

Fertility Decline and Missing Women

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The desire for smaller families is conjectured as one reason the male-to-female sex ratio has increased with economic development in several countries. Families that strongly want at least one son are less likely to obtain him by chance at low fertility, which could increase their use of sex-selective abortion. This paper quantifies the relationship between desired fertility and the sex ratio in India by eliciting sex composition preferences at specified fertility levels. I find that the desired sex ratio increases sharply as fertility falls and that fertility decline explains one third to one half of India's recent sex ratio increase.

In India and several other countries with son preference, the male-biased sex ratio has worsened over the past several decades despite gains for girls along other dimensions such as school enrollment (Kishor and Gupta 2009). One reason is the increased availability of prenatal sex-diagnostic technology, which has made sex-selective abortions possible. Another less obvious potential factor is the decline in desired family size. Suppose a couple strongly wants at least one son. If they wish to have six children, there is a 99 percent chance at least one will be a son, but if they want only two children, this chance falls to 76 percent.¹ Because they are less likely to have a son by chance the fewer children they have, the likelihood that they manipulate the sex of their children (through sex-selective abortion, infanticide, or neglect) might increase.

Eldest sons are exalted in many societies with highly skewed sex ratios, including India and China. In patrilineal and patrilocal kinship systems, parents live with their eldest son when they are older, and he takes over the family lineage (Dyson and Moore 1983; Das Gupta 1987). In addition, within Hinduism, a male heir is needed to light his parents' funeral pyres and organize death-anniversary ceremonies (Arnold et al. 1998). Similarly, in China under Confucianism, sons play an essential part in ancestor worship rituals. For these reasons, son preference often takes the form of intensely wanting at least one son.

The time trends in many parts of the world are consistent with declines in the desired number of children putting upward pressure on the sex ratio. Figure 1

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¹The probability is more than 75 percent because the natural sex ratio is slightly skewed toward males.

shows that the total fertility rate in India has been declining since 1960, while the sex ratio has been rising.² Previous scholars have conjectured that falling fertility could help explain time trends in the sex ratio in South Asia (Das Gupta and Bhat 1997; Basu 1999), East Asia (Park and Cho 1995), and the Caucasus region (Guilmoto 2009). These previous papers do not test the conjecture, however, and other factors could account for the sex ratio trends, such as falling costs of sex-selective abortions or an upward trend in son preference.^{3,4}

This paper's contribution is to directly estimate the causal relationship between family size and the desired sex ratio and to quantify an important cause of rising sex ratios. The challenge in estimating this effect is to isolate exogenous variation in the fertility level. The approach I use is to elicit sex composition preferences at different fertility levels: A hypothetical fertility level is specified to the survey respondent, and she is asked, given that fertility level, what is her preferred composition of boys and girls.⁵ By imposing the total number of children, one can characterize the respondents' sex ratio preferences at different exogenously determined fertility levels.

The survey questions were asked of men and women in Haryana, a state in north India. The sample comprises parents of adolescents. The fertility-preference questions asked the respondents about the fertility outcomes they desired for their adolescent child rather than themselves, thus avoiding the problems associated with retrospective questions. The survey questions were administered to adults rather than children for practical reasons; the assumption is that parents' preferences influence their children's preferences and behavior, which seems to be true in this setting (Dhar, Jain and Jayachandran 2016).

Haryana has the most male-biased sex ratio in India, with a child sex ratio (0 to 6-year-olds) of 1.20 based on the 2011 Census. However, Haryana is typical of north India in terms of the desire to have a son. Where it differs is that fertility is lower than in the rest of the region, as shown in Appendix Table 1.⁶ This paper's thesis is that Haryana's low fertility and high sex ratio are connected: Due to its

²I define the sex ratio as males to females. The decline in actual fertility reflects a decline in desired fertility over this period, as shown in section II.C. Other reasons for fertility decline are improved access to contraception which reduces unwanted births, and prenatal sex-diagnostics, which enable parents to select the sex of their children rather than exceeding their desired fertility to achieve their desired number of sons.

³There is a large literature on the opposite direction of causality: Son preference affects the gap between actual fertility and desired fertility if families use fertility-stopping behavior to achieve their desired number of sons (Das 1987; Yamaguchi 1989; Norling 2015).

⁴I use "sex ratio" as shorthand for sex ratio at birth. In the data, the sex ratio at birth is sometimes proxied by the child sex ratio. The population sex ratio is also affected by excess mortality of adult women (Anderson and Ray 2010).

⁵To avoid respondents anchoring on their first answer, each respondent was asked the sex composition question for only one, randomly chosen, fertility level.

⁶Appendix Table 1 compares Haryana to the other "Hindi belt" states in north India using India's most recent Demographic and Health Survey (DHS), called the National Family Health Survey (NFHS). Haryana is wealthier than the other Hindi belt states, as measured by electrification, access to piped water, education, and a broad-based wealth index. Actual and desired fertility are lower in Haryana. Son preference, measured as the proportion who want more sons than daughters or the gender gap in schooling, is similar (slightly lower) in Haryana.

low fertility, son preference translates into a worse sex ratio there than elsewhere. Thus, Haryana may be a harbinger of how the sex ratio will evolve in the rest of north India as fertility falls.

These facts illustrate an important distinction between son preference and how that preference manifests itself in the sex ratio. Families have both a preferred number of sons at any given fertility level (which I call *son preference*) and a preferred fertility level (*family size preference*). According to the hypothesis of this paper, holding son preference fixed, the desired ratio of sons to daughters will change when family size preference changes. Specifically, if son preference is characterized by a strong desire to have at least one son, then the desired sex ratio will increase when the preferred family size decreases.

This distinction between son preference and how it manifests in the sex ratio is not just specific to India. Appendix Figure 1 shows that among low- and middle-income countries, higher average female education is associated with a weaker desire to have more sons than daughters yet a more male-skewed sex ratio: Female education appears to mitigate son preference but not the problem of missing girls. (The same patterns are seen replacing female education with GDP per capita or other measures of development). Meanwhile, desired fertility falls sharply with female education.⁷ What the figure also shows is that India is not a large outlier in terms of wanting more sons than daughters, but it is in terms of its low desired fertility and its high sex ratio. Thus, both the worldwide patterns and the ways in which India is anomalous are consistent with the ideas put forth in this paper.

Using the fertility preference data collected in Haryana, I find that the desired sex ratio increases sharply as fertility falls. When the family size specified to the respondent is 3 children, the desired sex ratio is 1.12, while with 2 children, it rises to 1.20. Interestingly, between 1981 and 2011, the actual child sex ratio in Haryana rose from 1.12 to 1.20, while desired fertility fell from 2.83 to 2.11.⁸ When the hypothetical family size falls to 1, the vast majority of people want a son, and the desired sex ratio rises to 5.6. Meanwhile, for family sizes larger than 3, respondents actually prefer slightly more daughters than sons.

These data suggest a strong desire to have at least one son and a preference for gender balance thereafter. This is consistent with the favoritism toward eldest sons described above. If the lower labor market potential of women or the need to pay dowries loomed large in fertility decisions, then the desired number of sons would be more “homothetic” with respect to family size.

Next, I use the data to estimate how much of the recent sex ratio trend in India is due to fertility decline. My first approach combines the fertility preference data

⁷The data are from DHS surveys of ever-married women age 15 to 49. All three univariate relationships are statistically significant at the 5 percent level. The magnitude of the negative relationship between female education and wanting more sons than daughters might be underestimated because, as shown later, wanting more sons than daughters is more common when family size is smaller (so when female education is higher).

⁸Desired fertility is calculated from NFHS data, as described in section II.C.

with data on desired fertility. The second approach postulates that son preference takes the form of strongly wanting at least one son and being otherwise indifferent about child gender, a form of preferences suggested by the data. These estimates suggest that one third to one half of the increase in the sex ratio over the past thirty years can be accounted for by the shift toward smaller families.

This paper contributes to the literature on son preference and the determinants of the sex ratio. Several papers provide suggestive evidence on the link between fertility levels and the sex ratio, but few papers directly estimate the effect. Bhat and Zavier (2003) analyze the standard DHS fertility preference question that asks the respondent simultaneously for her desired family size and the sex composition of those children, and find that those who want a smaller family size want a *lower* proportion of boys. However, estimating the fertility-sex ratio relationship from cross-sectional variation gives biased estimates if there is a systematic correlation between an individual's desired family size and degree of son preference. Intuitively, those with more traditional values might want larger families and also have stronger son preference (and, indeed, my data show that such a correlation exists). Ebenstein (2010) uses cross-region variation in fines for having extra children to show that the One Child Policy in China led to a more skewed sex ratio. The concern with interpreting his estimate as causal is that the level of fines might be related to the degree of son preference in the region. Anukriti (2015) analyzes a program in Haryana, India, that rewarded parents if they had either fewer children or a larger fraction girls: The highest payout was for having one girl (and then becoming sterilized) and a smaller payout was given for having either just one boy or two girls. She finds that the policy reduced fertility and led to a more male-skewed sex ratio. Because the policy simultaneously incentivized low fertility and a less male-skewed sex ratio, the analysis likely underestimates the effect of fertility on the sex ratio.⁹

I. Data

A. Sample

The data for the analysis were collected between September 2013 and January 2014 as part of a baseline survey conducted to evaluate a secondary-school-based gender attitude-change program in Haryana, India. The four study districts—Jhajjar, Panipat, Rohtak, and Sonipat—are adjacent to New Delhi and have

⁹A 1997 Gallup poll asked respondents in several countries the preferred gender if they were to have one child (Gallup Organization 1997). In India, 40 percent of respondents preferred a boy, 27 percent preferred a girl, and the remainder had no opinion. This level of son preference is smaller than in my sample (and in fact similar to the level of son preference in Gallup's US sample). Survey details that might shed light on why the results differ, such as their survey methods or sample characteristics, are not published. Pörtner (2014) estimates a model of fertility in India, using the sex of births and length of birth spacing to infer abortion. He finds that educated and urban women are particularly likely to have sex-selective abortions, which he speculates is due to their low desired fertility. In his review article on son preference and the sex ratio, Bongaarts (2013) also discusses the link between desired fertility and the sex ratio.

lower fertility and a more skewed sex ratio than average for Haryana.

We selected 314 government secondary schools for the study by excluding schools with low enrollment or high attrition and including at most one school per village. Within these schools, on average 45 students were chosen to be interviewed. Grade 6 girls comprise 33.3 percent of the sample, and grade 6 boys, grade 7 girls, and grade 7 boys each comprise 22.2 percent of the sample. Many features of the sampling strategy were for the purpose of the program evaluation, such as a maximum of one school per village to minimize spillovers and oversampling grade 6 girls for whom we expect the largest program impacts.¹⁰

The data analyzed in this paper were collected from the students' parents. For a random 40 percent of the surveyed students, one of their parents was surveyed; we surveyed only a subset of parents because of budgetary constraints. For the subsample, surveyors visited the household, and either the mother or father was randomly chosen to be surveyed. If the parent was not available to be interviewed in the three attempts the survey team made, a replacement household was randomly chosen. In total, attempts were made to interview 3,587 mothers and 3,503 fathers, with a completion rate of 89.6 percent for mothers and 70.2 percent for fathers. The lower rate for fathers is unsurprising as men were more likely away from home working when the surveyor visited. The final sample comprises 3,215 mothers and 2,460 fathers.¹¹

Descriptive statistics are presented in Table 1. Female respondents are 35 years old on average, and male respondents, 40 years old. The illiteracy rate is 39 percent among females and 16 percent among males. The sample is 95 percent Hindu, and about 18 percent of respondents belong to a scheduled caste. The average number of children the respondents have is 3.5 and the percent sons among their children is 54 percent.¹²

B. Elicitation of fertility preferences

The survey asked prospective questions about the fertility of the respondent's child (or the child's future wife). The reason for asking prospective rather than retrospective questions about the respondent's own fertility, as is done in the DHS, was to avoid the bias associated with retrospective questions (Westoff and Ryder 1977; Rosenzweig and Wolpin 1993). These forward-looking questions are relevant when projecting future fertility patterns as long as parents' preferences influence their children's fertility. (The desired fertility questions were also asked

¹⁰For a student to be eligible for the survey, a parent needed to provide informed consent and the student needed to provide informed assent. The surveys of students were conducted in the schools.

¹¹An additional 701 households were interviewed in which the child lived with only one parent. Because some of the analysis will compare results for mothers and fathers and it would not have been possible to randomly select which parent to interview in cases where the child lives with one parent, the analysis is restricted to parents of students who live with both parents. The results are nearly identical when including the additional 701 respondents and are available from the author.

¹²Percent sons is calculated excluding the sampled student; because the sampling frame includes more girls than boys, percent sons is mechanically lower (51 percent) if the sample student is included. Two percent of parents have a missing value for the percent sons variable because they have only one child.

of some students, referring to their own future fertility, and the patterns are similar to those seen among the adult sample.)

Importantly, the survey questions differ from the standard ones in that a fertility level is specified, and the parent simply gives the gender mix: “Suppose your son/daughter [the specific grade 6 or 7 child we surveyed] was going to have N children. How many of them would you want to be boys and how many would you want to be girls?” The question did not elaborate on why N was constrained, but in pretesting of the question, respondents generally understood the wording.¹³

In principle, each respondent could have been asked about several values of N but to avoid anchoring, each parent was asked the question for only one value of N , randomly chosen with equal likelihood from the integers between 1 and 5. Given the randomized design, cross-person comparisons should accurately measure within-person preferences at different fertility levels. Appendix Table 2 compares the subsamples assigned different values of N .¹⁴

The standard DHS fertility question was also asked (about the respondent’s child), in which the respondent specified both the desired number and sex composition: “How many children do you want your son/daughter to have? How many of these children would you like to be boys, how many would you like to be girls, and for how many does the gender not matter?” This question was asked before the one that randomly specified the fertility level.¹⁵

The new fertility preference question intentionally does not allow the respondent to state “no opinion”; it elicits the respondent’s preferred outcome, rather than a combination of her preferred outcome and the strength of that preference. In contrast, the DHS question allows for indifference. In the latest round of India’s DHS, only 25 percent of north Indians have son preference as measured by the DHS question (see Appendix Table 1). It seems unlikely that the majority of north Indians are exactly indifferent about the gender of their children, as the DHS question would suggest. Thus, the decision to disallow indifference was in order to elicit the respondent’s “bliss point,” under the assumption that a negligible fraction of individuals are exactly indifferent. If those who are indifferent about child gender give random answers, then I *de facto* am correctly treating them as indifferent; in the analysis, their preferred sex ratio will be 1, or essentially the natural sex ratio. Of course, behavior (e.g., having a sex-selective abortion)

¹³It is possible that some respondents misunderstood the question to mean, “Suppose your son/daughter were the type of person who wanted N children” and responded with the gender mix they associated with people who want N children. Such a misunderstanding would likely attenuate the correlation between N and the desired sex ratio, because people who want small families generally have less son preference.

¹⁴Characteristics, including answers to the standard DHS fertility question, are balanced across the groups, except for a marginal difference in the percent sons among the respondent’s children. The empirical results are robust to adjusting for baseline characteristics.

¹⁵This ordering was chosen because if the DHS question had come second, respondents might have anchored on the randomly assigned fertility level, contaminating their responses about desired fertility. When answering the randomized question, some respondents might have anchored on either the number of boys or number of girls or percent boys that they gave as a response to the DHS question. This anchoring could go in several directions, so *a priori*, it seems unlikely to lead to aggregate bias.

depends on not just the bliss point but also the strength of preferences, as well as many other factors such as the monetary and nonmonetary costs of having a sex-selective abortion and the costs of other options such as going beyond desired fertility to try again for a son. Thus, understanding preferences is very useful for but obviously not sufficient for predicting behavior.

II. Results

A. Negative effect of family size on percent sons desired

Figure 2 presents the relationship between family size and the sex ratio graphically. Along the horizontal axis are the five randomly assigned specified family sizes (number of children). The vertical axis plots the average percent sons that are desired by parents. (I use percent sons rather than the sex ratio because the sex ratio is undefined at the individual level if there are zero desired daughters.) When the family size is 1, the average percent sons desired is over 80 percent and declines sharply as family size increases. The lower the family size, the more the desired sex composition is skewed toward sons.

As can be seen, the responses are similar for mothers and fathers (mothers have slightly higher son preference). Thus, the rest of the analysis focuses on pooled results for mothers and fathers. Table 2 shows the full distribution of responses rather than just sample means. The first column is the subsample asked about a family size of 1. The vast majority of respondents, 84.9 percent, would want this one child to be a son. The bottom rows of the table aggregate these responses and report the average percent sons desired for the population (84.9 percent), and the corresponding sex ratio (5.6).

The second column is the subsample asked about a family size of 2. The most common preference is one boy, one girl (84.6 percent of respondents), with 12.4 percent preferring two boys and 3.1 percent preferring two girls. These responses correspond to a desired percent sons of 54.6 percent and sex ratio of 1.20. For family size of 3, the responses correspond to 52.8 percent sons, or a sex ratio of 1.12. While the change in percent sons seen between family size 1 and family size 2 is most stark, the changes are meaningful in magnitude at all family sizes: Reducing family size from 3 to 2 increases the desired population sex ratio from 1.12 to 1.20.

The pattern continues as family size increases to 4 and 5: The larger the family size, the lower the desired percent sons. One quite striking result is that the average percent sons is below 50 percent for family size of 4 and 5. Respondents appear to strongly want to have 1 or 2 sons but then prefer that the additional children are girls. For example, at a family size of 5, 18.1 percent of respondents have a preference for 4 or more girls, while only 3.3 percent have a preference for 4 or more boys. The preference for having more daughters than sons when family size is large need not be due to altruism toward girls; parents might want daughters so they can care for siblings and perform household chores. Anecdotally,

two reasons parents dislike having a lot of sons are that it leads to more conflict over splitting the family land and sons are less docile than daughters.

Table 3 tests the statistical significance of the negative relationship between family size and the percent sons desired. In an ordinary least squares regression, the percent sons decreases by 8.5 percentage points for every additional child, with a p -value < 0.01 . The analysis pools parents' responses about either their son or their daughter (whoever was surveyed for the student sample). The results are very similar for responses about sons and daughters. When the regression reported in Table 3, column 1, is estimated for the subsample of parents asked about their daughters, the coefficient is -0.086 ; for the subsample asked about their sons, the coefficient is -0.083 .

In column 2, which estimates the coefficients separately for each family size, the monotonic decline is statistically significant at the 10 percent level or lower at each increment. The results are nearly identical adjusting for differences in baseline characteristics (columns 3 and 4).

These strong patterns would not arise from respondents being indifferent about child gender and giving arbitrary answers when forced to choose. However, the desired percent sons and how sharply it declines with family size could be overestimated if respondents systematically broke their indifference by stating a preference for sons. To assess the magnitude of this potential bias, one can use the level of indifference about child gender expressed in the DHS-type question, which allowed for indifference to be consistent with the standard DHS question. About 8.0 percent of respondents had no preference about family size. Another 9.4 percent had a preference over family size and, when asked for their preferred breakdown by gender (sons, daughters, or either), gave a positive response for the "either" category; that is, they were indifferent about at least some children's gender. One can recalculate the degree of son preference assuming these two groups' responses to the randomized question in fact reflected indifference. For example, among the indifferent respondents asked randomly about a family size of 1, 77.6 percent stated a preference for a son. Thus, 13.5 percent of the sample (17.4 percent * 77.6 percent) stated a preference for a son, but might actually have been indifferent. Reassigning these 13.5 percent as indifferent would change the overall desired percent sons at a family size of 1 from 84.9 percent to 78.1 percent, which is still high.¹⁶ In addition, the results in Table 3 are nearly identical when one restricts the sample to the 82.6 percent of respondents who expressed strict gender preferences over each child's gender in the standard DHS question; the coefficient in column 1 remains -0.085 .

To summarize, as family size grows, the desired percent sons falls sharply. To first approximation, families want one son, and if that preference is satisfied, they want close to an equal number of sons and daughters. These patterns point to

¹⁶A more conservative approach is to use the level of indifference expressed in the DHS question by those whose desired family size is an odd number; respondents whose preference is a family size of 2 with one son and one daughter might actually mean they are indifferent about both children's gender. In this case, the desired percent sons at a family size of 1 is 72.8 percent.

the desire for an eldest son as the central feature of son preference.

Parents' preferences likely influence their children's fertility behavior (for example because parents shape their children's preferences). But one concern is that the children's own preferences matter more. For a smaller sample of adolescents, similar data were collected in which they were asked about their future fertility. The same negative effect of family size on the percent sons desired is observed, as shown in Appendix Figure 2. The average percent sons desired is 76 percent when family size is 1 and declines monotonically to 50 percent by a family size of 5, with boys showing stronger son preference than girls.¹⁷

B. Correlation of family size preference and son preference

Table 4 shows that respondents with a preference for a larger family also have stronger son preference. Each column is a subsample that reports a different desired family size when asked the standard DHS question. The modal response is 2 children.¹⁸ Each row is a subsample asked about sex composition for a different randomly-specified family size (which more often than not differed from their desired family size). Each cell reports the average percent sons desired at the randomly-specified family size for the subsample defined by the row and column. First, within columns, the pattern seen earlier is present: The desired proportion sons is higher the smaller the specified family size. Second, looking within rows, the desired proportion of sons at each randomly-specified family size is increasing in the desired family size. In other words, son preference and family size preference are positively correlated across individuals. The aggregate pattern is shown in Figure 3: The average desired percent sons at randomly-specified family sizes—that is, average son preference—is higher among those preferring a larger family size. Appendix Table 3, columns 1 and 2, show the regression estimates for this relationship. Wanting one extra child is associated with a 6.6 percentage point increase in average percent sons desired.

If one uses responses to the standard DHS question and calculates how the desired proportion of sons at the endogenously chosen family size varies with that family size, the pattern differs from the monotonic negative relationship shown in Figure 2. Percent sons desired at the *desired* family size is nonmonotonic in desired family size, as shown in Figure 3.¹⁹ The pattern reflects the combination of the negative effect of desired family size on the percent sons desired and the fact that individuals who prefer a larger family also have stronger son preference. On

¹⁷The questions were fielded to the first 22 percent of students surveyed (3387 students). The Haryana Department of Education then requested that the questions be removed (the student surveys were conducted in schools), as they deemed 11 to 13 years old too young for these questions.

¹⁸Because only 9 respondents report a desired family size larger than 4, they are grouped with those desiring a family size of 4. Respondents are excluded from this analysis if they did not give a numerical answer to the question, either responding "Up to God," responding "Up to spouse/family," saying they did not know, or giving an inconsistent answer in which the number of desired children by gender did not add up to their desired number of children.

¹⁹Following the DHS, the individual answered how many of the desired children ideally would be boys, girls, or either gender. The either-gender children are counted as 0.5 sons and 0.5 daughters.

average, this relationship is negative; desired percent sons declines by -0.023 with each additional desired child on average (Appendix Table 3, column 3). However, this effect size is much smaller in magnitude than was seen in Table 3, column 1 (coefficient of -0.085), where the measure of son preference was independent of the respondent's family size preference. Because of the positive correlation between family size preference and son preference, using the standard fertility question underestimates the negative effect of family size on the desired sex ratio. This likely explains why previous work using the DHS questions concludes that the sex ratio will become less skewed when desired fertility falls (Bhat and Zavier 2003).

C. How much of the sex ratio trend can fertility decline explain?

The fact that the desired sex ratio increases substantially when family size is smaller suggests the time trend in total fertility shown in Figure 1 could be an important cause of the simultaneous time trend in the child sex ratio. In this subsection, I quantify how much of the time trend in the sex ratio could be explained by falling fertility. Of course, several other factors besides falling fertility also likely contribute to changes in the sex ratio; the goal here is to assess whether the contribution of fertility decline is large or small.

METHOD 1: USING DATA ON DESIRED PROPORTION OF SONS. — As a first approach, I combine the average desired percent sons at different fertility levels shown in Table 2 and annual data on desired fertility. I construct desired fertility from the National Family Health Survey (NFHS). Pooling the three NFHS rounds, I observe women from a large range of birth cohorts and can thus calculate, year by year, the distribution of desired number of children among women who were age 25 to 34 in that year (i.e., in their prime childbearing years). The average desired fertility by year is shown in Figure 4.^{20,21}

I assume that some fraction θ of the population deviates from the natural sex ratio to attain their desired sex ratio or, equivalently, their desired proportion of boys. I assume that the remainder of the population does not manipulate the gender of their children and has the natural proportion of sons, possibly using stopping rules to achieve their desired number of sons.²² I use 1.02 as the natural sex ratio (equivalent to the proportion of sons being 50.74 percent).²³

²⁰Actual fertility exceeds desired fertility, both because some families use stopping rules to achieve their desired number of sons and because of incomplete access to contraception.

²¹The first NFHS was conducted in 1992 and samples women up to age 49, so I can construct desired fertility of 25 to 34 year olds only starting in 1977. Thus, I restrict the time period for this exercise to 1981 to 2011. The sex ratio data are from the Census, and 1981 is the first Census year after 1977.

²²Stopping rules do not affect the population sex ratio; each birth is a random draw at the natural sex ratio.

²³Following the literature, I assume the natural sex ratio at birth in India is the observed value for Sub-Saharan Africa, which is 1.033 (Sen 1992; Garenne 2011). The natural sex ratio for 0 to 6 year olds (the age range for which sex ratio data are available for India) is lower than this because the natural rate of infant and child mortality is higher for boys than girls. The sex ratio of children age five years

For each year from 1981 to 2011, I use the distribution of desired fertility (from the NFHS) and the desired proportion of boys for different levels of fertility (from the Haryana parent survey) to construct the average desired proportion of boys.^{24,25}

To determine θ , the fraction of the population that manipulates its sex ratio, I calculate the value of θ that allows one to match the *level* of the sex ratio in 1981. In other words, there is a unique θ that yields the actual 1981 sex ratio of 1.0395 given the distribution of desired fertility in that year. This value of θ is 0.216, or 21.6 percent of individuals. I assume this fraction remains fixed over time (as does every other factor such as son preference, access to ultrasound, and costs of sex-selective abortions). I calculate how the sex ratio evolves after 1981 simply due to falling desired fertility. The goal is to determine how much of the *change* in the sex ratio between 1981 and 2011 is explained by fertility decline.

The results of this exercise are shown in Figure 4. The line marked with diamonds is the projected sex ratio; it is rising over time, though not as much as the actual sex ratio (line marked with squares). The projected sex ratio matches the trend more closely for the second half of the period, which is consistent with the diffusion of ultrasound being the main driver of the rising sex ratio in the 1980s and early 1990s, and then fertility decline playing a major role in the last decade, once access to ultrasound was widespread; families could more fully optimize with respect to their fertility and gender preferences once they were unconstrained by technology. Overall, declining fertility leads to an increase in the sex ratio that is 36 percent of the actual increase over the 1981 to 2011 period. Undoubtedly, another key factor is the increasing availability of prenatal sex-diagnostics, so it is reassuring that the projection does not explain all (or more than all) of the actual increase in the sex ratio.²⁶

METHOD 2: POSITING A PREFERENCE FOR AT LEAST ONE SON. — As a second approach, I posit a specific form of son preference, informed by the fertility preference data: People have a strong preference for at least one son and are indifferent about other children's gender if this has-a-son requirement is met. I assume

and younger is 1.017 in Rwanda and 1.021 in Kenya, so I use 1.02 as the best estimate of the natural sex ratio among 0 to 6 year-olds in India (Government of Rwanda 2009; Republic of Kenya 2009).

²⁴Because the highest family size for which I have fertility preference data is 5, I assume that for desired family size larger than 5, the desired percent sons is the same as it is for a family size of 5.

²⁵The data on desired fertility and the child sex ratio are for all of India, while the data on desired sex composition are from the sample of parents in Haryana. Using preference data for Haryana could either overstate or understate how much fertility decline has caused the sex ratio to rise for India. While Haryana's level of son preference is higher than average for India (because south India has lower son preference), what is relevant for the projection is the slope, i.e., how fast the desired number of sons falls as desired fertility falls, and this slope could be higher or lower in Haryana. Also, because θ is set by matching the 1981 sex ratio, when the level of son preference is higher, the proportion of people manipulating child gender is assumed to be lower, and the net effect on the projected trend in the sex ratio is ambiguous.

²⁶Other factors affecting the sex ratio that could also have been changing over time include average son preference in the population, the composition of births across women of different son preference, the costs and risks of abortion, and child mortality.

that the only individuals who might resort to sex selection are those who do not naturally have at least one son within their desired fertility.

The advantage of this second approach is that it builds in an asymmetry, which is likely realistic, between those who have more versus fewer boys than their preferred sex composition. The disadvantage relative to the first approach is that it disregards other features of preferences besides the desire for an eldest son, such as the fact that at a family size of 3, one third more people want two sons than want two daughters.

Figure 5(a) uses desired fertility from the NFHS to calculate the proportion over time who, given the natural sex ratio, would be son-less within their desired fertility. The likelihood of being son-less is decreasing in desired fertility and therefore increasing over time.

For this calculation, I allow the proportion of people who use sex selection to vary over time and infer this proportion by matching the actual sex ratio data in each Census year. The second line plotted in Figure 5(a) is the inferred proportion of those who remain son-less within their desired fertility who use sex selection; this rate increases from 6 percent to 13 percent between 1981 and 2011.

This inferred rate of sex selection combined with the assumption that only the son-less use sex-selection provides a second estimate of how much of the time trend in the sex ratio is driven by declining desired fertility. Specifically, I estimate the portion of the sex ratio trend that is *not* explained by desired fertility by holding fixed the desired fertility distribution from 1981 but allowing the proportion of the son-less who use sex selection to evolve. The unexplained portion quantifies how much of the upward sex ratio trend is caused by the downward fertility trend. Figure 5(b) plots the projected sex ratio were desired fertility to have remained constant, as well as the actual sex ratio. The projected trend is 44 percent of the actual trend, implying that declining fertility could explain 56 percent of the rising sex ratio. Consistent with the results of the first approach, in the 1980s when prenatal sex diagnostic technology was rapidly diffusing, changing access to sex selection seems to explain most of the sex ratio trend, but over the past twenty years, declining desired fertility has played a larger role.

III. Conclusion

This paper made both a methodological and substantive contribution related to son preference and skewed sex ratios. The methodological innovation was a survey question that elicited desired sex composition at a randomly determined fertility level specified to the respondent. This question generates a measure of son preference that, unlike those based on the standard fertility preference questions, is not biased by the fact that individuals who desire a larger family size tend to have stronger son preference.

A first substantive contribution was to quantify how much declining fertility contributes to the worsening of the male-skewed sex ratio in India. The smaller the family size, the less likely a family is to have a son by chance and more likely,

perhaps, to obtain one via sex-selective abortions. This paper showed that this effect is quantitatively important: Falling fertility explains roughly a third to a half of India's sex ratio increase over the past thirty years.

Tracing out how the desired sex composition varies with family size is also revealing about the specific nature of son preference. Families appear to strongly want one son rather than always preferring having a son over a daughter. At a family size of one, the vast majority of respondents want that one child to be a son, but at a family size of two, having one daughter and one son is much more often preferred than having two sons. Moreover, at a family size larger than three, respondents actually prefer to have more daughters than sons. This pattern of son preference suggests that favoritism toward boys is not driven primarily by considerations such as low earning capacity of girls or dowry, which are not diminishing in the number of daughters. The culturally-rooted desire for an eldest son is central to parents' sex-composition preferences.

A key message of the paper is that son preference is best thought of as a vector of desired number of sons at different possible fertility levels. The manifestation of son preference in the sex ratio depends on this son preference vector, and also on the desired fertility level. One implication is that factors that lead to more progressive attitudes, such as female education, might perversely worsen the sex ratio. On the one hand, we expect female education to lead to weaker son preference, that is, a desire for fewer sons at any given fertility level. On the other hand, it likely causes a decline in desired fertility, which will lead to a higher desired sex ratio, all else equal. Thus, combined, it is ambiguous how increased female education—and progressive forces more generally—will affect the desired sex ratio. One direction for future work is to causally estimate how family size, son preference, and the sex ratio jointly evolve as women become more educated.²⁷

Another direction for future work is to elicit preferences not only for the “bliss point” of sex composition and fertility level, but also the disutility of deviations. For example, at a family size of two, most people want one son and one daughter. A reasonable guess is that they would more likely resort to a sex-selective abortion to achieve this preferred sex composition if the alternative were two daughters than if it were two sons; having zero sons is much more undesirable to them than having zero daughters. Similarly, some families will prefer to try again for a son and use stopping rules rather than sex-selective abortions. Quantifying the asymmetry in how much individuals dislike having more boys versus more girls than their ideal sex composition and how much they dislike going beyond their desired family size would help further characterize son preference and family size preference and how the skewed sex ratio and fertility levels will evolve in the future.

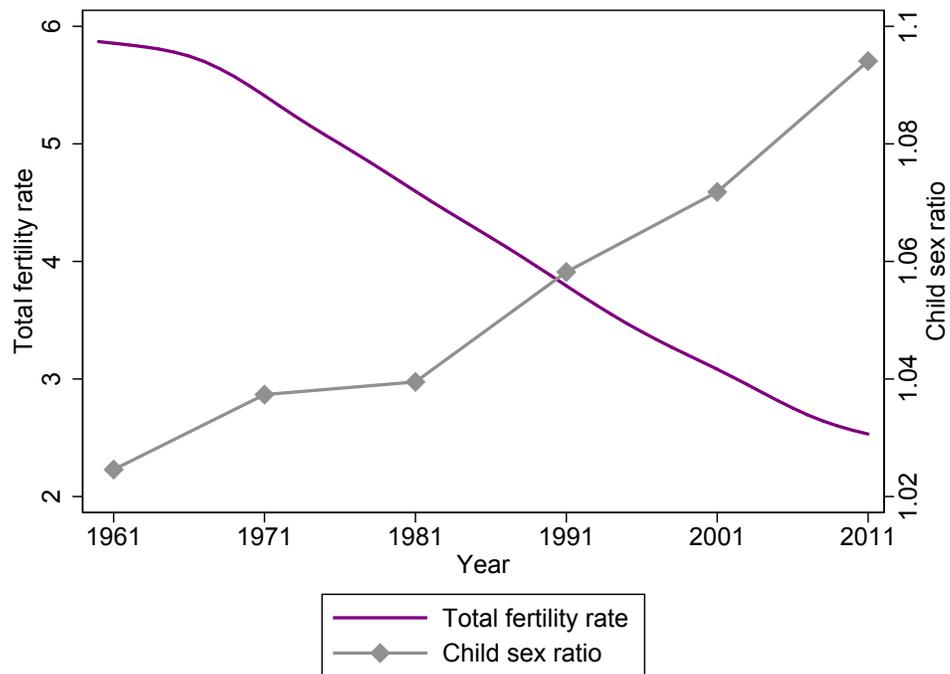
²⁷In the data used in this paper, female education is associated with a smaller desired family size and lower son preference, and is associated with neither a decrease nor increase in the desired sex ratio.

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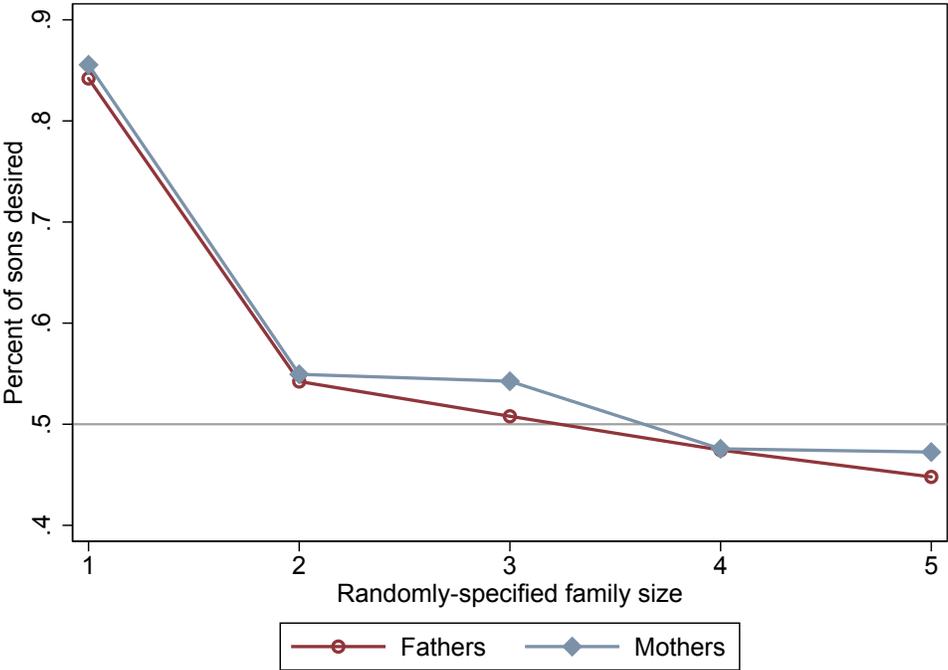
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FIGURE 1. TREND IN THE FERTILITY RATE AND CHILD SEX RATIO IN INDIA



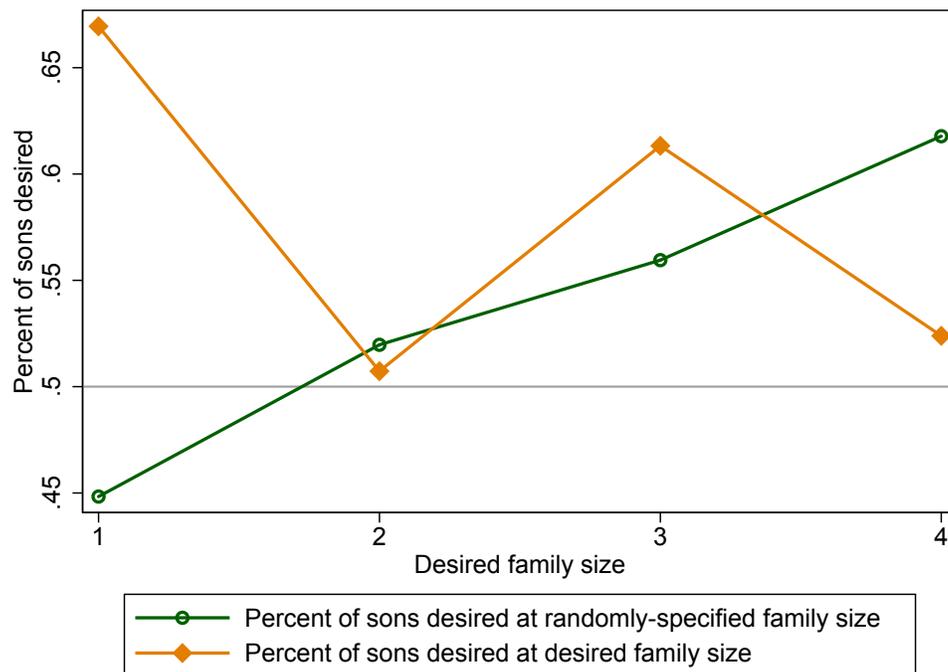
Notes: Data sources are Indian Census of Population (child sex ratio, every 10 years) and World Bank Indicators (total fertility rate, annual). Child sex ratio is the ratio of males to females among children 0 to 6 years old.

FIGURE 2. PERCENT OF SONS DESIRED AT RANDOMLY-SPECIFIED FAMILY SIZES



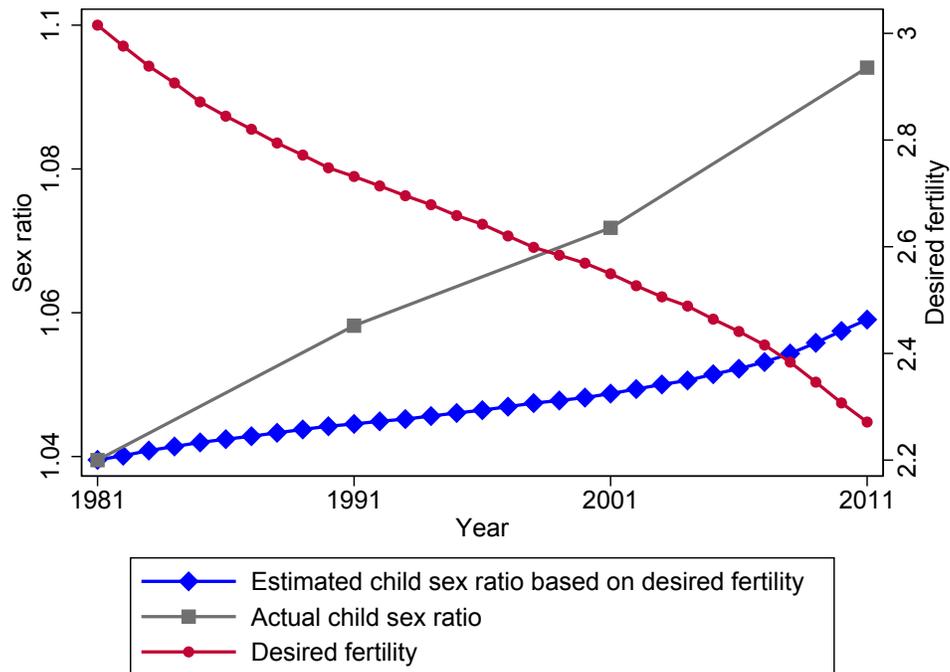
Notes: The vertical position of each data point is the average percent sons desired among respondents asked about the family size indicated on the horizontal axis. Respondents were randomly assigned a hypothetical family size of 1, 2, 3, 4 or 5.

FIGURE 3. PERCENT OF SONS DESIRED BY RANDOMLY-SPECIFIED VERSUS DE-SIRED FAMILY SIZE



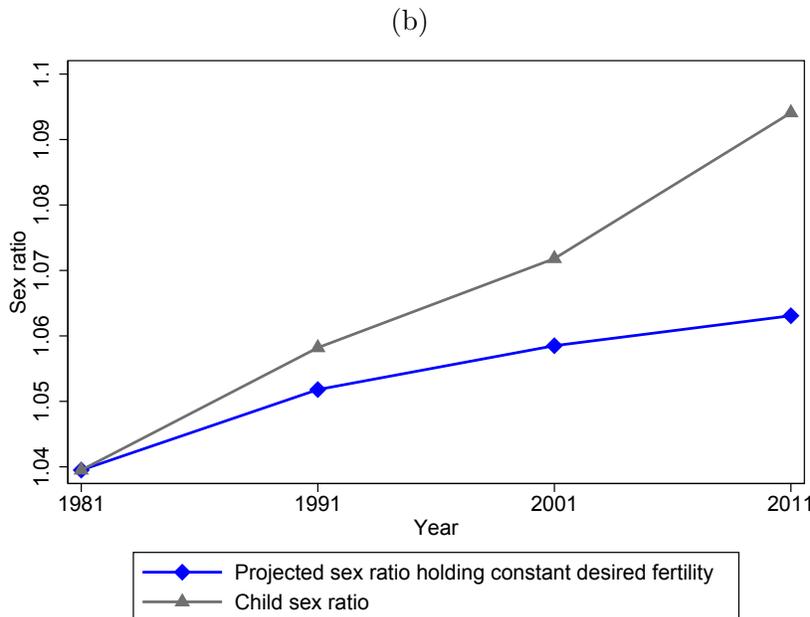
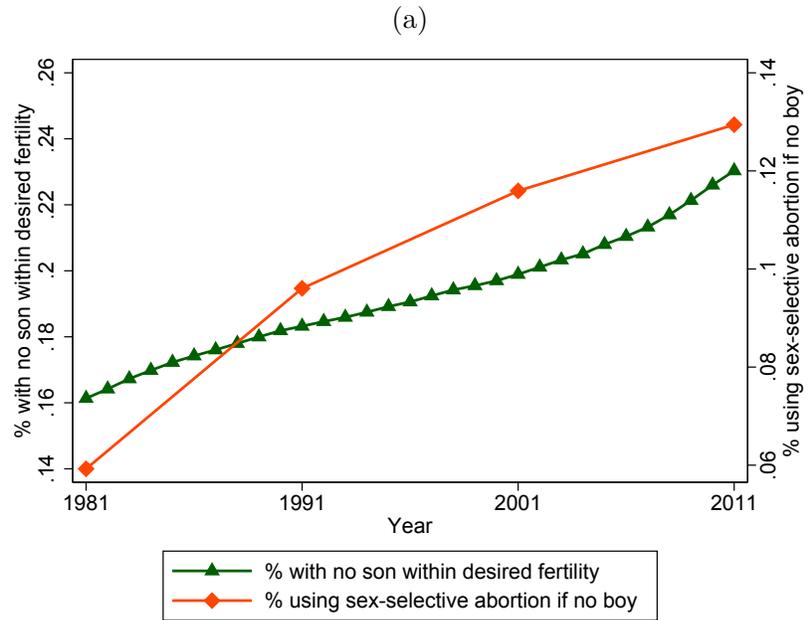
Notes: The line marked with circles shows how son preference, measured using an exogenous fertility level, varies across respondents with different desired fertility levels. The line marked with diamonds shows how the traditional measure of son preference based on DHS-type fertility questions varies across respondents with different desired fertility levels.

FIGURE 4. HOW MUCH OF THE SEX RATIO TREND CAN FERTILITY DECLINE EXPLAIN? (METHOD 1)



Notes: The line marked with squares is the child sex ratio from Indian Census of Population data. The line marked with diamonds projects how the sex ratio changed after 1981 due to declining desired fertility by combining (a) the actual decline in desired fertility over the time period and (b) the survey data described in this paper on how the desired sex ratio varies with the fertility level. The line marked with circles plots the average desired fertility level among women age 25 to 34 in the given year, based on responses in the National Family Health Survey Rounds 1 to 3.

FIGURE 5. HOW MUCH OF THE SEX RATIO TREND CAN FERTILITY DECLINE EXPLAIN? (METHOD 2)



Notes: The top panel uses the NFHS desired fertility data to calculate the proportion of women who would not have at least one son naturally within their desired fertility level. The line marked with triangles shows the time trend in this proportion. The line marked with diamonds is the inferred proportion of the first group who uses sex selection to obtain a son; it is the proportion that allows one to match the actual child sex ratio data. In the bottom panel, the line marked with triangles shows the actual child sex ratio. The line marked with diamonds shows the projected sex ratio holding desired fertility fixed at its 1981 level; the gap between the two lines is the portion of the sex ratio trend that is attributable to declining desired fertility.

TABLE 1—DESCRIPTIVE STATISTICS

	Mothers	Fathers
Age	34.975 [5.611]	40.495 [6.732]
Illiterate	0.349 [0.477]	0.137 [0.344]
Finished primary	0.312 [0.463]	0.248 [0.432]
Finished Class 8	0.180 [0.384]	0.229 [0.420]
Finished Class 10	0.124 [0.329]	0.266 [0.442]
Finished Class 12+	0.035 [0.184]	0.120 [0.325]
Hindu	0.942 [0.234]	0.953 [0.212]
Muslim	0.055 [0.228]	0.043 [0.203]
Scheduled caste	0.191 [0.393]	0.168 [0.374]
Scheduled tribe	0.010 [0.099]	0.010 [0.100]
Number of children	3.578 [1.304]	3.514 [1.266]
Percent sons among children	0.542 [0.326]	0.540 [0.329]
Surveyed student is female	0.563 [0.496]	0.543 [0.498]
Surveyed student is grade 6	0.537 [0.499]	0.547 [0.498]

Notes: Sample comprises 3,215 mothers and 2,460 fathers. The table reports subsample means with standard deviations in brackets.

TABLE 2—DESIRED NUMBER OF SONS BY RANDOMLY-SPECIFIED FAMILY SIZE:
SAMPLE MEANS

Desired number of sons at randomly-specified family size:	Randomly-specified family size:				
	1	2	3	4	5
0	0.151	0.031	0.020	0.014	0.028
1	0.849	0.846	0.405	0.176	0.153
2		0.124	0.546	0.726	0.350
3			0.029	0.063	0.436
4				0.021	0.018
5					0.015
Average percent of sons desired	0.849	0.546	0.528	0.475	0.462
Sex ratio desired	5.639	1.204	1.117	0.905	0.858
Observations	1,102	1,101	1,182	1,178	1,112

Notes: Cells in the first 6 rows report the proportion of respondents who want a particular number of sons at the hypothetical randomly-specified family size. The remaining rows report the aggregated average percent sons, corresponding sex ratio, and sample size for each randomly-specified family size.

TABLE 3—PERCENT OF SONS DESIRED BY RANDOMLY-SPECIFIED FAMILY SIZE:
REGRESSION RESULTS

	Percent of sons desired at randomly-specified family size			
	(1)	(2)	(3)	(4)
Randomly-specified family size	-0.085*** [0.003]		-0.084*** [0.003]	
Randomly-specified family size is 2		-0.303*** [0.014]		-0.302*** [0.013]
Randomly-specified family size is 3		-0.322*** [0.013]		-0.321*** [0.013]
Randomly-specified family size is 4		-0.374*** [0.013]		-0.374*** [0.013]
Randomly-specified family size is 5		-0.387*** [0.013]		-0.386*** [0.013]
Controls for baseline characteristics	No	No	Yes	Yes
p-values for equality of coeffs				
Family size 1=Family size 2		0.000		0.000
Family size 2=Family size 3		0.034		0.032
Family size 3=Family size 4		0.000		0.000
Family size 4=Family size 5		0.070		0.115
Observations	5,675	5,675	5,675	5,675

Notes: Each observation is a parent respondent. In columns 3 and 4, all baseline characteristics listed in Appendix Table 2 (as well as indicator variables for missing values) are included as control variables. Standard errors, clustered by school, are in brackets.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

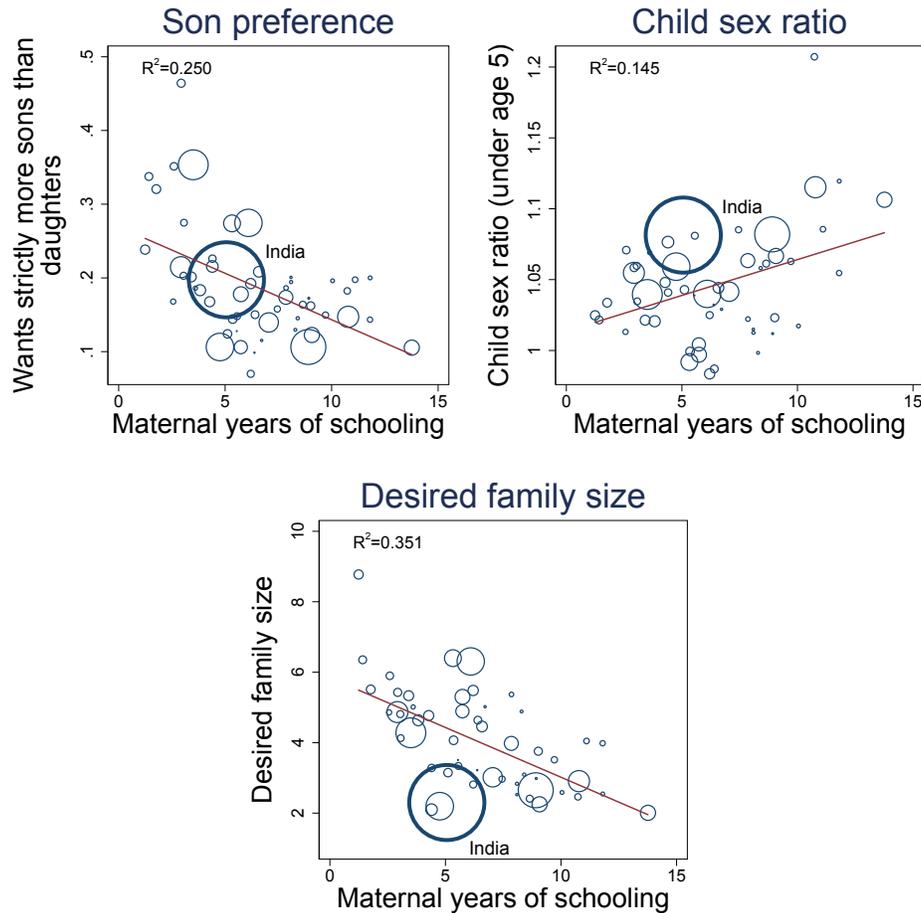
* Significant at the 10 percent level.

TABLE 4—PERCENT SONS DESIRED BY RANDOMLY-SPECIFIED VERSUS DESIRED FAMILY SIZE: SAMPLE MEANS

Randomly-specified family size	Desired family size			
	1	2	3	4+
1	0.647	0.861	0.828	1.000
2	0.527	0.541	0.620	0.583
3	0.433	0.530	0.609	0.700
4	0.440	0.477	0.512	0.500
5	0.393	0.471	0.490	0.600
Avg. percent of sons at randomly-specified family size	0.448	0.520	0.560	0.618
Avg. percent of sons at desired family size	0.669	0.507	0.613	0.524
Observations	298	4,460	284	50

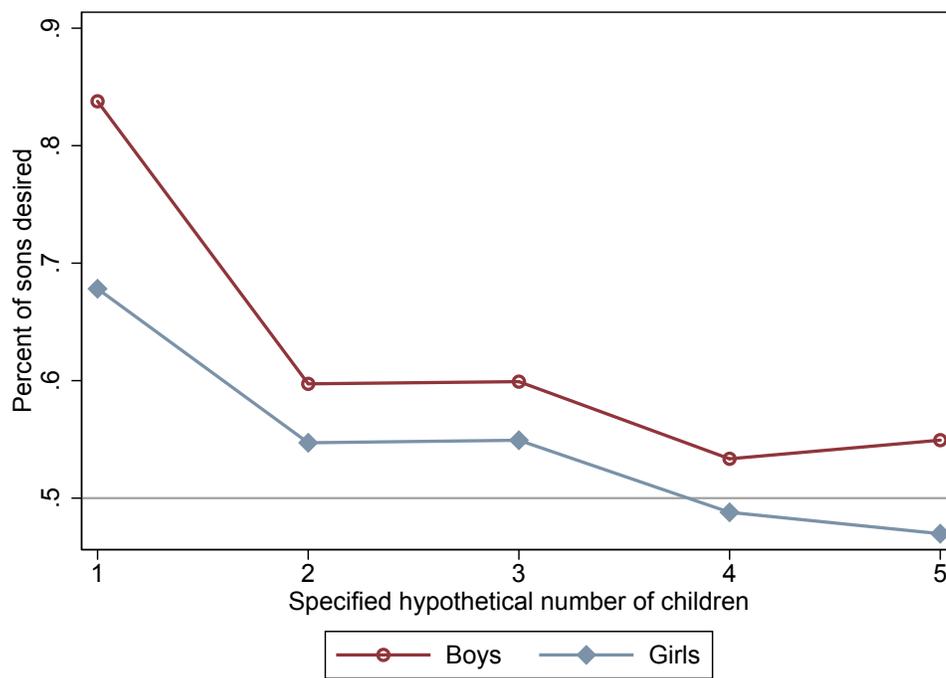
Notes: Each column is a subsample defined by the respondent's desired family size for his or her child. The first 5 rows report the average percent sons desired by respondents randomly assigned to different specified family sizes. The sixth row aggregates the data in the first 5 rows and reports the average percent sons at the randomly-specified family size. The seventh row reports the percent sons desired based on responses to the standard DHS-style fertility question where the respondent chooses the desired family size and sex composition simultaneously.

APPENDIX FIGURE 1. CROSS-COUNTRY RELATIONSHIPS: FEMALE EDUCATION VERSUS SON PREFERENCE, CHILD SEX RATIO, AND DESIRED FAMILY SIZE



Notes: Data are from Demographic and Health Surveys (DHS) of ever-married women age 15 to 49. The sample comprises countries that conducted a DHS between 2005 and 2014; the most recent DHS per country is used. Each circle represents a country; the size of the circle is proportional to the DHS sample size. The R^2 is based on an unweighted regression where the dependent variable is the outcome on the vertical axis and the independent variable is log GDP per capita. The line plots the fitted values from the regression. Each of the three univariate relationships is statistically significant at the 5 percent level. *Wants more sons than daughters* and *desired family size* are based on the DHS question that asks the respondent how many children she would ideally want and what their sex composition would be, if she could go back to the start of her childbearing. *Child sex ratio* is the ratio of boys to girls among respondents' currently-alive children age 5 and under. GDP per capita is the World Bank's PPP-adjusted value in US dollars for the survey year.

APPENDIX FIGURE 2. PERCENT SONS DESIRED BY RANDOMLY-SPECIFIED FAMILY SIZE: ADOLESCENT DATA



Notes: The sample consists of 3,387 secondary schools students (22 percent of the total students surveyed; the fertility preferences were then removed from the student questionnaire at the request of the Haryana government). The survey questions asked their preferred gender composition if, in the future, they were to have the specified number of children.

APPENDIX TABLE 1—WEALTH, FERTILITY LEVELS, AND SON PREFERENCE IN NORTH INDIA

	Haryana	Other Hindi-belt states
Dwelling has piped water	0.40 [0.49]	0.29 [0.46]
Dwelling has electricity	0.93 [0.26]	0.72 [0.45]
Wealth index	0.23 [0.88]	-0.04 [1.08]
Number of births	2.24 [1.95]	2.42 [2.32]
Desired family size	2.18 [0.81]	2.40 [0.89]
Wants strictly more sons than daughters	0.22 [0.42]	0.26 [0.44]
Years of schooling (boys)	4.13 [2.54]	3.40 [2.56]
Years of schooling (girls)	3.92 [2.66]	3.15 [2.59]

Notes: Respondents are ever-married women age 15 to 49 from the National Family Health Survey, round 3. The Hindi-belt states, excluding Haryana, are Bihar, Chhattisgarh, Delhi, Himachal Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Uttaranchal. The sample size comprises 2,790 respondents for Haryana and 42,608 for the other Hindi-belt states; schooling is based on 2,464 children age 7-14 in Haryana and 37,949 children in the other Hindi-belt states. The wealth index is constructed by the NFHS using principal component analysis of several asset ownership and dwelling characteristics variables, and is normalized to be mean 0 and standard deviation 1 for the India-wide sample.

APPENDIX TABLE 2—RANDOMIZATION BALANCE CHECK

	Randomly-specified family size:					Equality of means p-value
	1	2	3	4	5	
Age	37.666 [6.601]	37.512 [6.813]	37.445 [6.946]	37.186 [6.457]	37.201 [6.733]	0.392
Illiterate	0.264 [0.441]	0.254 [0.436]	0.247 [0.431]	0.262 [0.440]	0.260 [0.439]	0.843
Finished primary	0.284 [0.451]	0.294 [0.456]	0.280 [0.449]	0.268 [0.443]	0.295 [0.456]	0.625
Finished Class 8	0.187 [0.390]	0.187 [0.390]	0.206 [0.404]	0.213 [0.410]	0.213 [0.410]	0.377
Finished Class 10	0.187 [0.390]	0.191 [0.393]	0.194 [0.396]	0.188 [0.390]	0.166 [0.372]	0.637
Finished Class 12+	0.077 [0.266]	0.074 [0.262]	0.073 [0.261]	0.070 [0.255]	0.066 [0.248]	0.847
Hindu	0.942 [0.234]	0.952 [0.214]	0.950 [0.218]	0.952 [0.213]	0.936 [0.245]	0.365
Muslim	0.054 [0.225]	0.044 [0.204]	0.048 [0.214]	0.044 [0.205]	0.060 [0.238]	0.326
Scheduled caste	0.175 [0.380]	0.174 [0.380]	0.184 [0.388]	0.176 [0.381]	0.191 [0.393]	0.884
Scheduled tribe	0.007 [0.083]	0.007 [0.083]	0.018 [0.134]	0.009 [0.094]	0.008 [0.091]	0.316
Number of children	3.531 [1.297]	3.608 [1.303]	3.561 [1.265]	3.535 [1.332]	3.516 [1.238]	0.857
Percent sons among children	0.554 [0.320]	0.513 [0.325]	0.541 [0.329]	0.544 [0.332]	0.552 [0.327]	0.083
Surveyed student is female	0.535 [0.499]	0.573 [0.495]	0.556 [0.497]	0.560 [0.497]	0.545 [0.498]	0.519
Desired family size	2.038 [0.405]	2.014 [0.389]	2.002 [0.391]	2.017 [0.390]	2.015 [0.384]	0.583
Actual percent of sons desired at desired family size	0.521 [0.106]	0.522 [0.113]	0.526 [0.120]	0.524 [0.104]	0.521 [0.125]	0.545

Notes: Standard deviations in brackets. The statistical test for joint equality of means across subsamples allows for clustering within a school.

APPENDIX TABLE 3—RELATIONSHIP BETWEEN DESIRED FAMILY SIZE AND SON PREFERENCE

	Percent of sons desired at randomly-specified family size		Actual percent of sons desired at desired family size	
	(1)	(2)	(3)	(4)
Desired family size	0.066*** [0.010]		-0.023*** [0.008]	
Desired family size is 2		0.093*** [0.019]		-0.162*** [0.018]
Desired family size is 3		0.133*** [0.024]		-0.056*** [0.020]
Desired family size is 4+		0.213*** [0.040]		-0.144*** [0.021]
Constant	0.439*** [0.021]	0.481*** [0.019]	0.569*** [0.018]	0.669*** [0.019]
p-values for equality of coeffs				
Family size 1=Family size 2		0.000		0.000
Family size 2=Family size 3		0.011		0.000
Family size 3=Family size 4+		0.041		0.000
Observations	5,092	5,092	5,092	5,092

Notes: Standard errors, clustered by school, are in brackets.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.