus, and Christians respectively. Land ownership also strengthens the intensification effect for these groups. Sikhs, non-low-caste Hindus, low-caste Hindus, and Christians have respectively 58%, 29%, 20%, and 17% higher offspring sex-ratios in large than in small families if they own land. These results indicate that the survival disadvantage faced by daughters in small relative to large families is higher for those with educated fathers and greater wealth.

Even though Muslim households with the reference group characteristics do not exhibit an intensification effect, Muslims with a medium or high standard of living and those who own land have offspring sex-ratios that are 11% and 8% higher in large than in small families, respectively. These results support the within-family-size analysis for Muslims and again suggest that for this social group anti-female disadvantage in survival is driven mostly by financial constraints.

These results show that daughters' survival chances relative to sons are much lower in families with only 1 or 2 children compared to those with 3 or more children, providing evidence of an intensification effect. While maternal education and urban residence slightly improve the relative survival disadvantage that daughters face in small compared to large families, factors that capture a household's wealth – namely, paternal education, a higher standard of living, and land ownership – intensify the anti-female disadvantage in survival in small relative to large families.

4 Conclusion

Our within-family-size results reveal that regardless of fertility decline, economic growth in India may worsen offspring sex-ratios mostly as a result of the increase in wealth that it is likely to generate. Between-family-size results indicate that fertility decline may severely deteriorate offspring sex-ratios due to an intensification effect that exists for the majority of households in India. While maternal education and urban residence slightly weaken the intensification effect, paternal education, a higher standard of living, and land ownership all strengthen it.

In order to predict how future changes in family size, parental education, wealth, and urbanization may change female-male offspring sex-ratios in India, we calculate changes in the deficit of daughters as the proportion of households with a small family, maternal and paternal education, a medium or higher standard of living, and urban residence increase.[12]

In Table 5, Panel A, we first provide the overall predicted offspring sex-ratio in our sample (row 1 of Panel A). We calculate the overall offspring sex-ratio of the population as a weighted

[12]These predictions are for illustrative purposes only since the use of point estimates of parameters to predict large changes in exogenous variables is unlikely to lead to exact results. Nevertheless, these numbers illustrate the magnitude of the issue and show nicely potential future trends.

average of the offspring sex-ratio of households with different characteristics.[13] We find that the overall predicted offspring sex-ratio is approximately 885 daughters per 1000 sons in India, which is very close to the estimate from the 2001 Census of India of 891 daughters per 1000 sons for ever-married women of all ages. Using the total number of surviving sons in the 2001 Census (roughly 385 million), we calculate the number of missing daughters compared to the case of equality – i.e. 1000 daughters surviving per 1000 sons. We find that the daughter deficit is approximately 44 million. We then allow the proportion of households with small families to increase by 5% and the proportion of large families to decrease by 5% (row 2 of Panel A) and find that this change will result in an additional deficit of 3.7 million daughters. Similarly, a 10%, 15%, 20%, and 25% increase in the proportion of small families will result in an additional deficit of 7.4, 11.2, 14.9, and 18.6 million daughters, respectively.

We conduct a similar exercise for increases in the proportion of households with maternal education in Panel B of Table 5. Even though our within- and between-family size differences indicate that maternal education increases daughters' survival chances relative to sons, we find that a 5%, 10%, 15%, 20%, and 25% increase in the proportion of households with educated mothers will *increase* the current deficit of daughters by 0.02, 0.04, 0.07, 0.09, and 0.1 million, respectively. Since female education is a significant factor in inducing fertility decline, a disproportionately high number of small (large) family households also have educated (uneducated) mothers. Among all households in our sample, 28% have small families and educated mothers and 17% have small families and uneducated mothers. On the other hand, 21% have large families and educated mothers whereas 33% have large families and uneducated mothers. Therefore, an exercise that increases the proportion of households with educated mothers also increases the proportion of small family households. That the overall effect of an increase in maternal education is to worsen daughters'

[13]each of the five broad social groups – i.e. non-low-caste Hindu, Muslim, Christian, Sikh, and low-caste Hindu families – are divided into large and small families, resulting in 10 groups. In addition, there are 32 combinations of the five household characteristics that we control for in our estimation – namely, maternal education, paternal education, a medium or high standard of living, land ownership, and urban residence. Thus, we have a total of 320 groups of households, for which we estimate offspring sex-ratios using the coefficients of our empirical analysis. We also calculate the proportion of each of these 320 groups in the overall population and use these as weights to find the overall predicted offspring sex-ratio in the population.

survival chances relative to sons indicates that the indirect adverse effect of female education on offspring sex-ratios (via fertility decline) dominates any direct survival advantage that daughters face relative to sons with educated mothers.

In Panels C, D, and E of Table 5 we conduct a similar analysis for paternal education, a medium or high standard of living, and urban residence, respectively. The deficit of daughters decreases in two cases – as the proportion of households with paternal education increases as well as the proportion of urban households increases. However, as the proportion of households with a medium or high standard of living increases while the proportion of households with a low standard of living falls, the deficit of girls increases substantially. While these 3 factors are also drivers of fertility decline, they are not as significant in decreasing family size as is female education. Therefore, the direct effect of changes in these factors on offspring sex-ratios appear to dominate their indirect effect (via fertility decline). Thus, paternal education and urban residence increase daughters' survival chances relative to sons, which is consistent with our within-family-size results for most social groups. On the other hand, a medium or high standard of living decreases daughters' survival chances relative to sons, which also supports our within-family-size results.

Even though increasing levels of paternal education and urbanization may create more balanced offspring sex-ratios in India, maternal education, increased wealth, and especially fertility decline may counter any improvement in anti-female survival disadvantage and even worsen the country's already skewed sex-ratios. The deterioration in offspring sex-ratios that may occur as India's economy develops and fertility declines suggests an urgent need for policies that attempt to lower son preference. While economic growth and the changes it will bring about – such as higher levels of education and wealth – are much needed to improve human development levels in India, these changes can be detrimental to the survival of females. Moreover, even though policies that control fertility are of utmost importance to curb India's spiraling population, fertility decline may dramatically deteriorate offspring sex-ratios in the country. Thus, policies that target son preference and the economic returns to raising daughters and sons are essential in order to restore more balanced sex-ratios in India. Such policies need to make daughters more economically attractive to parents by providing education, health, and food subsidies to families with only daughters. Provision of free education to girls, not only in school but also in college as well as reserving skilled jobs for women may help raise the economic return to investing in daughters relative to sons. Further, strict enforcement of the minimum age at marriage for women and anti-dowry legislation may make daughters a more attractive option for parents.

References

Das Gupta, M. (1987), 'Selective discrimination against female children in rural Punjab, India', *Population and Development Review* **13**(1), 77–100.

Das Gupta, M. & Bhat, M. P. (1997), 'Fertility decline and increased manifestation of sex bias in India', *Population Studies* **51**, 307–315.

Ding, Q. J. & Hesketh, T. (2006), 'Family size, fertility preferences, and sex ratio in China in the era of the one child family policy: results from national family planning and reproductive health survey', *British Medical Journal* **333**, 371–373.

Drew, J., Blumberg, B. & Robert-Lamblin, J. (1986), 'Hepatitis B virus and sex ratio of offspring in east Greenland', *Human Biology* **58**, 115–120.

Ebenstein, A. Y. (2007), Fertility choices and sex selection inAsia. Mimeo.

Guimarães, P. (2005), 'A simple approach to fit the beta-binomial model', *The Stata Journal* **5**(3), 385–394.

Guimarães, P. & Lindrooth, R. (2007), 'Controlling for overdispersion in grouped conditional logit models: A computationally simple application of dirichlet-multinomial regression', **10**(2).

Hudson, V. M. & den Boer, A. M. (2004), *Bare Branches: The Security Implications of Asia's Surplus Male Population*, MIT Press, Cambridge, Massachusetts.

Hull, T. (1990), 'Recent trends in sex ratios at birth in China', *Population and Development Review* **16**(March), 63–83.

Mosiman, J. E. (1962), 'On the compound multinomial distribution, the multivariate β-distribution, and correlations among proportions', *Biometrika* **49**(1 and 2), 65–82.

Muhuri, P. & Preston, S. (1991), 'Effects of family composition on mortality differentials by sex among children in Matlab, Bangladesh', *Population and Development Review* **17**, 415–434.

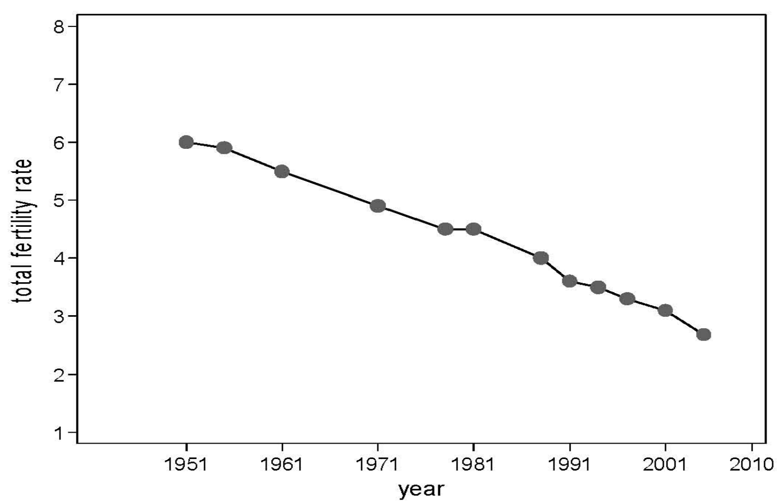
Oster, E. (2005), 'Hepatitis B and the case of the missing women', *Journal of Political Economy* **113**(6), 1163–1216.

Oster, E. (2007), Does increased access increase equality? Gender and child health investments in India. mimeo., University of Chicago.

Pebley, A. & Amin, S. (1991), 'The impact of a public health intervention on sex differentials in childhood mortality in rural Punjab, India', *Health Transition Review* **1**, 143–169.

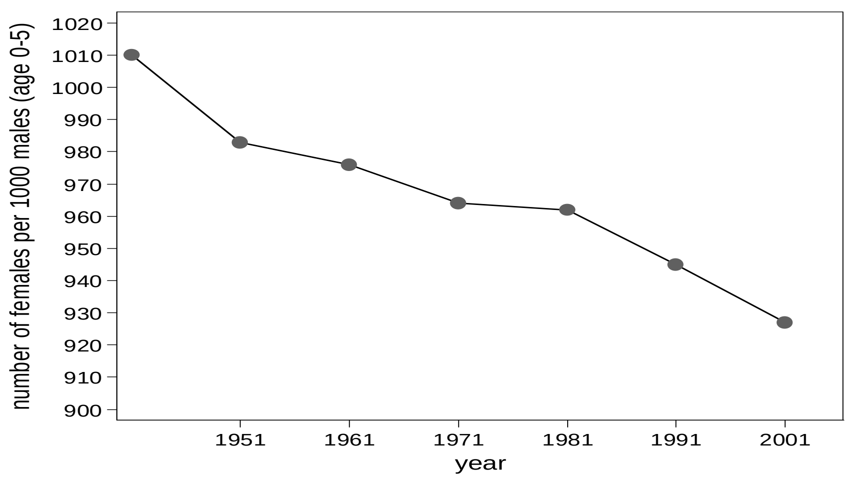
Yi, Z., Ping, T., Baochang, G., Yi, X., Bohua, L. & YongPing, L. (1993), 'Causes and implications of the recent increase in the reported sex ratio at birth in China', *Population and Development Review* **19**, 283–302.

Figure 1: Total Fertility Rate: India (1951-2005)



Source: Various issues of the Census of India, Sample Registration System Bulletins, and NFHS-3 (2005-2006).

Figure 2: Female-Male Child Ratios: India (1941-2001)



Source: Various issues of the Census of India.

Figure 3: Female-Male Birth Ratios: Indian Districts, 2001

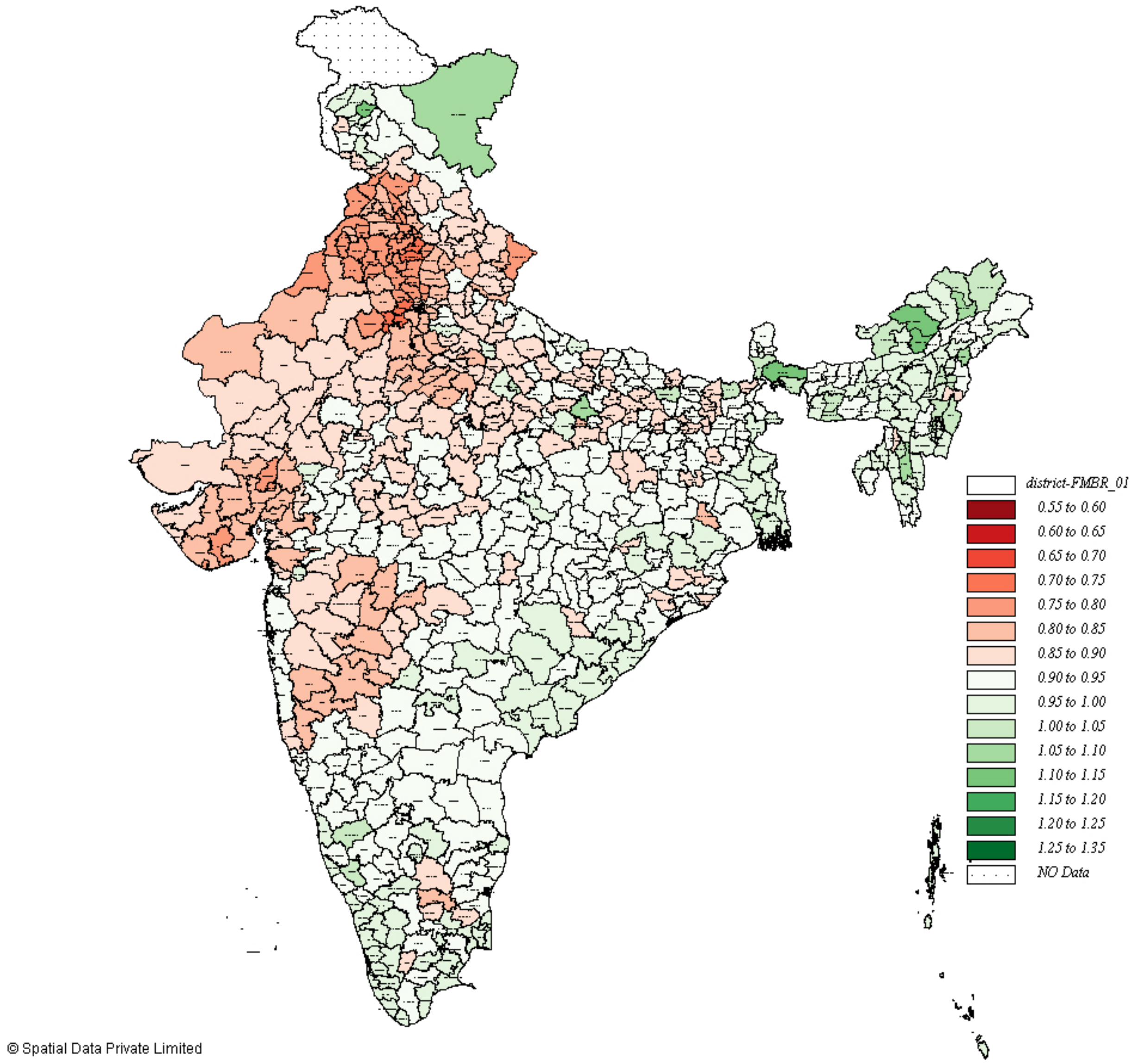
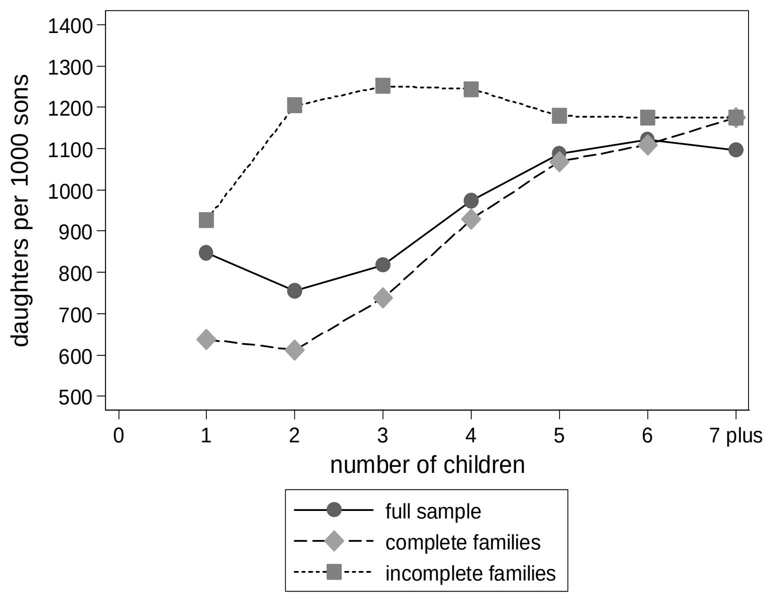
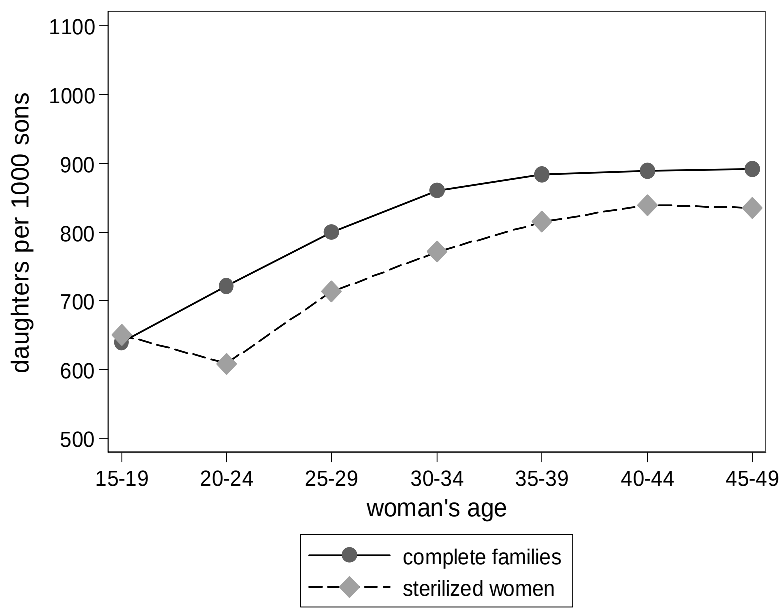


Figure 4: Family Size and Offspring Sex-Ratios in India



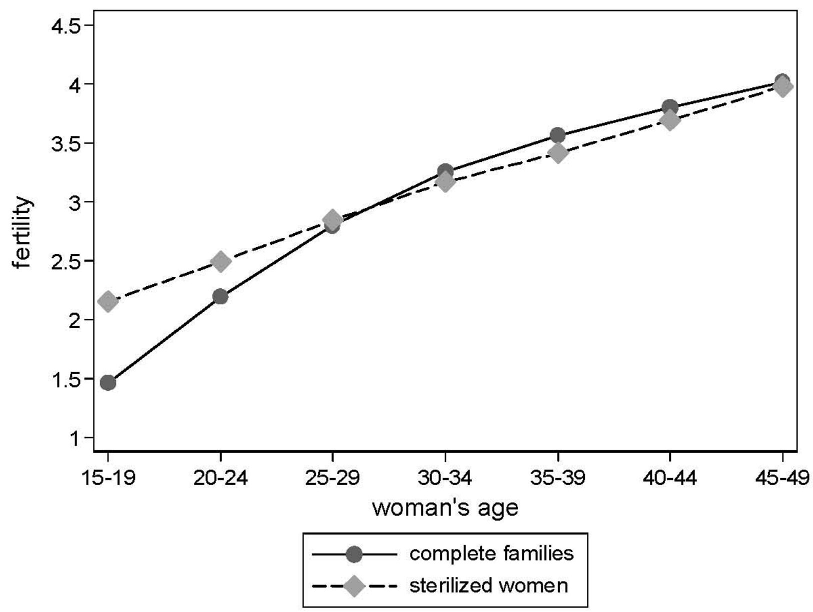
Source: NFHS-2 (1998-1999).

Figure 5: Cohort Differences in Offspring Sex-Ratios in India



Source: NFHS-2 (1998-1999).

Figure 6: Cohort Differences in Fertility in India



Source: NFHS-2 (1998-1999).

Table 1: Description of Dependent & Explanatory Variables

Variable	**Description**
Dependent Variable Categories	
y^b	number of surviving sons
y^g	number of surviving daughters
y^n	number of years in marriage without a birth of a son or daughter
Household Characteristics	
Muslim	1 if household is Muslim, 0 otherwise
Christian	1 if household is Christian, 0 otherwise
Sikh	1 if household is Sikh, 0 otherwise
Low-Caste	1 if household belongs to scheduled caste, scheduled tribe, or other backward caste, 0 otherwise
Mother Educated	1 if mother has primary, middle, or higher education, 0 otherwise
Father Educated	1 if father has primary, middle, or higher education, 0 otherwise
Medium or High SLI	1 if household has medium or high standard of living index (SLI), 0 otherwise
Land Ownership	1 if household owns land, 0 otherwise
Urban	1 if household resides in urban sector, 0 otherwise
Small Family	1 if there are 1 or 2 children, 0 otherwise

Source: NHFS-2 (1998-99). In addition to all the households characteristics listed in Table 1, interactions of the indicator for small families with all other household characteristics are also included.

Table 2: Relative Offspring Sex-Ratios Within Large and Small Families: Religion and Caste

	Household Characteristic	Large Family (3 or more Children) (1)	Small Family (1 or 2 Children) (2)
(1)	Muslim versus non-low-caste Hindu	0.9620	1.1908
		(7.83)***	(23.79)***
(2)	Christian versus non-low-caste Hindu	1.0076	1.0982
		(0.13)	(4.50)**
(3)	Sikh versus non-low-caste Hindu	0.9786	0.8154
		(0.38)	(12.85)***
(4)	Low-caste versus non-low-caste Hindu	0.9728	1.0730
		(6.88)***	(10.42)***

Source: NHFS-2 (1998-99). The reference household has the following characteristics: non-low-caste, uneducated parents, low SLI, landless, and rural. Chi-square test statistics and significance are reported in parentheses. For each relative sex-ratio, we conduct a chi-square test to test whether the relative sex-ratio is equal to 1 under the null hypothesis and not equal to 1 under the alternate hypothesis. Critical chi-square values with 1 degree of freedom are 6.63, 3.84, and 2.71 at the 1%, 5%, and 10% levels of significance, respectively.

Table 3: Relative Offspring Sex-Ratios Within Large and Small Families: Education, Wealth, Land Ownership, and Sector of Residence

	Household Characteristic	Non-Low-Caste Hindu		Low-Caste Hindu		Muslim		Christian		Sikh	
		Large Family (1)	Small Family (2)	Large Family (3)	Small Family (4)	Large Family (5)	Small Family (6)	Large Family (7)	Small Family (8)	Large Family (9)	Small Family (10)
(1)	Educated Mother	1.0524	1.0180	1.0237	1.0924	1.0124	1.2122	1.0604	1.1180	1.0298	0.8301
		(18.89)***	(0.54)	(1.94)	(6.18)**	(0.43)	(17.49)***	(6.45)**	(5.21)**	(0.62)	(9.30)***
(2)	Educated Father	1.0365	0.9634	1.0083	1.0338	0.9971	1.1472	1.0444	1.0580	1.0143	0.7855
		(9.49)***	(2.00)	(0.26)	(0.86)	(0.02)	(8.56)***	(3.17)*	(1.21)	(0.14)	(15.59)***
(3)	Medium or High SLI	0.9782	0.9209	0.9516	0.9881	0.9411	1.0965	0.9857	1.0113	0.9573	0.7508
		(3.60)*	(11.40)***	(9.49)***	(0.12)	(12.10)***	(4.58)**	(0.37)	(0.05)	(1.52)	(24.90)***
(4)	Landed	1.0024	0.9458	0.9752	1.0149	0.9644	1.1262	1.0101	1.0387	0.9810	0.7712
		(0.05)	(6.46)**	(2.54)	(0.21)	(3.82)*	(7.32)***	(0.17)	(0.59)	(0.26)	(19.32)***
(5)	Urban	0.9954	1.0249	0.9683	1.0997	0.9576	1.2204	1.0029	1.1255	0.9740	0.8357
		(0.13)	(0.95)	(3.63)*	(7.07)***	(5.59)**	(19.03)***	(0.01)	(5.07)**	(0.49)	(8.21)***

Source: NHFS-2 (1998-99). The reference household has the following characteristics: uneducated parents, low SLI, landless, and rural. Chi-square test statistics and significance are reported in parentheses. For each relative sex-ratio, we conduct a chi-square test to test whether the relative sex-ratio is equal to 1 under the null hypothesis and not equal to 1 under the alternate hypothesis. Critical chi-square values with 1 degree of freedom are 6.63, 3.84, and 2.71 at the 1%, 5%, and 10% levels of significance, respectively.

Table 4: Offspring Sex-Ratios of Large Relative to Small Families

	Household Characteristic	Non-Low-Caste Hindu (1)	Low-Caste Hindu (2)	Muslim (3)	Christian (4)	Sikh (5)
(1)	Reference Household	1.2156	1.1328	1.0208	1.1069	1.4908
		(46.40)***	(27.06)***	(0.29)	(4.19)**	(51.13)***
(2)	Educated Mother	1.1940	1.1128	1.0028	1.0873	1.4644
		(27.21)***	(10.91)***	(0.00)	(2.64)	(42.88)***
(3)	Educated Father	1.2617	1.1759	1.0596	1.1489	1.5474
		(65.01)***	(40.06)***	(2.16)	(8.03)***	(62.02)***
(4)	Medium or High SLI	1.3200	1.2302	1.1086	1.2020	1.6189
		(81.36)***	(52.05)***	(6.96)***	(13.81)***	(80.61)***
(5)	Landed	1.2852	1.1977	1.0793	1.1703	1.5762
		(82.93)***	(56.76)***	(3.98)**	(10.43)***	(69.93)***
(6)	Urban	1.1860	1.1053	0.9960	1.0800	1.4546
		(27.40)***	(10.93)***	(0.01)	(2.10)	(40.72)***

Source: NHFS-2 (1998-99). The reference household has the following characteristics: non-low-caste, uneducated parents, low SLI, landless, and rural. Chi-square test statistics and significance are reported in parentheses. For each relative sex-ratio, we conduct a chi-square test to test whether the relative sex-ratio is equal to 1 under the null hypothesis and not equal to 1 under the alternate hypothesis. Critical chi-square values with 1 degree of freedom are 6.63, 3.84, and 2.71 at the 1%, 5%, and 10% levels of significance, respectively.

Table 5: Predicted Offspring Sex-Ratios With Fertility Decline and Increases in Education, Standard of Living, and Urban Residence

Panel A	Percentage of Households with Large Families	Percentage of Households with Small Families	Overall Number of Daughters per 1000 sons	Daughter Deficit per 1000 sons	Actual Daughter Deficit	Change in Daughter Deficit
Current	54.51	45.49	884.79	115.21	44,374,257	
Scenario 1	49.51	50.49	875.08	124.92	48,113,548	3,739,291
Scenario 2	44.51	55.49	865.37	134.63	51,852,838	7,478,581
Scenario 3	39.51	60.49	855.66	144.34	55,592,129	11,217,872
Scenario 4	34.51	65.49	845.95	154.05	59,331,419	14,957,162
Scenario 5	29.51	70.49	836.25	163.75	63,070,710	18,696,453
Panel B	**Percentage of Households with Uneducated Mothers**	**Percentage of Households with Educated Mothers**	**Overall Number of Daughters per 1000 sons**	**Daughter Deficit per 1000 sons**	**Actual Daughter Deficit**	**Change in Daughter Deficit**
Current	50.87	49.13	884.79	115.21	44,374,257	
Scenario 1	45.87	54.13	884.73	115.27	44,398,464	24,207
Scenario 2	40.87	59.13	884.66	115.34	44,422,671	48,414
Scenario 3	35.87	64.13	884.60	115.40	44,446,878	72,620
Scenario 4	30.87	69.13	884.54	115.46	44,471,084	96,827
Scenario 5	25.87	74.13	884.47	115.53	44,495,291	121,034
Panel C	**Percentage of Households with Uneducated Fathers**	**Percentage of Households with Educated Fathers**	**Overall Number of Daughters per 1000 sons**	**Daughter Deficit per 1000 sons**	**Actual Daughter Deficit**	**Change in Daughter Deficit**
Current	26.75	73.25	884.79	115.21	44,374,257	
Scenario 1	21.75	78.25	884.88	115.12	44,338,406	-35,851
Scenario 2	16.75	83.25	884.97	115.03	44,302,555	-71,702
Scenario 3	11.75	88.25	885.07	114.93	44,266,704	-107,553
Scenario 4	6.75	93.25	885.16	114.84	44,230,853	-143,404
Scenario 5	1.75	98.25	885.25	114.75	44,195,002	-179,255
Panel D	**Percentage of Households with Low SLI**	**Percentage of Households with Medium or High SLI**	**Overall Number of Daughters per 1000 sons**	**Daughter Deficit per 1000 sons**	**Actual Daughter Deficit**	**Change in Daughter Deficit**
Current	28.91	71.09	885	115	44,374,257	
Scenario 1	23.91	76.09	883	117	45,126,091	751,833
Scenario 2	18.91	81.09	881	119	45,877,924	1,503,667
Scenario 3	13.91	86.09	879	121	46,629,757	2,255,500
Scenario 4	8.91	91.09	877	123	47,381,591	3,007,333
Scenario 5	3.91	96.09	875	125	48,133,424	3,759,167
Panel E	**Percentage of Rural Households**	**Percentage of Urban Households**	**Overall Number of Daughters per 1000 sons**	**Daughter Deficit per 1000 sons**	**Actual Daughter Deficit**	**Change in Daughter Deficit**
Current	68.62	31.38	884.79	115.21	44,374,257	
Scenario 1	63.62	36.38	884.81	115.19	44,367,223	-7,035
Scenario 2	58.62	41.38	884.82	115.18	44,360,188	-14,069
Scenario 3	53.62	46.38	884.84	115.16	44,353,154	-21,104
Scenario 4	48.62	51.38	884.86	115.14	44,346,119	-28,138
Scenario 5	43.62	56.38	884.88	115.12	44,339,085	-35,173

Source: NHFS-2 (1998-99).