NIPFP Working paper series

The Effect of Age-Specific Sex Ratios on Crime: Instrumental Variable Estimates from India

No. 214
20-Nov-2017

Rashmi Barua, Prarthna Goel and Renuka Sane

National Institute of Public Finance and Policy
New Delhi

The Effect of Age-Specific Sex Ratios on Crime: Instrumental Variable Estimates from India.*

Rashmi Barua† Prarthna Goel‡ Renuka Sane§

November, 2017

Abstract

Using data from 1961 to 2001, we show the impact on crime of two age-specific sex ratios corresponding to pre-marital (ages 10 to 16) and marriageable (ages 20 to 26) age groups in India. To deal with the endogeneity of sex ratios, we use an Instrumental Variable (IV) strategy that exploits district level variation in historical area under wheat-rice cultivation, and time-variation in relative producer prices of wheat-rice. We find that an increase in 10-16 age sex ratio by one female per 1000 males leads to a 1.5% decline in violent crime, and a decline of almost 1% for both non-violent and property crimes. The results are not robust to alternate specifications for the effect of sex ratio in the 20-26 age group. These estimates suggest that the imbalance in the sex ratio in India between 1961 and 2001 have resulted in a 28.5% increase in violent crimes and 21% increase in non-violent and property crimes.

JEL Codes: J16; J18; C26
Keywords: Sex Ratio; Crime; Instrumental Variables.

*We thank Abhiroop Mukhopadhyay and Madhav Aney for useful comments. Thanks to all participants at the seminars at Indian Statistical Institute (Delhi Centre), Jawaharlal Nehru University, Ashoka University and the Asia Pacific Economic Association conference in South Korea. The views expressed herein and all errors are our own.

†barua.bhowmik@gmail.com, School of International Studies, Jawaharlal Nehru University
‡prarthnagl@gmail.com, Jawaharlal Nehru University & Indraprastha University
§renuka@saner.org.in, National Institute of Public Finance and Policy

1 Introduction

According to the 2011 census, there were about 7.1 million fewer girls than boys under the age of six in India. This gap has grown substantially overtime; the 2001 census found 6 million fewer girls, while in 1991 there were approximately 4.2 million fewer girls than boys under age six. Skewed sex ratios are also common in other developing countries. For example, Sen (1990) showed that in parts of the developing world, more than 100 million women were missing due to gender discrimination. This has led to a renewed interest in studying the economic and social consequences of "missing women".

The early literature on male sex ratios (defined as the number of males per 1000 females) was focused on its impact on the marriage market. As sex ratios increased, the marginal product of wives would increase. This increasing marginal product would thereby lead men to invest in themselves to increase their earning potential (Becker, 1974; Angrist, 2002).

Recent evidence suggests that a higher male sex ratio has a positive effect on reported crime (Dreze & Khera, 2000). Imbalances in sex ratios are found to have accounted for a one seventh increase in crime in China (Edlund, Li, Yi & Zhang, 2013). In India, South, Trent and Bose (2014) estimate an association between male-female sex ratio and self-reported victimization cases of theft, breaking, entering and assault. The findings also suggest that a higher male sex ratio is associated with frequent harassment of unmarried females.

Using district level data from India, spanning across five census years since 1961, we study if an improvement in the sex ratio in favor of women, [1] i.e. an increase in the number of women per 1000 men, causes a reduction in crime. There are at least three shortcomings in the existing literature which this paper addresses.

First, previous studies have not been able to deal with the potential endogeneity of the sex ratio itself. Cultural norms that lead to son preference, also may determine tolerance towards crime. Moreover, crime itself may lead to poor sex ratios. For example, Oldenburg (1992) suggests that in a society predominated by crime, son preference arises as men in the family provide security against violence, while women are seen as a liability. While there has been an attempt at solving the endogeneity issue by using the labour force participation of women as an instrument (Dreze & Khera, 2000), this may not be an appropriate instrument as it may affect crime directly and thus violate the exclusion restriction (Cantor & Land, 1985; Gartner, Baker & Pampel, 1990).

We solve the endogeneity problem by using an instrumental variable (IV) approach. Our identification strategy relies on the variation in the area under rice and wheat cultivation

[1] In this paper we refer to this as the "female sex ratio".

across Indian districts. At a given point in time, unobserved factors that determine agricultural cropping patterns might also be correlated with crime. The IV, therefore, exploits exogenous district level variation in historical (1961) area under wheat-rice cultivation and across time variation in relative producer prices of wheat-rice.

The use of our IV rests on the literature in phycology and sociology that shows the relation between historical agricultural practices and gender inequality. For example, Ester (1970) argued that societies that traditionally practiced plough agriculture (a relatively male intensive technique of production) – rather than shifting cultivation – developed a specialization of production along gender lines.

In more recent work, Alesina, Giuliano and Nunn (2013) argue that societies that practiced plough farming hold beliefs that are less gender equal portraying poor participation of females in political, social and financial arenas. Plough farming is intensive in body strength and grip as compared to rice farming which is more labour intensive but requires less strength. This gave males a greater say in financial and social arenas, leaving females to more traditional roles in wheat growing areas. Moreover, these societies have a greater prevalence of attitudes favoring gender inequality.[2]

We argue that variation in child sex ratios can be explained by differences in women's economic value – that is driven by the intensity of female participation in the agricultural activities (Bardhan, 1974). The higher demand for female labor in rice areas makes them more valuable than in wheat areas, thus contributing to less discrimination against girls in rice-growing regions. Moreover, the exclusion of women from production leads to their exclusion from holding property rights, thereby resulting in a stronger preference for the male child (Miller, 1981; Sarangi, Jha & Hazarika, 2015). More recent research by Qian (2008) shows that adult income affects the desirability of daughters relative to sons through changing both the consumption and investment value of having a girl relative to a boy. Further, in non-unitary households, a change in adult income can also affect the relative desirability of girls by changing the bargaining power of parents (Browning & Chiappori, 1998).

Second, most studies have focused on the effect of sex ratios at marriage-age on crime. These studies have addressed only one of the channels through which sex ratio may affect crime i.e. due to a shortage of brides, a greater pool of unmarried men might stimulate an environment of unrest and criminal activities. We argue that pre-marital sex ratio, that is the sex ratio at ages 10-16, may also have an effect on crime.

[2]The appendix provides a close visual association of North and North-West India states in India that are found to experience more acute neglect of females as compared to Eastern and Southern states. The latter are mainly paddy growing states that are intensive on female labor as compared to dry states of North and North West that are mainly wheat producing and more intensive on male labor. The latter also depict high female to male ratios.

When the sex ratio in the premarital cohort rises, families of the over-represented gender compete with each other to raise their savings rate in response to the rising pressure in the marriage market (Wei & Zhang, 2011). [3] As the sex ratio improves in favor of women among the pre-marital cohort, parents of daughters might increase savings in countries (such as India) where the bride side has to bear a disproportionate share of marriage related expenses (Horioka & Terada-Hagiwara, 2016).

Theoretically, in an inter-temporal framework, bride-price affects both consumption and labor supply. In the case of the brides family, there is an unambiguous decline in consumption (and increase in savings) and an increase in work hours in anticipation of a dowry payment in future. On the other hand, the groom's family may or may not increase current consumption and leisure depending upon imperfections in the credit market.

Consistent with this, Anukriti, Kwon and Prakash (2016) show that as expected dowry increases, firstborn girl families in rural India significantly increase per capita savings and labor supply relative to firstborn boy families. Moreover, among boy families, they find no significant change in savings in response to expected dowry implying the presence of credit constraints. Economic theory suggests that the income associated with increased work should reduce the motivation to commit crime for economic benefit (Becker, 1968).

We disentangle the two channels by studying the impact on crime of sex ratios at two different age groups, namely, the 10-16 year olds (pre-marital) and the 20-26 (marital) year olds.

Third, most studies look at the effect of aggregate population sex ratios on crime. However, the adult sex ratio composition in a region may change with migration, relative mortality rates, cross-border marriages and anti-female biases in provision of nutrition and health care facilities. We correct for this potential measurement bias by using the sex ratio at birth (age 0-6) in previous Census years to proxy for current age specific sex ratios. For example, the sex ratio among 10 to 16 year olds (or 20 to 26 year olds) in district D in 2001 is proxied by the sex ratio at birth in district D in 1991 (or the sex ratios at birth in 1981).

Our data is based at the district level in India, and comes from different sources. The crime data is obtained from the National Crime Records Bureau (NCRB), which processes crime statistics at the national level. The sex ratio and the district level control variables comes from the decennial Census statistics from 1961 to 2011. Data on crop-production comes from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) while the time series data for producer food prices was obtained from

[3] Wei and Zhang (2011) call this the competitive saving motive. Their estimates suggest that, in China, an increase in the male sex ratio from 1990 to 2007 can explain about 60 percent of the actual increase in the savings rate.

the Food and Agriculture Organization of the United Nations (FAO).

Our estimates suggest that the imbalance in the pre-marital sex ratio in India between 1961 and 2001 have resulted in a 28.5% increase in violent crimes and 19% increase in non-violent and property crimes. On the other hand, the effect of marital age sex ratio (i.e. 20 to 26 years) on crime, though large in magnitude, is not robust to specification checks. This calls into question, at least in the context of India, the view that a shortage of brides may lead to an environment of criminal activities.

Our results have significance in the backdrop of trend of masculinization of the sex ratio. In fact, there has been a literature documenting India's *missing women* but relatively less is known about the consequences of a skewed sex ratio. Our paper is a contribution towards this literature. Further, our results suggest that an improvement in sex ratio in favor of women not only has direct economic benefits but also leads to lower crime rates.

The remainder of the paper is structured as following. The next section (Section 2) explains the identification strategy. In section 3 we present the data and descriptive statistics. Section 4 shows the results while sensitivity analysis is conducted in section 4.3. Finally, we conclude the discussion in section 5.

2 Empirical Strategy

Consider the simple OLS regression:

$$Crime_{it} = \gamma SR_{it} + \delta X_{it} + \epsilon_{it} \tag{1}$$

Where SR refers to the female sex ratio (here onward referred to as the sex ratio) in region i at time t defined as the number of females to 1000 males. X_{it} is a vector of time and region specific controls.

However, the population sex ratio composition in a region may change with migration, relative mortality rates, cross-border marriages, anti-female biases in provision of nutrition and health care facilities (Agarwal, 1986; Basu, 1992; Murthi, Guio & Dreze, 1995; Kaur, 2004). Thus, we estimate the following OLS regression:

$$Crime_{it} = \alpha_1 SR_{ait} + \beta_1 X_{it} + S_i + T_t + \epsilon_{it} \tag{2}$$

Where SR_{ait} refers to the sex ratio for age group a at time t in region i, where $t = 1, 2, 3, 4, 5$ ranges over five census years from 1961 to 2001. S is a state fixed effect and T

are time dummies. The subscript a takes two values, $a = 1$ (ages 10 to 16) and $a = 2$ (ages 20 to 26). We proxy for SR_{ait} using the child sex ratio (i.e. 0 to 6 year olds) in previous decennial census years.[4] For example, the sex ratio among 10 to 16 year olds (or 20 to 26 year olds) in district D in 2001 is proxied by the child sex ratio in district D in 1991 (or the child sex ratios at birth in 1981). We control for proportion of scheduled tribe and schedule caste, proportion of population living in the urban areas and the percentage that is literate. Heteroskedasticity robust standard errors are clustered at the state level.

This choice of age groups also allows us to study the effect of age specific sex ratios (namely, 10-16 year olds and 20-26 year olds) on crime. On the one hand, as the pre-marital sex ratio (10 to 16 year olds) increases in favor of women, female pre-marital investments should increase making crime more expensive. On the other hand, an increase in sex ratio in favor of females among 20 to 26 year olds would decrease crime through competition in the marriage market. A priori, it is not clear which of these mechanisms will have a larger effect on crime.

An OLS regression of age-specific sex ratio on crime will be biased due to the endogeneity of sex ratio owing to two reasons. First, omitted variables can affect both sex ratio and crime. For instance cultural and societal norms that lead to a preference for sons may also determine tolerance towards crime. These norms may even vary at the district level. Secondly, while poor sex ratio may lead to more crime, an unsafe environment in turn may feed into son preference. To correct for the endogeneity of sex ratio, we propose an IV strategy that exploits variation in economic value of rice and wheat across districts in India.[5]

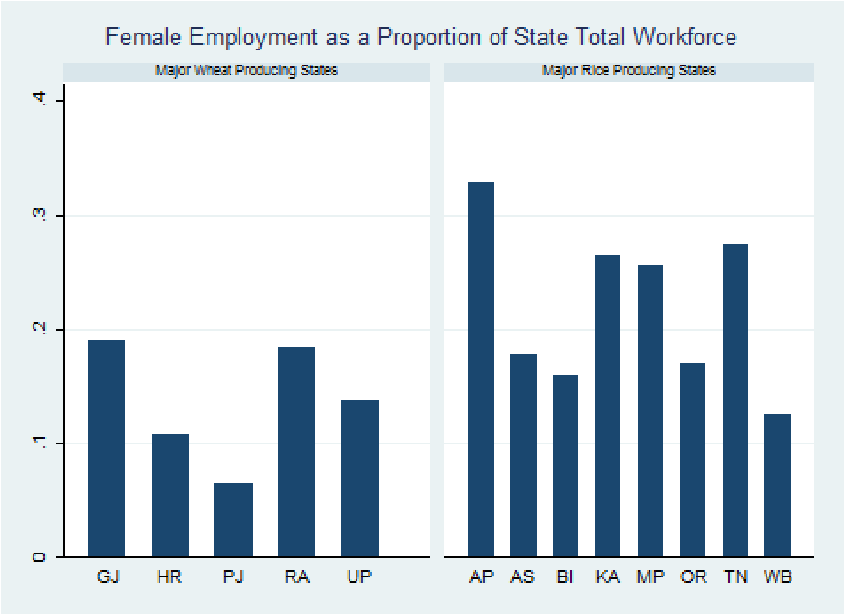
Variation in child sex ratios can be explained by differences in women's relative employment, across districts in India, in rice versus wheat farming. As shown in the maps in Appendix, Northern and North-Western states of India are found to experience more acute neglect of females as compared to Eastern and Southern states. A predominant reason of this is the regional differences in female workforce participation in agricultural activities. States of East and South are mainly paddy growing states that are intensive on female labor as compared to dry states of North and North West that are mainly wheat producing and more intensive on male labor. This preference, therefore, is an important factor that drives the sex ratio differentials.

Figure 1 shows the female employment as a proportion of total state workforce for the

[4]We do not assume that child sex ratio is exogenous to the factors that may bias adult sex ratio, but that it is driven more strongly by factors such as technology and self-selective abortions.

[5]Note that OLS estimates found in the literature that study the effect of sex ratio on crime would suffer from both these problems. In our paper, since sex ratio is lagged, simultaneity bias won't pose a threat to OLS estimates. However, omitted variable bias is still a concern as cultural norms that determine gender biases tend to persist and may impact crime in future.

Figure 1 Female employment for rice and wheat producing states



major rice and wheat producing states of India.[6] The major rice producing states include Andhra Pradesh (AP), Assam (AS), Bihar (BI), Karnataka (KA), Madhya Pradesh (MP), Orissa (OR), Tamil Nadu (TN) and West Bengal (WB). The wheat producing states include Gujarat (GJ), Haryana (HR), Punjab (PJ), Rajasthan (RA) and Uttar Pradesh (UP). As is evident from the figure, female employment shares, on an average, tend to be higher in rice producing states relative to wheat producing states.

We also tested this hypothesis by regressing male-female employment ratio on the wheat rice ratio (area) controlling for all variables described in equation 2. As shown in the first column of Table 1, models with state and time fixed effects yield positive and highly statistically significant results (at 1% level). This suggests that as the area under wheat production increases relative to rice production, the proportion of males relative to females in the workforce increases. Column (2) regresses child sex ratio (0-6 years) on the ratio of male to female employment. As the proportion of males to females in employment increases, the child sex ratio worsens.

Our instrument uses district level variation in historical (1961) area under wheat-rice cultivation and across time variation in relative producer prices of wheat-rice. In particular, we interact historical wheat-rice area ratio, from the year 1961, for each district i with the ratio of producer prices in India for wheat-rice at time t. Thus, the instrument takes the form;

$$Z_{it} = \left(\frac{Area\ under\ wheat}{Area\ under\ rice}\right)_{i,1961} * \left(\frac{producer\ wheat\ price}{producer\ rice\ price}\right)_{t}$$

[6]The employment data is from the decennial census while the crop production data is from ICRISAT. The next section describes this data in details.

Table 1 Validity

	Male/Female Employment	Sex Ratio (0 to 6 Age Group)
Wheat-Rice (Area) Ratio	54.742**	
	(20.589)	
Male to Female Employment		-1.378***
		(0.405)
Proportion Schedule Caste	-6.192	-43.020
	(11.572)	(52.207)
Proportion Schedule Tribe	-7.405*	59.379***
	(3.761)	(21.736)
Proportion Urban	16.477*	-21.974
	(9.374)	(17.843)
Proportion Literate	-22.619	-19.598
	(17.890)	(33.876)
Observations	1542	1589

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions include state and time fixed effects
Crime is measured per 100,000 of population

Thus, we estimate an IV regression based on the following first stage relation:

$$SR_{ait} = \alpha_2 Z_{i,t-a} + \beta_2 X_{it} + S_i + T_t + \epsilon_{it} \tag{3}$$

Where the data for Z corresponds to the same census year as the data on sex ratio at birth.

The available literature suggests that there has been a substantial change in the area under wheat and rice cultivation, specifically in South Asia (Huke & Huke, 1992). In other work, Byerlee (1992) argues that increasing supplies of irrigation water made a major contribution to increasing areas under cereal production in 1960s and 1970s in most of South Asia. Tong, Hall and Wang (2003) find cultural-economic changes and government policies as major contributors to changes in land use in rice, wheat and maize production in China. The authors' analysis suggests that factors such as changes in land policies, population migration, urbanization, agricultural product prices and world trade strongly affected use of land.

Though increasing irrigation facilities and improvement in agricultural technology such as hybrid seeds are less likely to have evolved simultaneously with crime rate, yet institutional changes and other socio-economic factors that impacted land use could have influenced criminal engagements. Thus, wheat-rice area, when used directly as an instrument, may not be completely exogenous to crime. To circumvent this problem, our instrument relies on exogenous variation in historical area under cultivation and global producer prices.[7]

It could be argued that global producer prices do not have much relevance in India as agricultural prices are subject to government policies to provide minimum support to farmers and protect against market volatility. Existing studies, however, suggest a strong positive association between global prices of staple cereals such as wheat and rice and domestic market prices. The policy responses of government are closely driven by the volatility in the international markets (Dorosh, 2009; Jones & Kwieciński, 2010). Global producer prices, hence, offer a close proxy to agricultural prices in the domestic market.

The identification strategy would be invalid if the value of wheat-rice production affected crime through channels other than sex ratio. This would be the case if areas that produce rice are culturally different from wheat producing areas and those same cultural differences lead to differences in crime rates. For instance, Talhelm et al. (2014) argue that a history of farming rice makes cultures more interdependent, whereas farming wheat makes cultures more independent, and these agricultural legacies continue to affect people in the modern world. The underlying theory rests on rice cultivation requiring greater cooperation for irrigation and resource pooling making them less self-centered and individualistic. Thus wheat-rice cultivation may impact several social outcomes.

However, Roberts (2015) refutes the findings of the Talhem paper on data grounds. Further, several researchers (Allik & Realo, 2004; Henrich, Heine & Norenzayan, 2010) show that individuals in regions from America dominated by corn and wheat production own similar or even greater holistic processing than China. Hence, wheat-rice ratio should not hold any significant relationship with social or psychological attributes such as empathy or universal approach. Moreover even if the agricultural patterns are related to behavioral attitudes or institutions, these cultural and institutional factors should not vary significantly across districts within a state. Any inter-state differences are accounted for in the panel analysis where we control for state fixed effects.[8]

In a particular year, adverse weather shocks may affect the production or prices of foodgrains and prevailing economic conditions. These may affect crime through channels other than sex ratios. However, since prices are included with a 10 or 20-year lag, they are unlikely to be associated with current crime rates. Nevertheless, we include rainfall as an additional control variable in all regressions to capture the effect of weather on crop yield as well as directly on crime.

Another concern with the analysis is that there may be changes over time within a state that might affect crime. For example, it is possible that improvements over time in

[7]Global wheat and rice producer price data is sourced from Food and Agricultural Organization (FAO).

[8]If differences in culture and institutions by cropping patterns remained within a state, our estimates would be upward biased.

education, or policing, might affect crime. Since the data varies across districts within a state, our main specification thus controls for state and time interactions.

3 Data

The analysis requires data on crime and sex ratios at the district level since 1961, crop production data for the year 1961 across all Indian district and time series producer food price data for India since 1961. Since the only source of data for district level sex ratios is the decennial census, we gathered information on sex ratio and other control variables from the five decennial censuses between 1961 to 2001.

3.1 Mapping districts

Districts in India are the third geographic tier for data dissemination after national and state-level tiers. Geographical structure of Indian districts has changed significantly since 1961. Not only has the number of districts increased from 340 in 1961 to 593 in 2001, but there have also been changes to the boundary of districts as a result of amalgamations and partitions within existing districts.

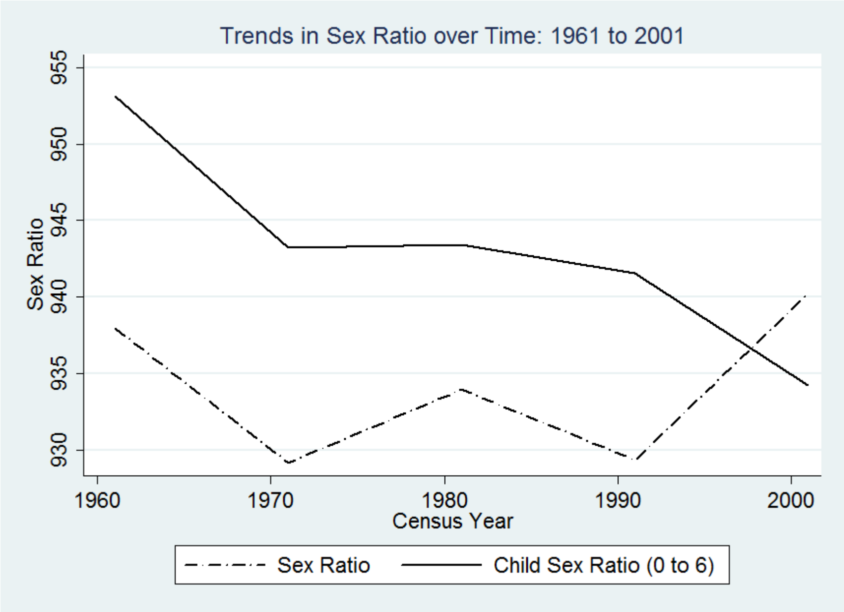
The changing boundaries of Indian districts across the census years make it difficult to control for historic, geographical and social characteristics relevant for the study. In order to use the panel structure of districts, we create a balanced panel of districts over different time periods.

District population weights are used to map districts across the years and the districts for each period are mapped to the administrative divisions in 1971. Mapping demands understanding of boundary changes and partitions through the decades. For each year, the districts are therefore characterized into three categories: districts with unchanged boundaries, districts created by partitioning any existing districts and current districts created from multiple districts in the previous period.

Approximately 38% of the districts over the period remained unaffected from the boundary changes. Nearly 22% were neat splits of boundaries; however around 40%, nearly 141 districts underwent intricate alterations and pose major challenge to a balanced panel. Data mapping is aided by two sources.

First, the national volumes for the general population and housing census for each census year provides the current territorial administrative units and changes from the previous census year. Second, the area and population figures released by the Office of the Registrar General & Census Commissioner, India (ORGI) are used as weights to map districts across

Figure 2 Female employment for rice and wheat producing states



time. The administrative information is supplemented by data on population proportions across the census years for district changes provided by (Kumar & Somanathan, 2009). More information on data mapping is provided in the appendix.

3.2 Data on sex ratios

Child sex ratio (Age 0-6) is measured as the number of females per 1000 males. Figure B.1 in the Appendix shows the variation in sex ratio in India. Figure 2 shows data on trends in the population sex ratios and child sex ratio (age 0 to 6) for the period 1961 to 2001.

There are few observations worth noting. First, the sex ratio for the 0 to 6 ages is significantly higher than the population sex ratio across all years except 2001. Second, the child sex ratio has declined overtime from an average of 953 girls per 1000 boys in 1961 to 934 girls per 1000 boys in 2001.[9] This could be due to the advancement in technology that allows for sex determination and sex selective abortions. On the other hand, the sex ratio for the general population has not changed much between 1961 and 2001.

[9]Child sex ratio, which shows the number of girls per 1000 boys between the ages 0-6, came down to 918 for India in 2011. In 2011, India's general sex ratio, which takes into account men and women of all ages, stood at 943 females per 1000 males. Note that these figures are official announcements as the 2011 Census data is not yet publicly available.

3.3 Data on crime

Crime data is obtained from National Crime Records Bureau (NCRB), India. The Bureau provides district level annual crime data since 1971. Violent crime is measured as the sum of murders, attempt to murder, rape, kidnapping, dacoity and riots. Non-violent crime comprises of robbery, burglary, theft, criminal breach of trust, cheating and counterfeiting. We also separately show results for the three crime variables that measure property crime, namely, robbery, burglary and theft. The crime variables are measured as per 100,000 persons in the district to account for population differences.

In Table 2 we present the descriptive statistics for disaggregated crime. Crime rates are highest for theft followed by burglary and riots.

Table 2 Descriptive statistics for disaggregated crime variables

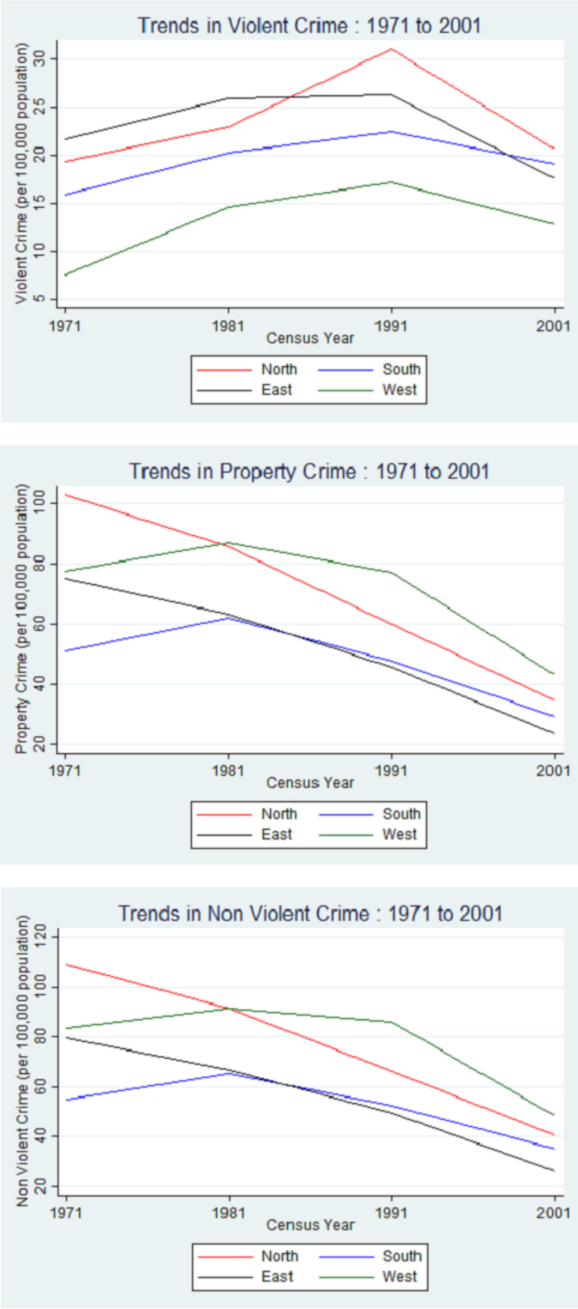
	Obs	Mean	Std. dev
	Violent crime		
Murder	1277	3.59	2.57
Attempt to Murder	1290	2.08	3.03
Rape	1277	1.25	1.38
Kidnapping	1277	2.13	2.22
Dacoity	1283	1.29	2.05
Riots	1277	11.10	12.08
	Non-violent crime		
Counterfeiting	1277	0.19	1.12
Cheating	1277	2.90	3.27
Breach of trust	1277	2.39	2.52
	Property crime		
Burglary	1277	20.32	17.29
Theft	1277	50.00	41.80
Robbery	1277	2.88	3.85

In Figure 3, we present the region wise trends in crime in India between 1971 to 2001. For violent crime, trends are almost parallel across regions with an increase in violent crime between 1970s to 1990s and then a decline in the 1990s. In recent times, the Northern part of India had the highest rates of violent crime while the Western part of India has had lowest rates of violent crime since 1970s. On the other hand, non-violent crime is highest in Western India since the 1980s and gradually declining over time in North India.

3.4 Data on wheat and rice production

Data on area under production for Wheat and Rice (in hectares) is obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The time series

Figure 3 Reported crime by region



data for producer food prices was obtained from the Food and Agriculture Organization of the United Nations (FAO). Figures B.2 and B.3 in the Appendix show the visual distribution of rice and wheat production across the country.

3.5 Data on other variables

We also obtained data from the census on female working population, male working population, total population, proportion of scheduled tribe and schedule caste. The other explanatory variables obtained from the census are the proportion of population living in the urban areas and the proportion that is literate.

3.6 Summary statistics

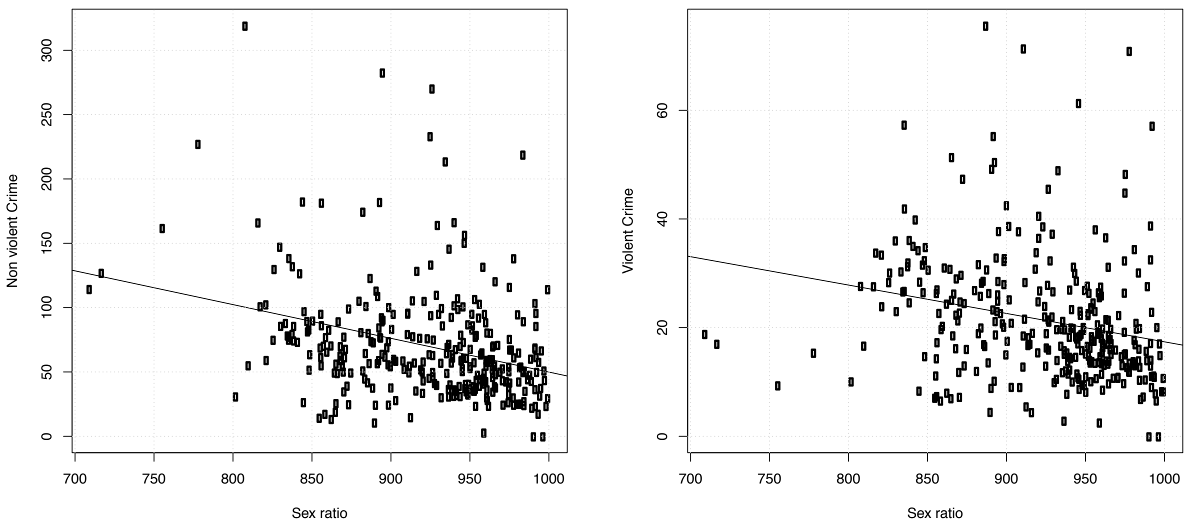
Table 3 shows descriptive statistics for key variables used in the analysis for all years combined. The average sex ratio at birth is 941 females to 1000 males for the entire country. Note that the biologically normal sex ratio at birth is 105-106 males for every 100 females. Thus, the sex ratio is severely unbalanced in India suggesting the parental preferences in favor of male child. Average literacy over the past four decades is 39%. The average rate of reported violent crime is 0.07% while that for non-violent crime is 0.021%.

Table 3 Descriptive statistics of Census and crime variables

	Obs	Mean	Std. dev
Sex ratio (age 0-6)	1216	941.41	941.41
Ratio of Wheat to Rice (Area)	1216	888.2	11660
Proportion Literate	1216	0.39	0.16
Proportion Scheduled Caste Population	1216	0.15	0.08
Proportion Scheduled Tribe Population	1216	0.10	0.18
Urbanization Rate	1216	0.21	0.16
Violent Crime per 100,000 population	1216	70.34	61.18
Non-Violent Crime per 100,000 population	1216	21.16	15.40

A visual inspection of sex ratio and crime rates in Figure 4 provides some preliminary evidence to show that sex ratio in favor of women is associated with lower violent and non-violent crime. The left hand panel shows the correlation between non-violent crime and sex ratios, while the right hand panel shows the correlation between violent-crime and sex ratios.

Figure 4 Crime and sex ratio



4 Results

4.1 OLS Estimates

Table 4 shows the regression result for the effect of aggregate population sex ratio on non-violent, violent and property crime. These results correspond to equation (1) and include state and time fixed effects.

Table 4 OLS estimates of the effect of population sex ratio on aggregate crime measures

	Non violent crime		Violent crime		Property crime	
Population Sex Ratio	-0.213***	-0.111	-0.045**	-0.043**	-0.196***	-0.106
	(0.070)	(0.070)	(0.017)	(0.018)	(0.063)	(0.066)
Proportion Schedule Caste		42.414		9.212		46.816*
		(26.678)		(5.717)		(25.048)
Proportion Schedule Tribe		9.047		4.510		9.581
		(10.405)		(4.900)		(9.651)
Proportion Urban		111.995***		2.907		97.564***
		(34.115)		(6.871)		(33.170)
Proportion Literate		59.254**		-1.929		57.690**
		(27.920)		(9.255)		(25.645)
Observations	1305	1277	1305	1277	1305	1277

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%
All regressions include state and time fixed effects
Crime is measured per 100,000 of population

There is a negative association between sex ratio and all aggregate measures of crime. However, once we include controls for education, urbanization and caste, sex ratio does not seem to have any significant effect on property and non-violent crime. On the other hand, violent crime declines by 0.043. Interestingly the coefficient for violent crime is not sensitive to including any additional control variables. The effect on violent crime is consistent with Dreze and Khera (2000) who find that districts with higher female-male ratios have lower murder rates.

As noted earlier, the population sex ratio composition in a region may be understated or overstated due to several factors. Thus, we create a sex ratio variable that is not subject to this measurement bias. In particular, we study the effect of pre-marital (10-16 year olds) and marital (20-26 year olds) age-specific sex ratio on crime where we compute the relevant sex ratios using information on sex ratio among 0-6 year olds from previous census years.

Table 5 shows results from OLS regressions corresponding to equation (2). Columns (1) to (4) show the results for the effect of 10-16 age-specific sex ratio on aggregate measures of crime with while columns (5) to (8) show comparable results for the 20-26 age-specific sex ratio. The preferred specification with all control variables, state and time fixed effects and their interactions shows that sex ratios (for both age groups) affects only violent crime. Moreover, the coefficients are comparable across the 10-16 and 20-26 age specific sex ratios.

Table 5 OLS estimates of the effect of age-specific Sex Ratio on Aggregate Crime Measures

	10-16 age group				20-26 age group			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non Violent Crime	-0.092*	-0.127***	-0.009	-0.00	-0.020	-0.114***	-0.010	-0.011
	(0.050)	(0.020)	(0.026)	(0.020)	(0.053)	(0.025)	(0.029)	(0.032)
Violent Crime	-0.050***	-0.041***	-0.041***	-0.044***	-0.043**	-0.049***	-0.047***	-0.049***
	(0.018)	(0.012)	(0.013)	(0.012)	(0.019)	(0.013)	(0.012)	(0.012)
Property Crime	-0.076	-0.119***	-0.013	-0.003	-0.003	-0.104***	-0.013	-0.013
	(0.049)	(0.020)	(0.024)	(0.020)	(0.051)	(0.025)	(0.027)	(0.029)
Observations	1262	1262	1006	1006	960	960	787	787
Additional Controls	No	No	Yes	Yes	No	No	Yes	Yes
State & time dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
State & time interaction	No	No	No	Yes	No	No	No	Yes

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Additional controls are proportion SC, ST, urbanization, literacy rate and rainfall
Crime is measured per 100,000 of population

In terms of the magnitude, adding one more female per 1000 males leads to a 0.19% reduction in violent crime (Coefficient of 0.04 relative to a mean of 21 registered records per 100,000 population). For the 20-26 age group, note that there is a drop in sample size for this group as we have data for three census years for the analysis once we lag sex ratio data by two decades (1981, 1991 and 2001).

4.2 Instrumental Variable Estimates

To address the endogeneity issue discussed earlier, we next present IV estimates. First stage estimates suggest that wheat-rice ratio has a negative effect on sex ratio. The coefficient on the instrument is negative and statistically significant at 5% level. The F-statistics is 38 for 10-16 sex ratio and 32 for age 20-26. Thus, the IV does not suffer from a weak instrument problem.

Comparing the OLS and IV estimates presented in Table 6, it is clear that the OLS estimates are severely downward biased. This could be explained by omitted factors that simultaneously affect both sex ratio and crime. For the effect of 10 to 16 age specific sex ratios, once we include state and time fixed effects, both the magnitude and standard errors of IV estimates are not very sensitive to addition of control variables or state and time interactions.

Table 6 Instrumental Variable Estimates of the Effect of age-specific Sex Ratio on Crime

	10-16 age group				20-26 age group			
Non Violent Crime	-0.116	-1.001***	-0.797***	-0.765***	0.023	-0.736*	-0.458	-0.572**
	(0.428)	(0.179)	(0.191)	(0.200)	(0.404)	(0.407)	(0.423)	(0.265)
Violent Crime	-0.047	-0.265***	-0.309***	-0.320***	-0.006	-0.171	-0.201	-0.223**
	(0.121)	(0.069)	(0.062)	(0.061)	(0.130)	(0.153)	(0.127)	(0.100)
Property Crime	-0.094	-0.917***	-0.746***	-0.718***	0.026	-0.736**	-0.474	-0.573**
	(0.393)	(0.131)	(0.171)	(0.187)	(0.373)	(0.285)	(0.351)	(0.216)
Observations	1262	1262	1006	1006	960	960	787	787
Additional Controls	No	No	Yes	Yes	No	No	Yes	Yes
State & time dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
State & time interaction	No	No	No	Yes	No	No	No	Yes

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions control for SC, ST proportions, urbanization and literacy rate
Crime is measured per 100,000 of population

We find that an increase in 10-16 sex ratio by one female per 1000 males leads to a reduction in violent crime by 0.32 which constitutes a 1.5% decline relative to a mean of 21 registered records per 100,000 population. The effect is 0.77 and 0.72 for non-violent and property crime respectively. This constitutes a fall of 1.1% for both types of crime. These numbers are relative to means of dependent variable; 68 and 63 registered records per 100,000 population for non-violent and property crime respectively. The results are highly statistically significant at 1% level and are robust to the inclusion of state and time fixed effects.

To put it in context, as shown in Figure 2, between 1961 and 2001, sex ratio among the 10-16 cohort declined from 953 to 934 girls per 1000 boys; a 19 point decline. According to our estimates, this would have resulted in a 28.5% increase in violent crimes and 21% increase in non-violent and property crimes over the last four decades.

Note that these numbers are in line with previous estimates from India. South et al. (2014) combine both the pre marital and marital age-groups and estimate the effect of sex ratio among 15-39 year olds on self-reports of victimization rates. They find that over a 20 year period, (between 1981 to 2011) the fall in sex ratio amounted to a 8-11% increase in theft/house break-in and 11% increase in assault.

We turn next to analyzing result of the 20-26 age-specific sex ratio on crime. For the sex ratio among 20-26 year olds, the IV estimates for the preferred specification suggest negative and significant effects on all types of crime. The magnitudes are smaller than those for ages 10 to 16 even though the decline in statistical power could be due to the smaller sample size. More importantly, the estimates are not stable across the different columns.

When we do not include state and time interactions in column (7), all estimates are statistically significant but upon including the interactions, the results change. Note that the crime data spans from the Census years of 1971 to 2001 for the 10-16 age-group and 1981 to 2001 for the 20-26 age group. If we drop 1971 from the analysis, so that sample size is comparable across the two specifications, estimates for column (4) do not change (and in fact are slightly larger) and continue to be highly statistically significant for all types of crime.

These results suggest that among the 10-16 age-group, not only are the negative effects on crime larger but also there is a significant negative effect on all types of aggregate crime measures. As explained earlier, theoretically this can be explained by increasing female pre-martial investments, making crime more expensive.[10] This is especially true if the over represented gender (females, in this case) bears a disproportionate share of marriage-related expenses or have to pay a significant dowry.

Recent work by Anukriti et al. (2016) has used the REDS survey data on actual dowry payments by brides and grooms. It finds that adjustments to savings are stronger in girl families (owing to a positive dowry burden in India), and that the magnitude of savings increases with the expected future dowry payment.

The effect of the 20-26 age specific sex ratio is large and significant for all measures of crime but the results are sensitive to different specifications. We explore this further in the next subsection where we conduct sensitivity analysis.

In Table 7 we show the effect of age-specific sex ratio on disaggregated crime. OLS is downward biased for most outcomes and the IV estimates suggest that 10-16 age-specific sex ratios have a significant negative effect on arrests due to murder and attempt to murder, rape, kidnapping, theft, robbery and riots. There is a positive effect on arrests

[10] For empirical support for this hypothesis, see (Wei & Zhang, 2011; Du & Wei, 2013; Horioka & Terada-Hagiwara, 2016)

Table 7 Effect of Sex Ratio on Disaggregated Crime Rates: OLS & IV Estimates

	10-16 age group		20-26 age group	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Murder	-0.012***	-0.067**	-0.012***	-0.068*
	(0.003)	(0.029)	(0.003)	(0.035)
Attempt to Murder	-0.006**	-0.062***	-0.010***	-0.057*
	(0.002)	(0.010)	(0.003)	(0.024)
Rape	0.000	-0.006***	0.000	-0.004
	(0.001)	(0.002)	(0.001)	(0.005)
Kidnapping	-0.006**	-0.041***	-0.005**	-0.028
	(0.002)	(0.008)	(0.003)	(0.017)
Dacoity	-0.006**	-0.008	-0.001**	-0.003
	(0.002)	(0.006)	(0.001)	(0.002)
Riots	-0.018	-0.115***	-0.019**	-0.040**
	(0.011)	(0.021)	(0.008)	(0.017)
Burglary	0.012**	0.259***	0.008	-0.066
	(0.006)	(0.038)	(0.006)	(0.049)
Theft	-0.018	-0.721***	-0.008	-0.330**
	(0.016)	(0.157)	(0.018)	(0.143)
Robbery	-0.007**	-0.101***	-0.003	-0.047***
	(0.003)	(0.023)	(0.002)	(0.007)
Counterfeiting	-0.000	0.007*	0.001	0.009**
	(0.001)	(0.004)	(0.001)	(0.004)
Cheating	0.002*	-0.022	0.002	0.008
	(0.001)	(0.016)	(0.002)	(0.030)
Breach of Trust	0.001	-0.022	-0.000	-0.007
	(0.001)	(0.021)	(0.001)	(0.024)
N	991	991	772	772

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions include state and time fixed effects and interactions
Regressions control for SC, ST proportions
urbanization and literacy rate
Crime is measured per 100,000 of population

due to burglary and counterfeiting. Among the 20-26 age-group, the negative effect is significant for murder (1% level), attempt to murder and riots in violent crime measures. There is also a negative effect on theft and robbery. The positive effect on arrests due to counterfeiting remains in this specification also. For the 10-16 age group, relative to the means shown in Table 2, these numbers translate into an approximate 1.5% or less decline in arrests due to individual crime variables. The largest effect is for robbery which declines by 3.5% with an addition of one female to thousand males.

4.3 Robustness checks

The IV uses producer prices of rice and wheat at time period t. It is possible that the relative economic value of females might be more sensitive to the long run relative price of crops rather than a one period price. We, therefore, create a new instrument that uses a five year average producer price. The results with the new instrument is shown in Panel A in Table 8. Results for the effect of both age-specific sex ratios are robust to this alternate instrument.

Gender and marriage norms between rural and urban areas vary within India and this might affect labor market opportunities differentially between males and females. For instance, in rural areas shortage of brides may be more acute as families may be reluctant to send their daughters to the poorest districts. Moreover, it is not unheard of in India that women from the poorest districts are married off in richer districts.

In Panel B we show results dropping the top 10% most urban districts and bottom 10% most rural districts. The coefficients for the effect of 10-16 age specific sex ratios are much larger in magnitude for non-violent and property crime and continue to be highly statistically significant for all measures of crime. On the other hand, all estimates become statistically insignificant for the effect of the 20-26 age-specific sex ratio. This suggests that the previously shown results for the marriage market channel may be driven by differences in gender and marriage norms between the most urban and rural districts of India.

Table 8 Robustness Checks: Average prices, and rural/urban

	10-16 age group	20-26 age group
Panel A: Average prices		
Non Violent Crime	-0.757***	-0.626**
	(0.195)	(0.269)
Violent Crime	-0.340***	-0.225**
	(0.061)	(0.099)
Property Crime	-0.715***	-0.618***
	(0.190)	(0.223)
Observations	1006	787
Panel B: Omitting top 10% Urban & bottom 10% rural districts		
Non Violent Crime	-1.362**	-1.383
	(0.556)	(1.230)
Violent Crime	-0.318**	-0.181
	(0.136)	(0.287)
Property Crime	-1.221**	-1.330
	(0.468)	(1.031)
Observations	833	657
Panel C: Omitting districts with extreme values of historical wheat-rice ratio		
Non Violent Crime	-0.749***	-0.729***
	(0.212)	(0.211)
Violent Crime	-0.340***	-0.303**
	(0.042)	(0.041)
Property Crime	-0.666***	-0.680***
	(0.204)	(0.206)
Observations	843	655

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions include state and time fixed effects
Regressions control for state time interactions
Regressions control for SC, ST proportions
urbanization and literacy rate
Crime is measured per 100,000 of population

In Panel C, we drop districts with extreme values of historical (1961) wheat-rice ratio. The districts with no or very small values of wheat and rice production are deleted (those which lie below the 20th percentile of the wheat rice distribution) and we also exclude districts in the top end (95th percentile and above) of the 1961 wheat-rice ratio distribution. As is clear from Table 8, the effect of age-specific sex ratio (for both age groups) are robust to deleting extreme values of historical wheat and rice ratio.

Next, we check whether our results are driven by any particular year in our sample. In Table 9, we check for the robustness of our results by dropping one census year at a time from the analysis. The effect on violent crime ranges from -0.274 to -0.410 for the 10-16 sex ratio and -0.452 to -0.888 for non-violent crime and the significance levels are high across all the regressions. The magnitude of the coefficients for non violent crime are more sensitive for the 20-26 age specific sex ratios ranging from -0.104 to -1.254. Moreover, the effects are insignificant in column (6) when we drop census year 1981 from the sample. For violent crime, the results are stable across all the columns for the effect of 20-26 age specific sex ratio.

Table 9 Robustness Checks II: Dropping Years

	Dropping 2001		Dropping 1991		Dropping 1981		Dropping 1971	
	10-16	20-26	10-16	20-26	10-16	20-26	10-16	20-26
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non Violent Crime	-0.628***	-0.621**	-0.888***	-1.254***	-0.452**	-0.104	-0.888**	-0.572**
	(0.154)	(0.232)	(0.286)	(0.446)	(0.214)	(0.068)	(0.353)	(0.265)
Violent Crime	-0.274***	-0.218*	-0.279***	-0.264***	-0.410***	-0.202**	-0.334**	-0.223**
	(0.056)	(0.119)	(0.058)	(0.093)	(0.093)	(0.089)	(0.125)	(0.100)
Property Crime	-0.603***	-0.626***	-0.802***	-1.173***	-0.410*	-0.125*	-0.859**	-0.574**
	(0.160)	(0.194)	(0.245)	(0.376)	(0.209)	(0.066)	(0.318)	(0.216)
N	768	529	726	499	765	546	759	787

Robust standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Regressions include state and time fixed effects and interactions
Regressions control for SC, ST proportions, urbanization and literacy rate
Crime is measured per 100,000 of population

We also check the robustness of our results by including region fixed effects after dividing all states into four major regions of India. The results for the pre marital age group are robust to inclusion of region fixed effects. Finally, the coefficients for 10-16 age group are not sensitive to dropping one state at a time from the analysis. These tables are available upon request.

5 Conclusion

Sex ratios may have both a negative and positive effect on crime. On the one hand, marriage is seen as a stabilizing factor on males. Thus a skewed sex ratio, where more men are competing in the marriage market over fewer women, could be a source of conflict and violence. On the other hand, Guttentag and Secord (1983) in their seminal book argue that when females are in shorter supply, men invest more in marriage and family, which in turn leads to a stable society with lower levels of violent crime. Similarly, high sex ratio increases female bargaining power in the marriage market, shifting resources to favor women.

While the effect of sex ratio on crime can go in either direction, recent empirical evidence has supported the former view i.e. imbalances in sex ratio lead to more violence. However existing studies have not been able to obtain credible estimates controlling for the endogeneity of the sex ratio itself. Moreover, these studies have mostly emphasized only on the effect of sex ratio on crime directly through the marriage market.

We solve the endogeneity problem by using an instrumental variable approach. We argue that the child sex ratio can be explained by differences in women's social and economic status. In agrarian economies such as India, women derive their economic value from participation in agricultural production. Rice cultivation engages more women as compared to wheat that requires plough farming and greater employment of men. Districts that produce rice would perceive greater value of daughters in comparison to wheat producing districts. Based on this argument, our IV approach exploits district level variation in historical area under wheat-rice cultivation and across time variation in relative producer prices of wheat-rice.

Wei and Zhang (2011) calculate that about half the increase in China's savings rate, a country where the groom's side bears marriage related expenses, in the last 25 years can be attributed to the rise in sex ratio in favor of women. In countries such as India, where bride's side of the family bears a disproportionate share of marriage related expenses, girl's parents tend to increase savings rate with a rise in female sex ratio. Thus, a sex ratio in favor of women should lead to a reduction in crime as parents of the over represented gender increase savings and work effort. We disentangle the marriage market channel from the savings motive channel by studying the effect on crime of sex ratio among two age groups, the pre-marital cohort (10-16 years) and the marital cohort (20-26 years).

We find that an increase in 10-16 age sex ratio by one female per 1000 males leads to significant decline in both non-violent and property crimes. The results are not robust to alternate specications for the effect of sex ratio in the 20-26 age group. These estimates suggest that the imbalance in the pre-marital sex ratio in India between 1961 and 2001 led to a 28.5% increase in violent crimes and 21% increase in non-violent and property crimes.

Improvements in education, labor market conditions and economic development have led to better opportunities for Indian women over the last two decades. Yet, there has been a downward trend in sex ratios at birth leading to an alarming demographic masculinization. According to World Bank projections, imbalances in sex ratio are likely to exacerbate by 2031 with only 898 girls in the 0-6 age group per 1000 boys. This decline in the sex ratio suggests that the availability and misuse of sex determination technology, particularly among the urban educated Indians, has overshadowed any improvements in status of Indian women through better labor market and education opportunities. Thus any attempt to change patriarchal social norms must be accompanied with stronger implementation of existing law, for gender imbalances have implications on several socio economic outcomes.

References

Agarwal, B. (1986). Women, poverty and agricultural growth in India. *The Journal of Peasant Studies*, *13*(4), 165–220.

Alesina, A., Giuliano, P. & Nunn, N. (2013). On the origins of gender roles: Women and the plough. *The Quarterly Journal of Economics*, *128*(2), 469–530.

Allik, J. & Realo, A. (2004). Individualism-collectivism and social capital. *Journal of cross-cultural psychology*, *35*(1), 29–49.

Angrist, J. (2002). How do sex ratios affect marriage and labor markets? evidence from America's second generation. *The Quarterly Journal of Economics*, *117*(3), 997–1038.

Anukriti, S., Kwon, S. & Prakash, N. (2016). Dowry: Household responses to expected marriage payments. *Unpublished Manuscript*.

Bardhan, P. K. (1974). On life and death questions. *Economic and Political Weekly*, 1293–1304.

Basu, A. M. (1992). Culture, the status of women and demographic behaviour: Illustrated with the case of India.

Becker, G. S. (1968). Crime and punishment: An economic approach. In *The economic dimensions of crime* (pp. 13–68). Springer.

Becker, G. S. (1974). A theory of marriage. In *Economics of the family: Marriage, children, and human capital* (pp. 299–351). University of Chicago Press.

Browning, M. & Chiappori, P.-A. (1998). Efficient intra-household allocations: A general characterization and empirical tests. *Econometrica*, 1241–1278.

Byerlee, D. (1992). Technical change, productivity, and sustainability in irrigated cropping systems of south asia: Emerging issues in the post-green revolution era. *Journal of International Development*, *4*(5), 477–496.

Cantor, D. & Land, K. C. (1985). Unemployment and crime rates in the post-world war ii United States: A theoretical and empirical analysis. *American Sociological Review*, 317–332.

Dorosh, P. A. (2009). Price stabilization, international trade and national cereal stocks: World price shocks and policy response in south asia. *Food Security*, *1*(2), 137–149.

Dreze, J. & Khera, R. (2000). Crime, gender, and society in India: Insights from homicide data. *Population and development review*, *26*(2), 335–352.

Du, Q. & Wei, S.-J. (2013). A theory of the competitive saving motive. *Journal of International Economics*, *91*(2), 275–289.

Edlund, L., Li, H., Yi, J. & Zhang, J. (2013). Sex ratios and crime: Evidence from China. *Review of Economics and Statistics*, *95*(5), 1520–1534.

Ester, B. (1970). Women's role in economic development. *American Journal of Agricultural Economics*, *53*(3), 536–537.

Gartner, R., Baker, K. & Pampel, F. C. (1990). Gender stratification and the gender gap in homicide victimization. *Social Problems*, *37*(4), 593–612.

Guttentag, M. & Secord, P. F. (1983). *Too many women? The sex ratio question*. Beverly Hills Calif./London England Sage Publications.

Henrich, J., Heine, S. J. & Norenzayan, A. (2010). Beyond weird: Towards a broad-based behavioral science. *Behavioral and Brain Sciences*, *33*(2-3), 111–135.

Horioka, C. Y. & Terada-Hagiwara, A. (2016). *The impact of pre-marital sex ratios on household saving in two Asian countries: The competitive saving motive revisited*. National Bureau of Economic Research.

Huke, R. & Huke, E. (1992). *Rice-wheat atlas of South Asia*. International Rice Research Institute, Los Banos, Philippines.

Jones, D. & Kwieciński, A. (2010). *Policy responses in emerging economies to international agricultural commodity price surges*. OECD Publishing.

Kaur, R. (2004). Across-region marriages: Poverty, female migration and the sex ratio. *Economic and Political Weekly*, 2595–2603.

Kumar, H. & Somanathan, R. (2009). *Mapping Indian districts across census years, 1971-2001* (Working Paper No. 176). Centre for Development Economics.

Miller, B. D. (1981). The endangered sex: Neglect of female children in rural North India.

Murthi, M., Guio, A.-C. & Dreze, J. (1995). Mortality, fertility, and gender bias in India: A district-level analysis. *Population and development review*, 745–782.

Oldenburg, P. (1992). Sex ratio, son preference and violence in India: A research note. *Economic and Political Weekly*, 2657–2662.

Qian, N. (2008). Missing women and the price of tea in China: The effect of sex-specific earnings on sex imbalance. *The Quarterly Journal of Economics*, *123*(3), 1251–1285.

Roberts, S. G. (2015). Commentary: Large-scale psychological differences within China explained by rice vs. wheat agriculture. *Frontiers in psychology*, *6*.

Sarangi, S., Jha, C. & Hazarika, G. (2015). *The role of historical resource scarcity in modern gender inequality* (Working Paper No. 2015-06). Department of Economics, E. J. Ourso College of Business, LSU.

Sen, A. (1990). More than 100 million women are missing. *The New York Review of Books*, *37*(20), 61–66.

South, S. J., Trent, K. & Bose, S. (2014). Skewed sex ratios and criminal victimization in India. *Demography*, *51*(3), 1019–1040.

Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X. & Kitayama, S. (2014). Large-scale psychological differences within China explained by rice versus wheat agriculture. *Science*, *344*(6184), 603–608.

Tong, C., Hall, C. A. & Wang, H. (2003). Land use change in rice, wheat and maize production in China (1961–1998). *Agriculture, Ecosystems & Environment*, *95*(2), 523–536.

Wei, S.-J. & Zhang, X. (2011). The competitive saving motive: Evidence from rising sex ratios and savings rates in China. *Journal of Political Economy*, *119*(3), 511–564.

Appendix

A District definitions

The following examples illustrate the methodology used to construct a balanced panel of districts mapped to census year 1971. As shown in the table below, district Kameng in Arunachal Pradesh in 1971, was split into West Kameng and East Kameng in 1981. West Kameng was further split into Tawang and West Kameng in 1991 and remained unchanged in 2001.

State	1971 district	1981 district	Share of 1981 district	1991 district	Share of 1991 district	2001	Share of 2001 district
Arunachal	Kameng	West Kameng	58.44	Tawang	34.34	Tawang	100
				West Kameng	65.66	West Kameng	100
		East Kameng	41.56	East Kameng	100	East Kameng	100

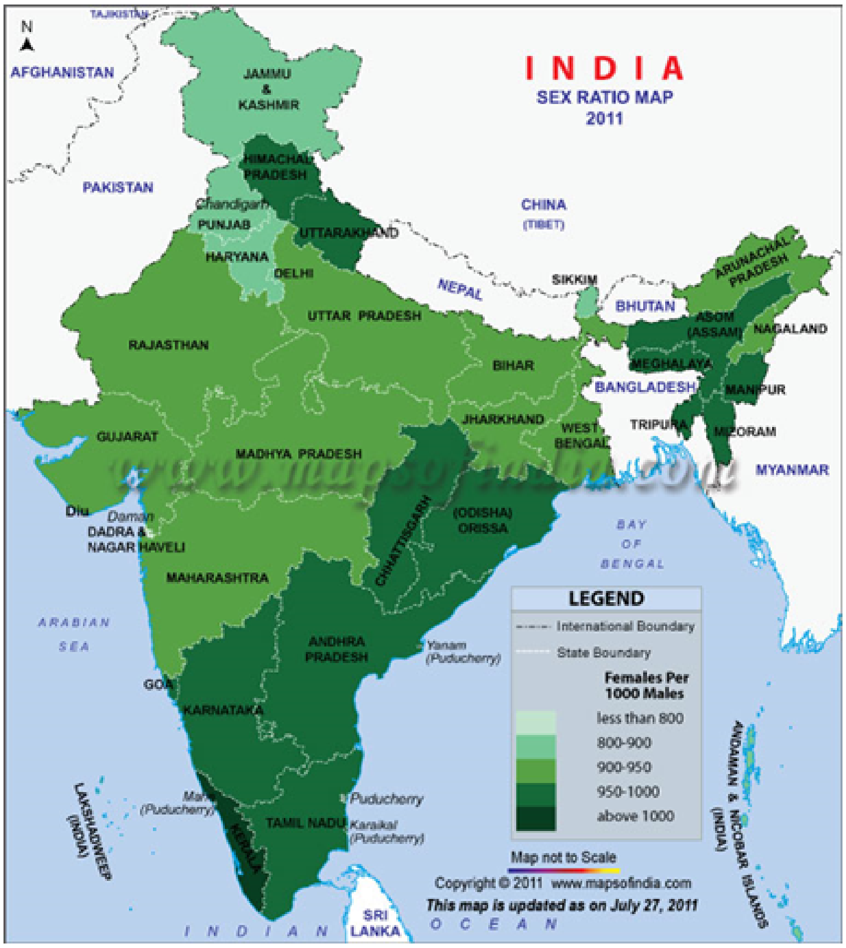
Mapping literate population in 2001 to the population in 1971 would therefore require aggregation of population of literates in Tawang, West Kameng and East Kameng to arrive at the final literate population figures for Kameng district in 1971.

The above example is a simpler version of districts mapping as compared to districts carved out of multiple districts in the previous census. For example Vizianagaram formed a new district in 1981 taking shares of area and population from both Srikakulam and Vishakhapatnam from 1971. To map to Srikakulam in 1971, 51.59 percent of literate population from Vizianagaram is added back to Srikakulam and 48.41 percent to Vishakhapatnam as shown in the table below.

State	1971 District	1981 District	Share of 1971 District in 1981
AP	Srikakulam	Srikakulam	100
		Vizianagaram	51.59
	Vishakhapatnam	Vishakhapatnam	100
		Vizianagaram	48.41

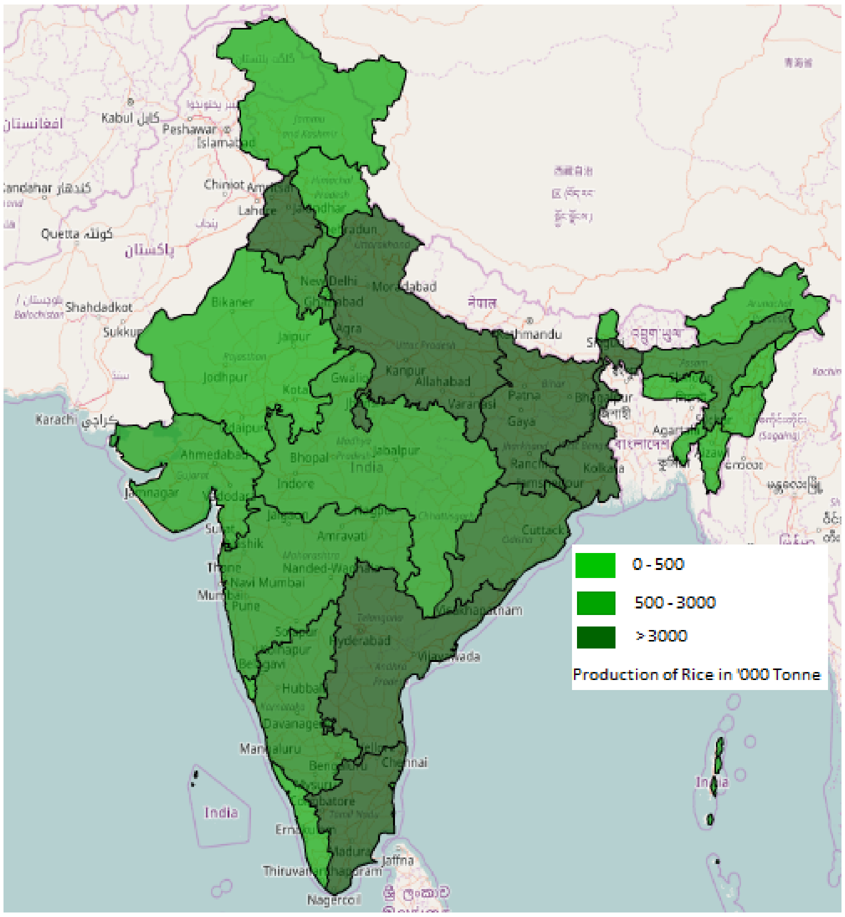
B Maps of India: Crops and sex ratio

Figure B.1 Sex ratios in Indian states



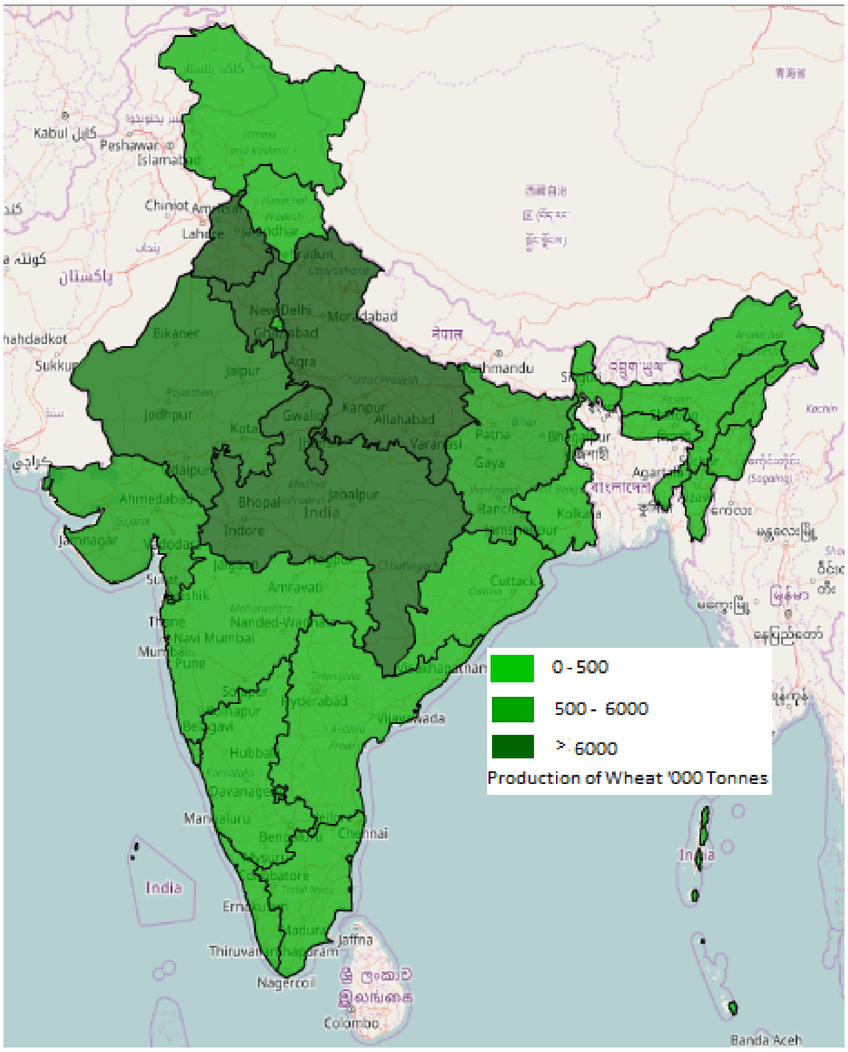
Source: www.mapsofindia.com

Figure B.2 Crop production: Rice



Source: Authors' calculation using ICRISAT data

Figure B.3 Crop production: Wheat



Source: Authors' calculation using ICRISAT data

MORE IN THE SERIES

- Sapre, A., and Sengupta, R., (2017). An analysis of revisions in Indian GDP data, WP No. 213.
- Halan, M. and Sane, R., (2017). Regulating consumer finance: Do disclosures matter? The case of life insurance, WP No. 212.
- Bhattacharya, R., (2017). Effectiveness of monetary policy in stabilising food inflation: Evidence from advanced and emerging economies, WP No. 209.

Authors:

Rashmi Barua is with the School of International Studies, Jawaharlal Nehru University.

ybarua.bhowmik@gmail.com

Prarthna Goel is with the Jawaharlal Nehru University & Indraprastha University.

zprarthnagl@gmail.com

Renuka Sane is a faculty at NIPFP, Delhi.

Corresponding author email: renuka.sane@nipfp.org.in

National Institute of Public Finance and Policy,
18/2, Satsang Vihar Marg,
Special Institutional Area (Near JNU),
New Delhi 110067
Tel. No. 26569303, 26569780, 26569784
Fax: 91-11-26852548
www.nipfp.org.in