Socio-Economic Determinants of Child and Juvenile Sex Ratios in India: A Longitudinal Analysis

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Abstract

The paper examines the determinants of the child and juvenile sex ratios in India in a multivariate framework, using district level data from the 1981, 1991, and 2001 Indian population censuses. The results strongly suggest that there are deep rooted cultural factors at play in the determination of the sex ratios at birth and at early ages, cultural factors that are not much responsive to the enhancement of women's agency or to economic development. However, the results also show that the behaviour of the juvenile sex ratio does respond to the enhancement of women's agency and to economic development. Policy implications of these findings are considered.

Keywords: child and juvenile sex ratios; socio-economic determinants; India; longitudinal analysis.

JEL Classifications: J10, J13, J17, J18.

Introduction

The human sex ratio (conventionally defined as the number of males per 100 females[1]) varies greatly between countries and regions. Differentials in mortality by sex are now nearly universally recognized; with equal care and feeding, females experience lower mortality. This is particularly so in advanced age and also during the neonatal period. There is greater biological frailty of the male infant with regard to congenital defects and the birth process. In western Europe and North America, female children typically have a substantial survival advantage. The biological norm is for about 105 boys to be born for every 100 girls more or less everywhere in the world. But given the greater survival rates of females, the sex ratio of the population in the West and in many other parts of the world leans in favour of women. In the UK, the ratio is 98, in the US, 97 and in the EU taken as a whole, 92. In the sub-Saharan Africa, where the life expectancy at birth for both males and females is quite low, the ratio is 99.

In contrast, there are many countries in the world – most notable China and India – where the ratio is abnormally high: in both China and India, the ratio is 106. It has been estimated that if India and China had the same sex ratio as in sub-Saharan Africa, then, given the number of males in these countries, there would have been 37 million more women in India and 44 million more women in China in the mid-1980s. According to Sen (1990), "These numbers tell us, quietly, a terrible story of inequality and neglect leading to the excess mortality of women".

The sex ratio of India's population has increased almost continuously throughout the last century (Table 1).British officials overseeing the first censuses conducted in India in the late nineteenth century had already commented on the masculinity of the population composition in the country. But a serious demographic analysis had to wait for the publication of Visaria's (1967, 1968) work which conclusively showed that higher female than male mortality was the principal cause of the male-heavy character of the Indian population. Subsequent research showed that the sex differential in child mortality was a substantial, probably the largest, contributor to India's abnormally high sex ratio in the recent past (see, among others, Agnihotri, 2000; Bhattacharya, 2006). It was the neglect of female children, especially when they fell sick, rather than some phenomenon of hidden female infanticide, that was primarily responsible for the female disadvantage in child survival.[2]

Table 1 Trends in the sex ratio (number of males per hundred females), India

Year	*SR*	*Year*	*SR*
1901	102.88	1961	106.27
1911	103.73	1971	107.53
1921	104.71	1981	107.07
1931	105.26	1991	107.87
1941	105.82	2001	107.18
1951	105.71	2011	106.38

Source: Census of India (2011). Note: SR = Sex Ratio

The female disadvantage in child survival (measured as the excess of female deaths over male deaths by age 5), however, has been declining in India in recent years, from 11.3 per thousand in 1981 to 6.4 per thousand in 1991, to 1.03 per thousand in 2001. Child mortality itself (defined as the probability of dying by age 5) also registered a major decline from about 157 per thousand in 1981 to 101 per thousand in 1991, to 70 per thousand in 2001. The ratio of female to male child mortality declined from 1.07 in 1981 to 1.06 in 1991, to 1.04 in 2001. At the same time, there has been a fall in adult female mortality rates relative to male adults. Taking all age groups together, the overall survival chances of females in India are now higher than those of males. Life expectancy at birth for both males and females has been increasing, but the gains for females have been much greater than for males in the past few years.[3]

This increase in female life expectancy should, in due course, be reflected in a lowering of the sex ratio. However, in recent years, another upward influence on the sex ratio has emerged; selective abortions of female foetuses. Consequently, the sex ratio of the population in the age group birth to 6 years has registered a major increase from 103.95 in 1981 to 105.82 in 1991, to 107.87 in 2001 and 109.41 in 2011. So while the overall sex ratio declined between 2001 and 2011 from 107.18 to 106.38 (see Table 1), the sex ratio of the population aged 0-6 has seen a significant increase. The sex ratio of the population aged 7-14 has also seen an increase over the period 1981 to 2011, though not by the same extent.

The most comprehensive analysis of the behaviour of the sex ratio over time in India is that by Bhat(2002). He noted that "in the first half of the last century, the sex ratio increased because of the increase at adult ages, especially at age 40 and over". After independence (in 1947), the increase had mainly been at ages below 15. Following a careful reading of the evidence, Bhat's conclusion was that the rise in the sex ratio until 1951 was mainly because of the control of famines that used to take a heavier toll of older men than women. Control of famines and declines in starvation-related deaths meant that fewer of these men were dying than before. "Thus it was not really females who went additionally missing" during this period, "but it appeared so because older men do not succumb to starvation as they did before". However, there was clear evidence that, after 1981 the sex ratio at birth had altered, pointing to the prevalence of sex selective abortions.

In the past, the sex ratio at birth (SRB) in India was not known to be different from the biological norm of about 105 (Visaria, 1968). Since the availability of sex detection tests in the early 1980s, however, the ratio has risen. The estimates of SRB from the Sample Registration System (SRS)[4] show the SRB to be close to 110 in the 1980s, and around 113 in the early years of this century. There are other estimates of SRB available from other sources. Kulkarni (2007) has provided a good assessment of these estimates. Kulkarni (2007) has also provided estimates of the number of "missing girls" for the age group birth to 14 years. If India had the SRB of 105 and the same mortality differentials by sex as in the West, then there would have been, according to Kulkarni's calculations, 9.85 million more girls in this age group in 2001. Of this, 3.78 million (38 per cent) Kulkarni attributed to excess female mortality and the rest, 6.07 million, to higher than the normal sex ratio at birth. This works out at 3.5 per cent of the female population in this age group. Kulkarni also estimated that during the 25 years since 1981, nearly 11 million sex – selective abortions were performed in India. This amounted to 3.6 per cent of female births or 1.7 per cent of live births. There have also been other estimates of sex-selective abortions in India. Based on the SFMS data, [5] Jha *et al.* (2006), for example, offered an estimate of 10 million sex-selective abortions over the twenty year period 1986-2005. Regardless of which estimate one accepts as the most likely to be correct (see also estimates by Arnold *et al.*, 2002; Bhat and Zavier, 2007), it is clear that the number of sex-selective abortions in India has been quite high.

While there are, as just noted, a number of studies discussing the rise in the child sex ratio and sex-selective abortions in India, none of these has addressed the question of the determinants of the child sex ratio in the context of a multivariate analysis. The purpose of the present paper is to study the determinants of the sex ratio of the population aged 0 - 6 years and the sex ratio of the population aged 7- 14 years, using data from the 1981, 1991 and 2001 population censuses. (Sufficiently detailed data from the 2011 census are not available at the time of writing and are unlikely to be available for a while yet). The analysis will be based on 326 districts contained within 14 major states, [6] and which, together, accounts for about 94 per cent of the total population of the country. The district is the basic unit of administration and the lowest level at which spatially disaggregated information on key demographic variable is available.[7] The focus on districts, we believe, is of some importance in studying demographic outcomes in India, as district-level policies undertaken and implemented by district-level politicians and officials may often be of critical importance in determining these outcomes. Also, the influence of social norms, many of which have been undergoing rapid changes in India in recent years, is probably more adequately captured in district-level than in household-level analysis (Sen 1999, pp. 218-219). However, the district and household-level analyses are not, of course, contradictory and are best viewed as complimentary.

Variables and Estimation Methods

This section describes the dependent and explanatory variables and the estimation methods employed. As just indicated, we shall use two dependent variables: the sex ratio of the population aged 0- 6 years (hereafter the 0-6 sex ratio), and the sex ratio of the population aged 7-14 years (hereafter the 7-14 sex ratio).[8] Definitions, means and standard deviations of all the variables are presented in Table 2. Data for the analysis come from standard census sources and details are provided in Table 2.

Explanatory Variables

In broad terms, the explanatory variables can be thought of as consisting of a number of distinct groups.

(1) To investigate whether the identified relationships vary significantly between different social groups, we examine the impact of belonging to one of the three minority groups: scheduled castes, scheduled tribes and Muslims. Formerly known as ‘untouchables’, a term applied to a wide range of Hindu groups belonging to the lowest rung in the caste hierarchy, the scheduled castes comprise about 16 per cent of India’s population.

Table 2. Variable definitions and sample means (standard deviations in parentheses), 1981, 1991 and 2001

Variable	Definition	1981	1991	2001
0-6 sex ratio	Number of males per 100 females in the population aged 0-6 years	104.2 (4.372)	106.3 (3.838)	108.6 (5.902)
7-14 sex ratio	Number of males per 100 females in the population aged 7-14 years	108.5 (7.819)	109.6 (7.599)	109.9 (5.632)
Scheduled caste	Percent of a district's population belonging to a scheduled caste	15.90 (7.075)	16.80 (6.977)	16.64 (7.027)
Scheduled tribes	Percent of a district's population belonging to a scheduled tribe	9.011 (15.38)	8.951 (15.21)	8.951 (15.01)
Muslim	Percent of a district's population whose household head is Muslim	9.765 (8.756)	10.41 (9.677)	10.95 (10.11)
Female literacy	Percent of a district's female population aged 15-59 that is literate	24.89 (17.17)	32.30 (18.54)	51.56 (17.51)
Female labour force participation	Percent of a district's female population aged 15-49 categorized as main workers	23.51 (16.84)	26.63 (17.06)	24.99 (13.07)
Pucca roads	Percent of villages in a district approached by pucca (surfaced) roads	41.88 (25.92)	47.82 (26.43)	63.26 (25.21)
Agricultural workers	Percent of a district's main workers aged 15-49 categorized as agricultural workers	68.08 (16.90)	67.21 (17.27)	57.70 (19.35)
Medical facilities	Percent of villages in a district having a medical facility	23.56 (21.80)	40.22 (29.87)	42.82 (25.01)
Safe drinking water	Percent of households in a district with access to safe drinking water	34.76 (22.92)	60.48 (21.30)	98.50 (11.37)
Rural population	Percent of a district's population living in rural areas	79.91 (15.14)	76.82 (16.30)	75.17 (17.11)
East dummy	Dummy = 1 for districts in the states of Bihar, Orissa, and West Bengal	0.184 (0.388)	0.184 (0.388)	0.184 (0.388)
West dummy	Dummy = 1 for districts in the states of Gujarat and Maharashtra	0.138 (0.345)	0.138 (0.345)	0.138 (0.345)
South dummy	Dummy = 1 for districts in the states of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu	0.215 (0.411)	0.215 (0.411)	0.215 (0.411)

SOURCES: Government of India (1989, 1994) for safe drinking water for 1981 and 1991. The remaining variables are calculated from Census of India 1981, Primary Census Abstract, Part II-B; Census of India 1981, General Economic Tables, Part III (A and B); Census of India 1981, General Population Tables; Census of India 1981, Social and Cultural Tables, Part IV; Census of India 1981, Series 1, Paper 3 of 1985, "Household population by religion of the head of household", Census of India 1981, District Census Handbooks; Census of India 1991, Primary Census Abstract, Part II-B; Census of India 1991, General Population Tables; Census of India 1991, Social and Cultural Tables, Part IV A-C2; Census of India 1991, Paper 1 of 1995 "Religion", Census of India 1991, Village Directory; Census of India 2001, Primary Census Abstract; Census of India 2001, General Population Tables; Census of India 2001, Social and Cultural Tables; Census of India 2001, General Economic Tables; Census of India 2001, Religion; Census of India, 2001, Tables on Houses, Household Amenities and Assets; and Census of India 2001, Village Directory.

They continue to suffer from persecution even though discrimination on the basis of caste has been declared illegal in the Indian constitution. The scheduled tribes include most so-called tribal or indigenous communities throughout India. Considered to be outside the Hindu caste system, they comprise about 8 per cent of India's population. Both scheduled castes and scheduled tribes are at the lowest level of the social scale. It would appear important to know the effect of their status, especially because minority groups that have been discriminated against for centuries may organize their family structure and gender relationships in ways different from those of the dominant groups. Muslims in India, who comprise about 11 per cent of the population in the study area, are also considerably deprived in many dimensions.

(2) The variables in the second group are designed to examine the role of women's agency. "Agency" is understood to be the power or freedom to exercise choice in one's actions, free from the constraints of social structure. The variables in this group are female literacy and female labour force participation. Education is believed to help women overcome the barrier set by low autonomy and low social and economic status. It is thought that education changes woman's "perceptions, ideas and aspirations", and so may lead to educated mothers discriminating less against their female children. Similarly, higher levels of female labour force participation may increase the value attached to the survival of a female child.

(3) The variables in the third group are designed to examine the impact of economic development and modernization. The variables in this group are pucca roads (properly surfaced roads) and agricultural workers. The justification for including these variables is as follows. District-specific indicators of income or expenditure are not available in India. We, therefore, use pucca roads and agricultural workers as proxies for a district's level of economic development. Indian authorities consider the availability of motorable feeder roads connecting villages to highways to be a critical indicator of development. Among other things, such roads facilitate the sale of agricultural surplus and import of manufactured goods. We also include a square term for this variable to see if the impact of development in this dimension on the sex ratio changes after a threshold is crossed for the availability of pucca roads. It has sometimes been argued that, following the availability of sex-selection techniques, there might be an inverted-U shaped relationship between the sex ratio at birth (SRB) and economic development in societies with strong son preference. The essential argument is that the SRB would first rise following the

availability of sex-selection techniques in such societies, but then over time as economic development continues, forces are set in motion to bring the SRB back towards its biological norm (see the discussions in Guilmoto,2007, 2009; Bhattacharya, 2013).

Another key element in the development process is the systematic change that occurs in the economic structure with economic growth. The pioneering work of Clark (1940) and Kuznets (1966) demonstrated that economic growth is usually accompanied by a decline in the share of the agricultural sector in total output and employment. Agriculture represents a declining share of national output and employment because of both the relatively low-income elasticity of demand for its products and the shifts in demand toward the products of other sectors, which are induced by changes in technology and in patterns of life and work associated with a growing economy. To capture these changes, the study includes as a variable the percentage of agricultural among all main workers [9] in a district. Districts with higher percentages of agricultural workers, *ceteris paribus*, would have experienced less change in their economic structure.

(4) A fourth group of variables is included to capture the effects of access to healthcare. The variables in this group are medical facilities and safe drinking water. Clearly, these two variables should be of some importance in the determination of child and juvenile sex ratios in India. As already noted, it is the neglect of female children, especially when they fall sick, rather than some phenomenon of hidden female infanticide that is primarily responsible for the female disadvantage in child survival in India. A number of studies found that girls received less medical care than boys and that health dysfunction is tolerated more in the case of girls than boys (see, among others, Dandekar, 1975; Miller, 1981). Several writers have argued that poverty must play an important role by forcing parents to choose among their children in the allocation of scarce resources. They argue that, given the overwhelming economic advantages of males, parents will provide for the survival of their sons over that of their daughters (Koeing and D’souza, 1986; Ware 1984). Others have argued that we must look instead at the low value of females relative to males in Indian society, where sons are not only considered to provide the best assurance of security in the parents’ old age, but are also needed to perform death rites. The effects of sex preferences on India’s demography, they claim, cannot be separated from the cultural context in which they originate.

In either case, it is likely that if and when medical facilities are made available, the survival chances of boys will increase relative to those of girls. To test this hypothesis we include the percentage of villages in a district having a medical facility as an explanatory variable. However, it is also possible that once medical facilities are widely available and so become almost "costless" for parents to access – "costless" not only in terms of money, but also in terms of time and effort – then girls too may receive medical attention and, given their inherent biological advantages in survival, survive better than boys as a result. Accordingly, we also include a square term for this variable to see if this indeed might be the case.

Many diseases are, of course, water borne. Thus, the purer and less contaminated the water supply, the less likely children are to become sick (and the higher the survival chances). In these circumstances, too, given their inherent biological advantage in survival, the survival chances of girls should increase relative to those of boys. We would, therefore, expect the variable safe drinking water to be associated with a lower child sex ratio.

(5) A final variable we include in our analysis is a measure of rural-urban residence. As we have already noted, sex- selective abortions have been a major feature of Indian demography in recent years. Clinics performing sex-determination tests and sex-selective abortions are located in urban areas. So, controlling for other variables, we would expect rural residence to be associated with a lower child sex ratio and we include rural population – the proportion of rural to total population in a district – as a variable to test this hypothesis.[10]

India is, of course, a vast country with diverse characteristics, and to identify regional patterns, we use three dummy variables: "East" for districts in Bihar, Orissa and West Bengal; "West" for Gujarat and Maharashtra, and "South" for Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The control region consists of Haryana, Punjab, Madhya Pradesh, Rajasthan and Uttar Pradesh ("the North"). The "South", in particular, is generally considered to be more liberal than other regions in the country in such characteristics as marriage customs, kinship and inheritance patterns. Women in the southern states are believed to have enjoyed a greater degree of freedom since the pre-Christian era (Dyson and Moore 1983; Kolenda 1987; Dommaraju and Agadjania 2009). Differences in cultural norms and values can, of course, have differing demographic consequences. Data on such measures as dowry and bride price practices, precise form of joint family systems, and inheritance patterns are not available through censuses or other macro-data sources.

Estimation

The estimation methods employed are simple ordinary lease squares (OLS), pooled OLS and generalized least squares random effects (GLS-RE). Our main results pertain to random-effects regressions, and we devote attention primarily to the discussion of these results, though we also report the results of some of the other estimates. A number of the explanatory variables – namely, scheduled castes, scheduled tribes, Muslim, and female labour force participation – changed little between 1981 and 2001, and random-effects estimates are accordingly preferred over fixed-effects estimates. (In the fixed-effects case, all time constant explanatory variables are removed prior to estimation, as these will be collinear with the unobserved effects).[11] All estimates have heteroscedasticity robust standard errors.

Determinants of the sex ratio of the population aged 0-6 years

This section discusses the determinants of the 0-6 sex ratio and the next discusses the determinants of the 7-14 sex ratio. Table 3 presents results for the 0-6 sex ratio. Results of the pooled OLS estimate are presented in column (4). Column (5) estimates a random-effects (RE) model. Our main interest is in the results of the RE estimates.

The explanatory variables account for around 52 per cent of the variation in 0-6 sex ratio across districts in 1981, around 72 per cent in 1991 and 70 per cent in 2001. Of the social group variables, the coefficient of the scheduled tribes variable is negative and statistically significant across all regressions. The coefficient of the Muslim variable is also negative and statistically significant across all regressions, except in the case of the 1981 OLS estimate, where it is negative but not statistically significant. Our primary interest is, of course, in the RE estimates. These results thus show that both the scheduled tribes and the Muslim status are associated with a lower 0-6 sex ratio, suggesting strongly that sex-selective abortions and/or discrimination against female children in this age group are lower or absent among these minority groups. The coefficient of the scheduled castes variable, however, is statistically insignificant across all regressions.

Table 3. Sex ratio of the population aged 0 – 6 years: Results of the regression analysis (dependent variable: 0 – 6 sex ratio)

	Cross – section estimates			Panel: 1981 – 2001	
	1981:OLS	1991:OLS	2001:OLS	Pooled OLS	GLS-RE
	(1)	(2)	(3)	(4)	(5)
Scheduled castes	-0.0241	-0.00721	0.00928	0.0141	0.0318
	(-0.79)	(-0.40)	(0.24)	(0.74)	(1.24)
Scheduled tribes	-0.108***	-0.0826***	-0.0984***	-0.0974***	-0.112***
	(-6.68)	(-8.46)	(-6.37)	(-12.66)	(-10.56)
Muslim	-0.0366*	-0.0628***	-0.128***	-0.0705***	-0.0576***
	(-1.89)	(-4.74)	(-5.86)	(-6.56)	(-4.23)
Female literacy	0.00550	-0.0519***	0.00568	-0.0122	-0.00369
	(0.42)	(-3.74)	(0.32)	(-1.53)	(-0.58)
Female labour force participation	-0.0734***	-0.0869***	-0.0505***	-0.0498***	-0.00433
	(-5.05)	(-7.73)	(-2.59)	(-5.99)	(-0.46)
Pucca roads	-0.00610	0.0293	-0.149***	-0.0311	-0.0285
	(-0.16)	(1.00)	(-2.90)	(-1.39)	(-1.29)
Pucca roads square	0.000326	0.000360	0.00227***	0.000912***	0.000773***
	(1.00)	(1.63)	(5.05)	(4.71)	(4.01)
Agricultural workers	-0.0162	-0.00642	0.00111	-0.00212	-0.00979
	(-0.98)	(-0.35)	(0.06)	(-0.23)	(-1.16)
Medical facilities	0.0685**	-0.0125	0.175***	0.0699***	0.0435***
	(2.30)	(-0.53)	(4.34)	(3.94)	(2.65)
Medical facilities square	-0.000954***	-0.000102	-0.00166***	-0.000822***	-0.000495***
	(-3.19)	(-0.46)	(-4.30)	(-4.98)	(-3.30)
Safe drinking water	-0.00132	-0.00210	0.0149	-0.00779	-0.0174***
	(-0.13)	(-0.30)	(0.76)	(-1.51)	(-3.42)
Rural population	0.00190	-0.00340	-0.00556	-0.0142	-0.0173*
	(0.10)	(-0.26)	(-0.41)	(-1.60)	(-1.83)
1991 time dummy				2.198***	2.217***
				(7.92)	(9.88)
2001 time dummy				3.704***	4.190***
				(8.34)	(10.58)
East	-3.735***	-3.766***	-2.966***	-3.601***	-3.482***
	(-7.23)	(-9.52)	(-5.08)	(-14.52)	(-10.72)
West	0.0405	0.555	-2.640***	-0.344	-0.807
	(0.05)	(1.16)	(-3.06)	(-0.87)	(-1.63)
South	-3.703***	-4.108***	-9.320***	-5.927***	-6.633***
	(-5.76)	(-8.40)	(-12.39)	(-15.11)	(-13.69)
Constant	108.8***	112.4***	109.0***	108.9***	109.1***
	(56.08)	(70.39)	(32.04)	(108.93)	(103.81)
Observations	326	326	326	978	978
R^2	0.524	0.724	0.694	0.628	0.608
within					0.456
between					0.665

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Of the two women's agency variables, the coefficient of female literacy is statistically insignificant across all regressions, except in the case of the 1991 OLS estimate where it is negative and significant. The coefficient of the female labour force participation is also statistically insignificant in the RE estimate. The two women's agency variables thus have no statistically significant effect on the 0-6 sex ratio in the RE estimate, the estimate of our primary interest.

Of the economic development and modernization variables, the coefficient of agricultural workers is insignificant across all regressions, showing that economic development (in leading to a reduction in the share of agricultural workers among total workers) has no significant effect on the 0-6 sex ratio. The coefficient of the pucca roads is also statistically insignificant in the RE estimate (and across all other regression except in the case of the 2001 OLS estimate). Thus, like the two women's agency variables, the two economic development variables too have no significant effect on 0 – 6 sex ratio in the RE estimate.

The coefficient of the medical facilities variable is positive and significant in the RE estimate, showing that the availability of medical facilities is associated with a higher 0-6 sex ratio. This is in accord with the finding that more is spent on the treatment of illnesses of boys than girls, so that when medical facilities become available, boys receive better medical treatment than girls and survive better as a result. However, it is interesting to note that the square term for this variable is negative and significant, showing that after the availability of medical facilities exceeds a threshold and medical facilities become widely available and, as it were, costless for parents to access, girls too well receive medical attention and, given their inherent biological advantages in survival, girls will now survive better relative to boys. The threshold for medical facilities in this dataset is reached when around 44 per cent of the villages in a district have access to medical facilities. It will, however, be noted from Table 2 that even in 2001, the average for the medical facilities variable was less than 44 per cent.

The coefficient of the safe drinking water is negative and significant in the RE estimate. Safe drinking water helps protect children from water borne diseases and the question of seeking medical treatment and the need for spending resources on their illnesses, therefore, do not arise. Given their inherent biological advantages in survival, girls therefore survive better relative to boys.

In line with our expectations, the coefficient of rural population is negative and significant in the RE estimate. In other words, urbanization – the obverse of rural population – and which we took to be a proxy for the availability of sex-selection technology, is associated with a higher 0-6 sex ratio.

The coefficients of two of the regional dummies – "South" and the "East" – are negative and significant across all regressions, showing that, controlling for the other variables, the 0-6 sex ratio is lower in these regions compared to the control region. The coefficient of the "West", too, has a negative sign in the pooled OLS and RE estimates, but it is not statistically significant. The census data show Gujarat and Maharashtra, the two western states, to have some of the highest sex ratios of the population aged 0-6 years in the country, higher than those in Uttar Pradesh and Madhya Pradesh, though lower than in Haryana, Punjab and Rajasthan.

The coefficients of time dummies for both 1991 and 2001 are both positive and significant. The impact of time on the 0-6 sex ratio is significantly greater in 2001 as compared to that in 1991 (more on this in the concluding section).

Determinants of the sex ratio of the population aged 7-14 years

Table 4 presents our estimates for the 7-14 sex ratio. Results for the 7-14 sex ratio differ in important respects from those for the 0-6 sex ratio. Of the social group variables, while the coefficient of the scheduled tribes variable continues to be negative and significant in the 7-14 case as in the 0-6 case, the coefficient of the Muslim variable now becomes insignificant across all regressions. Muslim status, in other words, has no significantly differing effect on the 7-14 sex ratio than that of the majority group status. The coefficient of the scheduled castes variable continues to be insignificant in this case as in the 0-6 case.

The coefficients of both the women's agency variables, female literacy and female labour force participation, which were statistically insignificant in the RE estimate in the 0-6 case, now becomes significant (with negative signs), showing that the enhanced women's agency has a significant effect on increasing the relative survival chances of female children in the 7-14 age group. The coefficient of agricultural workers, which too was insignificant in the 0-6 case, now becomes significant with a positive sign, showing that economic development (in leading to a reduction in the share of agricultural workers among total workers) also improves the relative

Table 4. Sex ratio of the population aged 7 – 14 years: Results of the regression analysis (dependent variable: 7 – 14 sex ratio)

	Cross – section estimates			Panel: 1981 – 2001	
	1981:OLS	1991:OLS	2001:OLS	Pooled OLS	GLS-RE
	(1)	(2)	(3)	(4)	(5)
Scheduled castes	-0.00753	-0.0466	-0.0777^{*}	-0.0206	0.0397
	(-0.13)	(-0.91)	(-1.77)	(-0.69)	(1.02)
Scheduled tribes	-0.152^{***}	-0.134^{***}	-0.116^{***}	-0.120^{***}	-0.129^{***}
	(-6.28)	(-5.61)	(-5.85)	(-9.16)	(-6.84)
Muslim	0.00892	0.00584	-0.0317	-0.0177	0.0193
	(0.23)	(0.18)	(-1.23)	(-0.94)	(0.72)
Female literacy	-0.0896^{***}	-0.153^{***}	-0.00857	-0.0765^{***}	-0.0352^{***}
	(-3.17)	(-5.23)	(-0.44)	(-5.65)	(-4.59)
Female labour force	-0.184^{***}	-0.154^{***}	-0.120^{***}	-0.153^{***}	-0.0626^{***}
participation	(-7.68)	(-5.84)	(-4.80)	(-11.13)	(-5.35)
Pucca roads	0.0390	0.0983	0.00687	0.0374	0.0266
	(0.58)	(1.38)	(0.11)	(1.03)	(0.84)
Pucca roads square	-0.000175	-0.000373	0.000225	-0.000246	-0.000172
	(-0.29)	(-0.67)	(0.45)	(-0.85)	(-0.68)
Agricultural workers	0.0213	0.152^{***}	0.0509^{***}	0.0616^{***}	0.0268^{***}
	(0.67)	(4.05)	(2.65)	(4.27)	(2.77)
Medical facilities	0.136^{***}	0.0702	0.163^{***}	0.148^{***}	0.0712^{***}
	(2.66)	(1.35)	(3.44)	(5.29)	(2.93)
Medical facilities	-0.00118^{**}	-0.000281	-0.00126^{***}	-0.00101^{***}	-0.000392^{*}
square	(-2.01)	(-0.58)	(-2.89)	(-3.82)	(-1.75)
Safe drinking water	-0.0743^{***}	-0.0545^{***}	0.0135	-0.0349^{***}	-0.0209^{***}
	(-3.79)	(-3.34)	(0.59)	(-3.75)	(-2.86)
Rural population	-0.0645^{**}	-0.119^{***}	0.000785	-0.0375^{***}	-0.00800
	(-2.00)	(-3.98)	(0.05)	(-2.91)	(-0.70)
1991 time dummy				2.026^{***}	1.448^{***}
				(4.31)	(4.32)
2001 time dummy				4.735^{***}	2.956^{***}
				(6.51)	(5.23)
East	-4.557^{***}	-2.444^{***}	-3.379^{***}	-4.120^{***}	-4.015^{***}
	(-5.12)	(-2.75)	(-5.03)	(-8.96)	(-5.60)
West	-2.568^{**}	-1.676	-2.953^{***}	-2.574^{***}	-3.325^{***}
	(-2.06)	(-1.31)	(-3.09)	(-3.99)	(-4.76)
South	-8.467^{***}	-6.374^{***}	-8.984^{***}	-7.594^{***}	-9.214^{***}
	(-7.37)	(-5.36)	(-11.50)	(-12.94)	(-15.74)
Constant	122.5^{***}	119.2^{***}	109.3^{***}	114.9^{***}	111.9^{***}
	(38.01)	(35.40)	(34.67)	(70.31)	(74.82)
Observations	326	326	326	978	978
R^2	0.605	0.613	0.528	0.553	0.516
within					0.069
between					0.576

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

survival chances of girls in the 7-14 age group.

The coefficient of the medical facilities variable is negative and significant in this case as in the 0-6 case, showing that the availability of medical facilities has a positive impact on the relative survival chances of boys in the age group of 7-14 years, too. However, again, as in the 0-6 case, the coefficient of medical square in this case, too, is negative and significant, showing that when the availability of medical facilities exceeds a threshold, the availability of medical facilities does improve the relative survival chances of female children. In this case, however, the threshold is reached when around 81 per cent of the villages in a district have access to medical facilities, in contrast to the 44 per cent threshold in the 0 – 6 case. The explanation for this higher threshold would appear to be the following: parents who (continue to) discriminate against female children in this dimension (i.e., neglecting female children when they fall sick) in the age group of 7 to 14 years are on average more entrenched in their prejudices in this dimension than those who discriminate against female children in the age group of 0-6 years, and require, if you like, more "incentive" to spend time, effort and money in treating the illnesses of their daughters.

The coefficient of safe drinking water is negative and significant in the 7-14 case as in the 0-6 case, showing that safe drinking water is associated with a higher female child survival.

The coefficient of rural population, which was negative and significant in the 0-6 case, now becomes insignificant. This result is perhaps not surprising. Urban population (the obverse of rural population) we have taken to be a proxy for the availability of sex-selection technology and we are now at an age beyond the stage and immediate impact of sex-selective abortions.

So far as the regional dummies are concerned, the coefficients of all the regional dummies are now negative and significant. The coefficient of the "West" which was insignificant in the 0-6 case now becomes significant. The two western states of Gujarat and Maharashtra would seem to do better for girls in these latter ages than they do for unborn girls and girls at younger ages.

A comparison: determinants of the 0-6 and 7-14 sex ratios

A comparison of the results in Tables 3 and 4 yields some interesting conclusions. As we have seen, the 0-6 sex ratio is not influenced by women's agency or the economic development variables (the coefficients of female literacy, female labour forces participation, and agricultural workers are all statistically insignificant in the RE estimate in the 0-6 case). Urbanization – the obverse of the rural population – and which we took to be a proxy for the availability of sex-selection technology, however, has a positive and significant effect on this sex ratio.

By contrast, the coefficients of the women's agency and economic development variables are all statistically significant in the 7-14 case, while the coefficient of rural population – the obverse of urbanization – is statistically insignificant. In other words, with respect to these variables, the results in the 7-14 case are exactly opposite of those in the 0-6 case.

Taken together, these results strongly suggest that there are deep rooted "cultural" factors at play in the determination of the sex ratio at birth and at early ages – cultural factors that are not much amenable to the enhancement of women's agency or to economic development. These cultural factors would appear to have interacted with the availability of sex-selection technology to contribute greatly to an increase in the 0-6 sex ratio in India in recent years. However, once female children are born and survive early critical stages, their survival chances do improve with the enhancement of women's agency and economic development.

Concluding remarks

Policies to correct sex ratio imbalances in India have, in recent years, concentrated on preventing sex-selective abortions. However, as we have noted, excess female child mortality still continues to be a problem in India. It is the neglect of female children, especially when they fall sick, which has been mainly responsible for the excess female child mortality. An important aim, therefore, should be to see that female children do not fall sick from infectious and communicable diseases. Our results suggest that the provision of safe drinking water would be of particular benefit here. The availability of "costless" medical facilities – i.e., "costless" to the parents - would also improve the relative survival chances of female children. And though this is not directly incorporated in our analysis (due to the lack of available data), clearly compulsory immunization programmes would also be of great benefit here (as may indeed be the provision of free school meals).

It is, however, undoubtedly the case that sex-selective abortions have been a major cause of child sex ratio rises in India in recent years. Our results suggest that there are deep rooted "cultural" factors at play here – factors which are not responsive to the enhancement of women's agency or to economic development. It is thus not surprising that the time dummies account for such a great part of the variations in the child sex ratio over time in our models. It is also interesting to note that two of our minority group variables – the scheduled tribes and Muslims – are also associated with a lower 0-6 sex ratio.

In the long run, of course, cultural factors may change in response to economic changes, as indeed would appear to have happened, for example, in South Korea where the sex ratio at birth peaked at 117 in 1990 – then the highest in the world – from being normal in 1980. The figure for 2007 is 106. Child sex ratios (which too were amongst the highest in the world) are also now normal (see, among others, Chung and Dasgupta, 2007).

There are now signs that in those states in India which have had the highest SRBs – Punjab and Haryana, in particular – SRBs have begun to decline.[12] However, this has to be set against the fact that the sex ratio of the population aged 0-6 years has seen an increase in some of the other states which previously had lower SRBs (see Paper 1, Provisional Population Totals, Census of India, 2011). There would thus appear to be a long way to go before SRBs return to normal in India, if indeed they do. [13]

Our results, however, do show that the enhancement of women's agency and economic development (in leading to a reduction in the share of agricultural workers among total workers) do lead to an improvement in the relative survival chances of female children in the age group of 7 to 14 years.

Finally, before concluding it may be worthwhile commenting on the link between fertility decline and sex-selective abortions in India. India's total fertility rate (TFR) declined from around 5 in 1981 to 4.4 in 1991, to 3.2 in 2001. Sex-selective abortion can, of course, contribute to a decline in fertility; however, it has been a minor cause of fertility decline in India. Calculations by Bhat (2003), for example, which assume that the rise in the sex ratio of the population aged 0-6 between 1981 and 2001 was due entirely to female feticide, showed that only 7 per cent of the fertility decline during this period could be attribute to this cause. It also does not appear to be the case that the SRB has necessarily been higher in those Indian states which have lower TFRs. Some of the states with the highest SRBs – Punjab, Delhi and Gujarat – do indeed have lower TFRs than the Indian average; but some others with high SRBs – Uttar Pradesh and Rajasthan – have high TFRs. Haryana has the TFR at the national average; however, the lowest TFRs are to be found in the southern states of Kerala and Tamil Nadu, which have normal or near normal SRBs. Clearly, factors other than just the level of SRB are involved in explaining variations in the TFR across states of India. The behaviour of TFR, in other words, may not be as culturally conditioned as sex-selective abortions are in India.

Notes

[1] India does not use the international convention of specifying the sex ratio (SR) as the number of males per 100 females. Instead, it measures the sex ratio in reverse of the usual standard by measuring it as the number of females per thousand males, usually called the female to male ratio or FMR. Clearly, FMR=10,000/SR. In this article, we follow the international convention for facilitating comparisons.

[2] Female infanticide, where it occurs, takes place within the first few weeks of life. The bulk of excess female child mortality in India, on the other hand, was found to occur after the age of 1, beyond the stage of female infanticide. See, among others, Bhattacharya (2006), and Miller (1981).

[3] In the early years of the twentieth century, the overall life expectancy was around 20 years. By 1961, this had risen to 41.3 years (41.9 for males, 40.6 for females). There was an increase to 61.9 years by 2000 (61 for males, 62.7 years for females). The figures for 2009 show life expectancy at 69.89 years, with that for males being at 67.46 years and for females at 72.61 years.

[4] India is unique among developing countries in that it regularly publishes annual statistics on births and deaths from its Sample Registration System (SRS), a monthly survey of 1.3 million households.

[5] The Special Fertility and Mortality Survey (SFMS) conducted by the SRS organization. SFMS covered 1.1 million households in 6,671 nationally representative units.

[6] The only major state missing is Assam, where no census took place in 1981. Three new states, namely, Chhattisgarh, Jharkhand and Uttaranchal (since renamed Uttarakhand), were formed in the year 2000, and were carved out of the existing states of Madhya Pradesh, Bihar and Uttar Pradesh, respectively. For this study, therefore, the terms, "Madhya Pradesh", "Bihar" and "Uttar Pradesh", referred to these states as they were before the formation of the new states, i.e., inclusive of the districts that now constitute Chhattisgarh, Jharkhand and Uttarakhand. There were 326 districts in the 14 states studied in 1981, and this rose to 362 districts in 1991 because 31 of the districts of 1981 had been split into two or more districts each. The number of the districts then rose to 469 in 2001, where a number of the districts of 1991 were split into two or more districts each. For this study, we merged each of the districts

of 1981 that had been subsequently split, using the population of the relevant separate districts in 1991 and 2001 as weights. In cases where a district had been split between 1981 and 1991, we calculated the 1991 value of a variable for a particular district as a population-weighted average over the relevant 1991 districts, and the same was performed for the value of a variable for 2001.

[7] It is to be noted, however, that the estimates of sex ratio at birth are not available at the district level.

[8] The sex ratio of a population can, of course, be influenced by migration rates (in- and out–migration). Most migrants, however, tend to be adults, and one of us has shown elsewhere (Bhattacharya ,2012) that in- and out-migration rates have played very little roles in affecting the sex ratios of the populations in the age groups we are interested in.

[9] In the Indian census, a main worker is defined as a person whose main activity is participating in economically productive work and who worked for 183 days or more in the year preceding the date of enumeration.

[10] Urbanization – the obverse of rural population – can also, of course, be an indicator of development. However, in the context of analyzing the child sex ratio in India and in the current state of development in India, the role of urban areas as providers of sex-selective abortions, we believe, outweigh any other roles that urban areas may play in the determination of the child sex ratio.

[11] See Wooldridge (2000, 2001) for a lucid discussion of the relevant issues.

[12] In the Punjab, according to the SRS data, the SRB declined from 129.03 in 1999-2001 to 120 in 2006-08. Similarly, in Haryana the SRB declined from 124.53 in 1999-2001 to 119.47 in 2004-06.

[13] It may also be noted in this context that our results for pucca roads and pucca roads square do not lend support to an inverted-U relationship between the SRB and economic development for India at this time.

References:

Agnihotri, S.B. (2000), Sex Ratio Patterns in the Indian Population: A Fresh Exploration, New Delhi: Sage.

Arnold, F., Kishor, S. and Roy, T.K. (2002), "Sex selective abortions in India", *Population and Development Review* 28(4): 759-85.

Bhat, P.N.Mari (2002, 2003), "On the trail of 'missing' Indian females", Parts 1 and 2, *Economic and Political Weekly* 37(21-27 December): 5105- 5118 and (28 December- 3 January): 5244- 5263.

Bhat, P.N. Mari and Zavier, A.J. Francis (2001), "Fertility decline and gender bias in Northern India", Discussion Paper No. 33, Institute of Economic Growth, Delhi.

_____(2007), "Factors influencing the use of prenatal diagnostic technique and the sex ratio at birth in India", *Economic and Political Weekly*, 42: 2292- 2303.

Bhattacharya, P.C. (2006), "Economic development, gender inequality, and demographic outcomes: Evidence from India", *Population and Development Review,* 32(2): 263- 291.

_____ (2009), "On adverse sex ratios in some Indian states", *Indian Journal of Gender Studies* 19, 469-80.

_____ (2013), "Gender inequality and the sex ratio in three emerging economies, *Progress in Development Studies* 13, 2, 117-133.

Chung, W. and Das Gupta, M. (2007), "The decline of son preference in South Korea: the roles of development and public policy", *Population and Development Review* 33(4): 757- 83.

Clark, C. C. (1940), Conditions of Economic Progress, Macmillan, London.

Dandekar, K. (1975). "Why has the proportion of women in India's Population been declining?", *Population and Development Review,* 13 (1): 77- 100.

Dommaraju, P.and Agadjanian, V. (2009)"India's north-south divide and theories of fertility change", *Journal of Population Research,* 26 (3): 249- 272.

Dyson, T. and Moore, M. (1983) 'On kinship structure, female autonomy, and demographic behaviour in India', *Population and Development Review,* 9 (1): 35- 60.

Government of India (1988) "Child mortality estimates of India", Occasional Paper No. 5, Demography Division, Office of the Registrar General, New Delhi.

Government of India (1989)"‘Census of India 1981: household literacy, drinking water, electricity and toilet facilities", Occasional Paper No. 1, Office of the Registrar General, New Delhi.

Government of India (1994) "Census of India 1991: housing and amenities: a data base on housing and amenities for districts, towns and cities", Occasional Paper No. 5, Office of the Registrar General, New Delhi.

Government of India (2011), Provisional Population Totals, Paper 1 of 2011, India Series 1, New Delhi, Office of the Registrar General & Census Commissioner.

Guilmoto, C.Z. (2007), “Characteristics of sex- ratio imbalances in India and future scenarios”, UNFPA.

_____ (2009), “The sex ratio transition in Asia”, Working Paper, Centre Population et Development, Paris.

Jha, P., Kumar,R., Vasa,P., Dhingra,N., Thiruchelvam,D. and Moineddin, R. (2006), “Low maleto-female sex ratio of children born in India: national survey of 1.1 million households”, *The Lancet,* 367 (9506): 211- 218.

Koeing, A. and D’Souza, S. (1986), “Sex differences in childhood mortality in rural Bangladesh”, *Social Science and Medicine,* 22(1): 15 – 22.

Kolenda, P. (1987), Regional Differences in Family Structure in India, Rawat Publications, Jaipur.

Kulkarni, P.M. (2007), “Estimation of missing girls at birth and juvenile ages in India”, UNPFA (http:/www.unfpa.org/gender/case_studies.htm).

Kuznets, S. (1966), Modern Economic Growth: Rate, Structure and Spread, Yale University Press, New Haven, CT.

Miller, B. (1981), The Endangered Sex, Ithaka: Cornell University Press.

Sen, A. (1990), “More than 100 million women are missing”, *New York Review of Books*, 37(20).

Sen, A. (1999), Development as Freedom, Oxford: Oxford University Press.

Visaria, P. (1967), “The sex ratio of the population of India and Pakistan and regional variations during 1901-61” in Bose, A. (ed), Patterns of Population Change in India, 334- 71, Mumbai: Allied Publishers.

_____(1968), Sex Ratio of India's Population, 1961 Census Monograph, Delhi: Controller of Publications.

Ware, H. (1984), "Effects of maternal education, women's roles, and child care in mortality" in W.H. Mosley and L.C.Chen (eds), Child Survival: Strategies for Research, *Supplement to Population and Development Review*, 10.

Wooldridge, J.M. (2000), Introductory Econometrics, Cincinnati: South-Western College.

_____(2002), Econometric Analysis of Cross section and Panel Data, Cambridge, M.A., The MIT Press.