The Effect of Sex Ratio on Crime: Instrumental Variable Estimates from India.

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Abstract

Research has documented the negative effect of high male sex ratio on crime, but has not been able to obtain credible estimates controlling for the endogeneity of the sex-ratio itself. We solve the endogeneity problem by using the area under rice-wheat cultivation as an instrument for sex-ratio. We focus on two age-specific sex ratios, corresponding to pre-marital (ages 10 to 16) and marriagable (ages 20 to 26) age groups.

We find that the effect of pre-marriage sex-ratios on crime are larger than the effect of marriageable age sex-ratio. This also suggests that previous literature has failed to account for the differential effect of age-specific sex ratios on crime. Once corrected for endogeneity, the effect of sex ratio on crime remain though only for the pre-marital age-group. Thus, the savings channel seems to explain a larger decline in crime than the direct effect of finding a match in the marriage market.

Keywords :Sex Ratio; Crime; Instrumental Variables.

1 Introduction

There is an emerging consensus in the literature that sex ratio, measured as the ratio of population of females to males, has a negative effect on reported crime. That is, the more women in a society relative to men, the lower is the reported crime (Dreze and Khera, 2000; Edlund, 2013).

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There are at least three reasons why sex ratios may affect crime. First, women discount future at a lower discount rate placing more value on the future than the present. Discount rates are also an important determinant of crime and individuals with higher discount rates may be more likely to commit crime (Lochner and Moretti, 2004).

Second, worsening of sex ratios creates shortage of brides. As marriage is believed to provide stability, responsibility and fear of law, a greater pool of unmarried men stimulates an environment of unrest and illicit activities (Barber, 2000; Sampson et. al., 2006).

Third, as female sex-ratio improves, and women increase their participation in non-traditional roles, their bargaining power in social and financial decisions gets enhanced (Allendorf, 2007; Katz, 1997; Kabeer, 2005). A larger say in decision making, makes women more likely to make investments on their on children's education (Buonanno and Leonida, 2009), which may have implications on society as whole.

The challenge of measuring the impact of sex-ratio on crime, however, is the potential endogeneity of the sex-ratio itself. This may be because, cultural norms that lead to son-preference, also may determine tolerance towards crime. It may also be that crime itself may lead to poor sex-ratios. Moreover, studying the impact of adult sex ratio on social variables such as crime may suffer from measurement bias. Adult sex ratio composition in a region may change with migration, relative mortality rates and cross-border marriages. While researchers have recognized this bias, they have not obtained credible estimates controlling for this endogeneity.

In this paper, we ask, if improvement in the sex ratio, i.e. an increase in the number of women per 1000 men, causes a reduction in crime? We solve the endogeneity problem by using the area under rice-wheat cultivation as an instrument for sex-ratio. In an economy where a large proportion of the population is engaged in agriculture, economic value of females is driven by the intensity of female participation in the agricultural activities (Bardhan, 1974). We focus on two age-specific sex ratios; ages 10-16 and 20-26.

Though the choice of age groups is determined by the availability of data, the age specific sex-ratios under study (namely, 10-16 year olds and 20-26 year olds) are crucial in disentangling some of the channels through which sex ratio affects crime.

On the one hand, as the pre-marital sex ratio (10 to 16 year olds) increases in favor of women, families with a girl child will presumably increase their saving. This is particularly true in the Indian context as the bride side of the family bears a disproportionate share of marriage-related expenses or have to pay a dowry (Horioka and Terada-Hagiwara, 2016). This should increase female pre-martial investments, making crime more expensive. On the other hand, an increase in sex ratio in favor of females among 20 to 26 year olds would affect crime through competition in the marriage market.

We use the sex ratio at birth (age 0-6) in previous years to proxy for current age specific sex ratios as child sex ratio is driven more strongly by other elements such as technology and sex selective abortions, and not mortality rates and migration.

We use district level data on crime, sex-ratios and crop production for each census year from 1961 to 2011 to estimate the impact of sex-ratios on crime. The crime data is obtained from the National Crime Records Bureau (NCRB), sex-ratios from Census data, and the ratio of wheat to rice both area sown (in hectares) are from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

The results suggest that among the 10-16 age-group, the negative effects on crime are larger than the effect of 20-26 age-specific sex ratio. Theoretically this can be due to increasing female pre-martial investments, making crime more expensive. This is especially true if the overrepresented gender (females, in this case) bears a disproportionate share of marriage-related expenses or have to pay a significant dowry. The IV may be invalid if crime and changes in area under wheat and rice cultivation would have evolved simultaneously due to factors such as changes in climate, culture, politics etc. We deal with this potential threat to identification by checking the robustness of our results to an alternate IV that does not directly use the variation overtime in areas of production. As we show in the results, our estimates are robust to this alternate instrument as well as to controls for rainfall.

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". Relatively little is known about the consequences of a skewed sex ratio. Our paper is a contribution towards this literature.

2 Background

2.1 Sex Ratio & Crime

Early literature on sex-ratios was focused on its impact on the marriage market. It predicted that increase in the male sex ratio would increase the demand for wives. Since marriage consisted of joint production, this would increase female marriage rates, and transfer part of the surplus generated by marriage from men to women (Becker, 197?). The idea behind this is that of scarcity - that which is scarce, has relatively higher bargaining power. When male sex ratio is higher, and there are fewer women, the women have the bargaining power. This was reinforced by Angrist (2002) who found that high male sex ratios had a large positive effect on the likelihood of female marriage, and a large negative effect on female labour force participation. Such a view assumes that male competition raises male premarital

investments, in the quest for a wife. As women become more scarce, the returns to such investments increase initially. For example, Wei and Zhang (2011) find that families with sons compete with each other to raise their savings rate in response to ever-rising pressure in the marriage market. However, over time fewer women lowers the value of the investment, and eventually this effect dominates and men reduce their investments. A greater pool of unmarried men might actually stimulate an environment of unrest and illicit activities (Barber, 2000; Sampson et. al., 2006; Edlund et. al., 2013).

In fact, a literature has emerged that shows that a higher male sex ratio has a negative effect on reported crime. The more men in a society, the higher is the reported crime (Dreze and Khera, 2000). Male sex ratios are found to have accounted for a one seventh increase in crime in China (Edlund et. al., 2013). In a similar analysis, South et. al. (2014) estimated an association between male-female sex ratio and self-reported victimization cases of theft, breaking, entering and assault. The findings also suggest that poor sex ratio is associated with frequent harassment of unmarried females.

A related question is if there is an improvement in the sex ratio, i.e. the number of women per 100,000 men increases, does this lead to reduction in crime? Our hypothesis is that this should indeed be the case for pre-marital age groups. Our argument rests in the bargaining power theory described earlier. As the female sex ratio increases, the pressure of finding a mate should now be on the females. This should increase female pre-martial investments. Horioka and Terada-Hagiwara (2016) suggest that families with a child who belongs to the overrepresented gender will presumably increase their saving in order to ensure that their child is able to secure an attractive spouse. This is especially so if the custom in that country is for families with a child, who belongs to the overrepresented gender, to bear a disproportionate share of marriage-related expenses. When families have to make investments in their young women, this should have a lower impact on the crime.

2.2 The Endogeneity of Sex Ratio

The challenge of measuring the impact of sex-ratio on crime, however, is the potential endogeneity of the sex-ratio itself. Cultural norms that lead to son-preference, also may determine tolerance towards crime. It may also be that 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.

Researchers have recognized the endogeneity bias. For example Dreze and Khera (2000) use the female labour force participation rate as an instrument for sex ratio and find that an

increasing female sex-ratio reduces crime. Female labour force participation, however, may not provide a true instrument for sex ratio. This is because female labour force participation may itself affect crime. As females step into the labour force, they are exposed to greater risks (Cantor and Land, 1985; Gartner et. al. 1990). In Mexico an increase in women's wage distribution led to an increase in rapes and "grievous bodily crimes" (Blanco and Villa, 2008). Iyer et. al. (2011) in their study using state level variations in India argues that any such increased numbers are a result of rise in documented crime. With women gaining status in the society and becoming more aware of their rights, there is an increase in crime reporting.

We address the endogeneity of sex ratio by using the area under rice-wheat cultivation as an instrument for sex-ratio. In an economy where a large proportion of the population is engaged in agriculture, economic value of females is driven by the intensity of female participation in the agricultural activities (Bardhan, 1974). 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 et. al., 2015).

As shown in the maps in Appendix, North and North-West India states in 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 labour as compared to dry states of North and North West that are mainly wheat producing and more intensive on male labour. This preference therefore is an important factor that drives the sex ratio differentials. Miller (1981) argues that females exclusion from agricultural production led to exclusion from holding property rights and hence a stronger preference for male child. Thus, 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 region.

The relation between historical agricultural practices and gender inequality has been a much studied topic among social phycologists and sociologists and a relatively understudied topic in economics. Boserup (1970) argued that societies that traditionally practised plough agriculture (a relatively male intensive technique of production) – rather than shifting cultivation – developed a specialization of production along gender lines. Alesina et. al. (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 favouring gender inequality. The appendix provides a close visual association of coastal areas which are high rice producing areas also depicting high female to male ratios.

3 Identification

Consider the simple OLS regression:

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

Where SR refers to 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.

An OLS regression of crime on sex ratio 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. Secondly, while a 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 exogenous instrument that is not subject to the limitations described above. We instrument for sex ratio using wheat-rice ratio i.e. the ratio of the amount of area used for wheat cultivation versus rice cultivation. However, in a particular year, adverse weather shocks may affect the production of food-grains and prevailing economic conditions. These may affect crime through channels other than sex ratios.

Moreover, studying the impact of adult sex ratio on social variables such as crime may suffer from measurement bias. Adult sex ratio composition in a region may change with migration, relative mortality rates and cross-border marriages. Kaur (2004) finds evidence that distorted sex ratios and wide variations in female-male proportions across regions have led to an increase in cross-border marriages. Studies have also found strong anti-female biases in provision of nutrition and health care facilities distorting adult sex ratios (Basu, 1992; Agarwal, 1986; Murthi et. al, 1995). To deal with such measurement issues in the adult sex ratios, we use the sex ratio at birth (age 0-6). The contention is not based on the assumption that child sex ratio is exogenous to such factors, but that it is driven more strongly by other elements such as technology and sex selective abortions.

Thus, we estimate the following OLS regression:

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

Where SR_{ait} refers to the sex ratio for age group a at time t in region i. S is a state fixed effect and T are time dummies. In our analysis, t =1961, 1971, 1981, 1991 and 2001. We proxy for SR_{ait} using the sex ratio at birth (i.e. 0 to 6 year olds) in previous decennial census years. The subscript "a" can take two values, $a = 1$ (ages 10 to 16) and $a = 2$ (ages 20 to 26) corresponding to sex ratios at birth from the previous two census years. 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). 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.

Though the choice of age groups is determined by the availability of data, the age specific sex-ratios under study (namely, 10-16 year olds and 20-26 year olds) are crucial in disentangling some of the channels through which sex ratio affects crime.

On the one hand, as the pre-marital sex ratio (10 to 16 year olds) increases in favor of women, families with a girl child will presumably increase their saving. This is particularly true in the Indian context as the bride side of the family bears a disproportionate share of marriage-related expenses or have to pay a dowry (Horioka and Terada-Hagiwara, 2016). This should increase female pre-martial investments, making crime more expensive. On the other hand, an increase in sex ratio in favor of females among 20 to 26 year olds would affect crime through competition in the marriage market.

Since SR_{ait} is endogenous, we instrument it using the ratio of the amount of area used for wheat versus rice cultivation in a region. Thus, we estimate an IV regression based on the following first stage relation:

$$SR_{ait} = \alpha_2 \frac{Wheat}{Rice}_{i,t-10} + \beta_2 X_{it} + S_i + T_t + \epsilon_{it} \quad (3)$$

Where the data on wheat-rice ratio corresponds to the same year as the data on sex ratio at birth.

Our identification strategy would be invalid if the rice-wheat ratio 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-centred and individualistic. The study thus points in the direction that rice-wheat cultivation may impact several social outcomes.

However, Roberts (2015) refutes the findings of the Talhem paper on data grounds. Further, several researchers (Allik and Realo 2004; Henrich et. al., 2010) show that individuals in regions from America dominated by corn and wheat production own similar or even greater holistic processing than China. Hence, ideally rice-wheat 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, ratio of wheat to rice production would 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.

The IV may be invalid if crime and changes in area under wheat and rice cultivation would have evolved simultaneously due to factors such as changes in climate, culture, politics etc.

The available literature suggests that there has been a substantial change in the proportionate area under wheat and rice cultivation, specifically in South Asia. Byerlee (1992) argue 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.

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 socioeconomic factors that impacted land use could have influenced criminal engagements over time.

We deal with this potential threat to identification by checking the robustness of our results to an alternate IV that does not directly use the variation overtime in areas of production. In particular, we interact wheat-rice area ratio in 1961 for each district i with the ratio of producer prices in India for wheat-rice at time t, where t ranges from 1961 to 2001. As in the main specification, since the prices are included with a 10-year lag, they are unlikely to be associated with crime directly. As we show in the results, our estimates are robust to this alternate instrument.

4 Data

The analysis required data on crime, sex ratios and crop production in India at the district level. Since the only source of data for district level sex ratios is the decennial census, we collected information for all variables for the five decennial census' between 1961 to 2001.

Districts in India are the third geographic layer for data dissemination after national and state-level setups. 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 time. The administrative information is supplemented by data on population proportions across the census years for district changes provided by Kumar & Somanathan (2009).

Child Sex ratio (Age 0-6) is measured as the number of females per 1000 males. We also obtained data from the census on female working population as a proportion of 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 percentage that is literate.

Data for crime 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. Similarly non-violent crime comprises of robbery, burglary, theft, criminal breach of trust, cheating and counterfeiting. The crime variables are measured as per 100,000 persons in the district to account for population differences.

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

Table 1: Descriptive Statistics of Census and Crime Variables

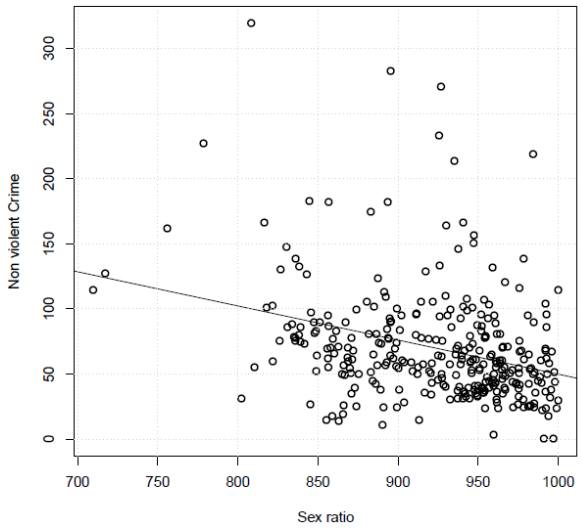
	Obs	Mean	Std. Dev.
Sex Ratio (Age 0-6)	1216	941.41	65.43
Ratio of Wheat to Rice (Area)	1216	888.18	11660.00
Proportion Literate	1216	0.39	0.16
Proportion Scheduled Caste Population	1216	0.15	0.08
Proportion Scheduled Tribe Population	1216	0.10	0.18
Urbanization Rate	1216	0.21	0.16
Violent Crime per 100,000 population	1216	70.34	61.18
Non-Violent Crime per 100,000 population	1216	21.16	15.40

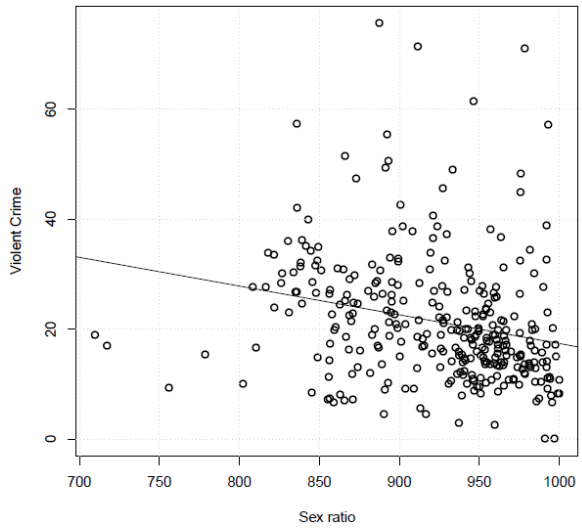
Table 1 shows descriptive statistics for key variables used in the analysis for all years combined. The average sex ratio at birth is 941 females to 1000 males for the entire country. Average literacy over the past four decades is 39%. The average rate of reported violent crime is 7% while that for non-violent crime is 2.1%. 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

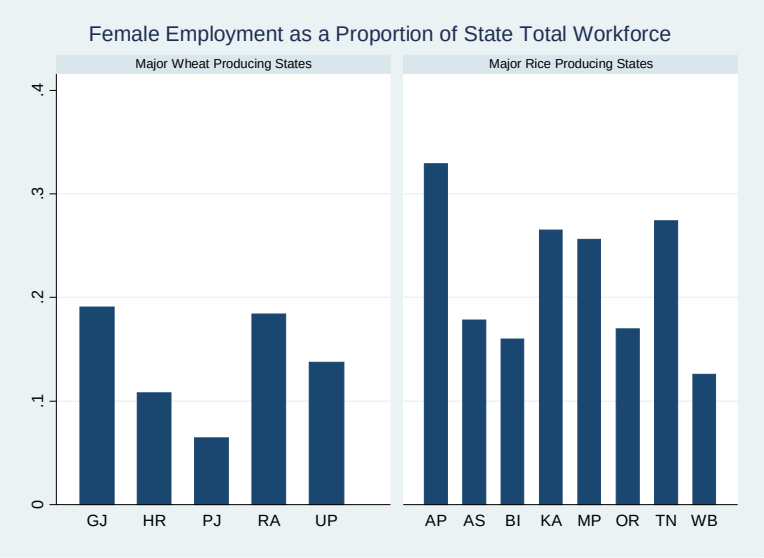
	Obs	Mean	Std. Dev.
Murder	1277	3.59	2.57
Attempt to Murder	1290	2.08	3.03
Rape	1277	1.25	1.38
Kidnapping	1277	2.13	2.22
Burglary	1277	20.32	17.29
Dacoity	1283	1.29	2.05
Theft	1277	50.00	41.80
Robbery	1277	2.88	3.85
Riots	1277	11.10	12.08
Counterfeiting	1277	0.19	1.12
Cheating	1277	2.90	3.27
Breach of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

A visual inspection of sex-ratio and crime rates provides some preliminary evidence to show that sex ratio in favor of women is associated with lower crime rates.





The figure below shows the female employment as a proportion of total state workforce for the major rice and wheat producing states of India.



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 in district level regressions of female share of employment in total workforce on the Wheat/Rice ratio (area) controlling for all variables described in the empirical strategy section. Models with state and time fixed effects yield negative and highly statistically significant results (at 1% level) suggesting that as the area under wheat production increases relative to rice production, the share of females in total employment declines.

5 Results

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%). The F-statistics range between 30 to 40 and predictive power is marginally higher for age 20-26.

Table 3 shows the regression result for the effect of 10-16 age-specific sex-ratio on non-violent, violent and property crime.

Table 3: Effect of 10 to 16 age-specific Sex Ratio on Aggregte Crime Measures

	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
Non Violent Crime	-0.127***	-0.034*	-0.835***	-0.537***
	(0.020)	(0.019)	(0.131)	(0.108)
Violent Crime	-0.041***	-0.040***	-0.230**	-0.233**
	(0.012)	(0.010)	(0.086)	(0.093)
Property Crime	-0.119***	-0.037**	-0.796***	-0.533***
	(0.020)	(0.017)	(0.072)	(0.087)
Observations	1262	1238	1229	1209
Additional Controls	No	Yes	No	Yes
State & Time Dummies	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Crime is measured per 100,000 of population

Regressions also control for proportion SC, ST, urbanization and literacy rate

Columns (1) and (2) show the results of the OLS regression on crime with and without additional control variables respectively. Columns (3) and (4) show comparable results of the IV regression. All specifications include time and state fixed effects. All estimates are negative and statistically significant suggesting that an increase in female to male sex ratio leads to a reduction in crime. Comparing the OLS and IV estimates, it is clear that the OLS estimates are downward biased though the sign is as expected. This could be explained by time varying factors that simultaneously affect both sex ratio and crime.

IV results confirm the hypothesis. In the case of violent crimes, we find that an increase in sex-ratio leads to a reduction in the crime rate by 0.23. In the case of non-violent crime and property crime, the effect is a little greater at 0.53. This constitutes a fall of almost 0.8% in non-violent & property crime. These numbers are relative to means of dependent variable; 68 and 63 arrests per 100,000 population for non-violent and property crime respectively. The decline is 1.1% for violent crime (relative to a mean of 21 arrests per 100,000 population). The results are highly statistically significant and are robust to the inclusion of state and time fixed effects.

Table 4: Effect of 20 to 26 age-specific Sex Ratio on Aggregte Crime Measures

	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
Non Violent Crime	-0.114***	-0.022	-0.736***	-0.417*
	(0.025)	(0.026)	(0.176)	(0.238)
Violent Crime	-0.049***	-0.050***	-0.194	-0.186
	(0.013)	(0.012)	(0.120)	(0.122)
Property Crime	-0.104***	-0.023	-0.737***	-0.430**
	(0.025)	(0.024)	(0.067)	(0.183)
Observations	960	934	960	934
Additional Controls	No	Yes	No	Yes
State & Time Dummies	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Crime is measured per 100,000 of population

Regressions also control for proportion SC, ST, urbanization and literacy rate

We turn next to analyzing result of the 20-26 age-specific sex-ratio on crime. Once again OLS is negative and statistically significant at 1% for all types of crime. IV estimates suggest that OLS is downward biased. Moreover, for the sex-ratio among 20-26 year olds, the IV estimates result in the coefficient of violent crime becoming insignificant. Relative to the means of non-violent and property crime, we find a 0.6% (significant at the 10% level) and 0.7% (significant at 5%) respectively.

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 violent crime. As explained earlier, theoretically this can be due to increasing female pre-martial investments, making crime more expensive. This is especially true if the overrepresented gender (females, in this case) bears a disproportionate share of marriage-related expenses or have to pay a significant dowry.

The effect on non-violent and property crime of the 20-26 age-specific sex ratios is comparable in magnitude to the effect of 10-16 age-specific sex ratio. On the other hand there is no effect on violent crime. Note that though the sample size drops and as a result standard errors are higher, the magnitude of the effect is also smaller for violent crime. Thus, the sex-ratios in the marriageable age does not significant affect violent crime.

Table 5: Effect of Sex Ratio on Disaggregated Crime Rates

	(1) OLS	(2) IV	(3) OLS	(4) IV
	10-16 age-specific sex ratio		*20-26 age-specific sex ratio*	
Murder	-0.012***	-0.066*	-0.012***	-0.070*
	(0.003)	(0.033)	(0.004)	(0.035)
Attempt to Murder	-0.004*	-0.052***	-0.011***	-0.072**
	(0.002)	(0.011)	(0.004)	(0.030)
Rape	0.000	-0.005	0.001	-0.001
	(0.001)	(0.006)	(0.001)	(0.006)
Kidnapping	-0.005**	-0.038***	-0.005**	-0.026
	(0.002)	(0.009)	(0.002)	(0.017)
Burglary	0.001	0.125***	0.004	-0.041
	(0.006)	(0.026)	(0.005)	(0.037)
Dacoity	-0.006**	-0.012	-0.001	-0.000
	(0.003)	(0.007)	(0.001)	(0.002)
Theft	-0.034***	-0.505***	-0.013	-0.292***
	(0.012)	(0.101)	(0.015)	(0.073)
Robbery	-0.008**	-0.072***	-0.003	-0.043***
	(0.004)	(0.017)	(0.002)	(0.005)
Riots	-0.014*	-0.062***	-0.020**	-0.012
	(0.007)	(0.019)	(0.008)	(0.027)
Counterfeiting	-0.000	0.008**	0.001	0.007***
	(0.001)	(0.003)	(0.001)	(0.003)
Cheating	0.003	0.004	0.002	0.008
	(0.002)	(0.017)	(0.001)	(0.027)
Breach of Trust	-0.000	-0.011	-0.001	-0.001
	(0.001)	(0.023)	(0.001)	(0.019)
N	1210	1181	906	906

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Crime is measured per 100,000 of population

Regressions also control for proportion SC, ST, urbanization and literacy rate

In table 5, we show the effect of age-specific sex ratio on disaggregated crime. The IV estimates suggest that 10-16 age-specific sex ratios have a highly significant negative effect on arrests due to attempt to murder, kidnapping, burglary, theft, robbery, riots and counterfeiting. Among the 20-26 age-group, the negative effect remains on attempt to murder, theft, robbery and counterfeiting. As is evident from the disaggregated effects, the drop in the coefficient for violent crime can be explained by the insignificant estimates for kidnapping and riots.

5.1 Robustness checks

Exogenous variation in wheat-rice ratio may face probable threat to identification if crime and changes in area under wheat and rice cultivation would have evolved simultaneously due to factors such as changes in climate, culture, politics etc.

Though increasing irrigation facilities and improvement in agricultural technology 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 may not be completely exogenous to crime.

We deal with this potential threat to identification by checking the robustness of our results to an alternate IV that does not directly use the variation overtime in areas of production. In particular, we interact wheat-rice area ratio in 1961 for each district i with the ratio of producer prices in India for wheat-rice at time t, where t ranges from 1961 to 2001. Thus, the new instrument takes the form; $\frac{(Wheat\ Area)}{(Rice\ Area)}_{i,1961} * \frac{(\text{Pr}oducer\ Wheat\ price)}{(\text{Pr}oducer\ Rice\ price)}_{t}$

All other control variables are similar to the main specification. Since the prices are included with a 10 or 20 year lag (for 10-16 and 20-26 year olds respectively), they are unlikely to be associated with crime directly. The first stage for this specifiction remains negative and significant at the 5% level.

Table 6: Effect of age-specific Sex Ratio on Crime: Alternate IV Specification

	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
	10-16 age-specific sex ratio		*20-26 age-specific sex ratio*	
Non Violent Crime	-0.034*	-0.692***	-0.022	-0.438
	(0.019)	(0.139)	(0.026)	(0.430)
Violent Crime	-0.040***	-0.263***	-0.050***	-0.168
	(0.010)	(0.076)	(0.012)	(0.151)
Property Crime	-0.037**	-0.646***	-0.023	-0.459
	(0.017)	(0.112)	(0.024)	(0.351)
Observations	1238	1238	934	934

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Crime is measured per 100,000 of population

Regressions also control for proportion SC, ST, urbanization and literacy rate, state and time fixed effects

The results from this alternate IV are shown in Table 6. Consistent with Table 3 and 4, OLS is downward biased. IV estimates in column (2) suggest that the negative effect on crime remains for the 10-16 age-specific sex ratio. Moreover, the coefficients are comparable to those in Table 3. On the other hand, there is no effect of the 20-26 age-specific sex ratio on crime though the coeffcients are similar to those in Table 4. This confirms our hypothesis that the effect of pre-marriage sex-ratios on crime are larger than the effect of marriageable age sex-ratio.

Finally, we check for robustness of our results to including rainfall as an additional explanatory variable. Results (available upon request) are robust to including weather fluctuations.

6 Conclusion

Research has documented the negative effect of high male sex ratio on crime, but has not been able to obtain credible estimates controlling for the endogeneity of the sex-ratio itself. We solve the endogeneity problem by using the area under rice-wheat cultivation as an

instrument for sex-ratio. We focus on two age-specific sex ratios, corresponding to pre-marital (ages 10 to 16) and marriagable (ages 20 to 26) age groups.

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". Relatively little is known about the consequences of a skewed sex ratio.

We find that the effect of pre-marriage sex-ratios on crime are larger than the effect of marriageable age sex-ratio. This also suggests that previous literature has failed to account for the differential effect of age-specific sex ratios on crime. Once corrected for endogeneity, the effect of sex ratio on crime remain though only for the pre-marital age-group. Thus, the savings channel seems to explain a larger decline in crime than the direct effect of finding a match in the marriage market.

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7 Appendix

7.1 Data Appendix

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.

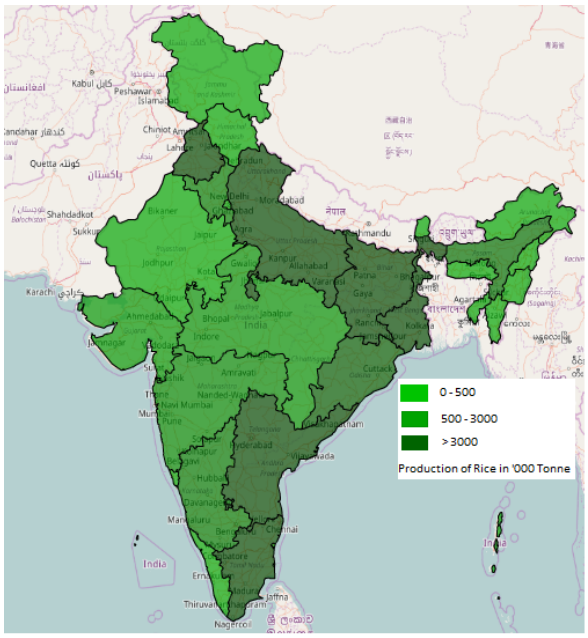
State	1971 District	1981 District	share of 1981 District	1991 District	share of 1991 District	2001	share of 2001 District
Arunachal Pradesh	Kameng	West Kameng	58.44	Tawang	34.34	Tawang	100.00
				West Kameng	65.66	West Kameng	100.00
		East Kameng	41.56	East Kameng	100.00	East Kameng	100.00

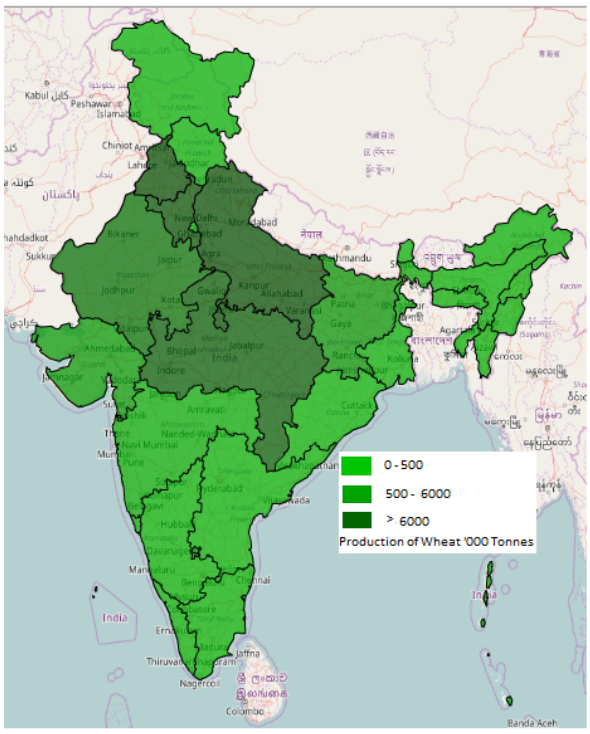
Mapping literate population in 2001 to the population in 1971 would therefore require aggregation of population of literates in Tawang, West Kameng and East Kameng to arrive at the final literate population figures for Kameng district in 1971.

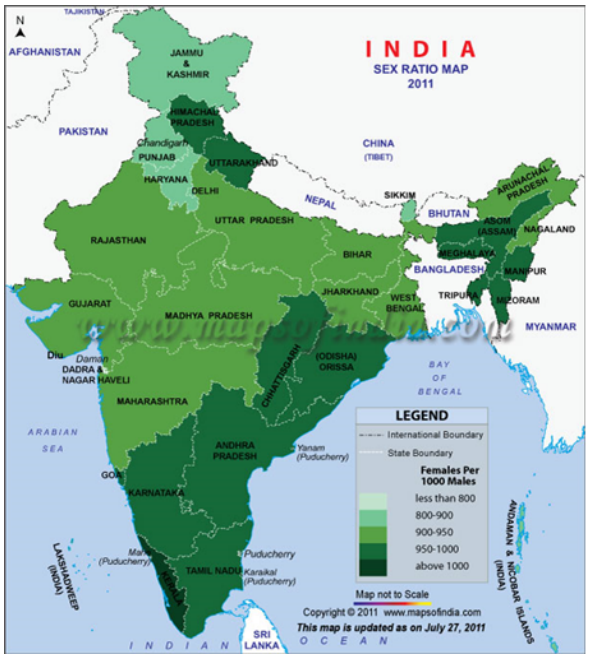
The above example is a simpler version of districts mapping as compared to districts carved out of multiple districts in the previous census. For example Vizianagaram formed a new district in 1981 taking shares of area and population from both Srikakulam and Vishakhapatnam from 1971. To map to Srikakulam 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
Andhra Pradesh	Srikakulam	Srikakulam	100.00
		Vizianagaram	51.59
	Vishakhapatnam	Vishakhapatnam	100.00
		Vizianagaram	48.41

7.2 Maps of India






INDIA
SEX RATIO MAP
2011
N
TAJIKISTAN
AFGHANISTAN
PAKISTAN
CHINA
(TIBET)
NEPAL
BHUTAN
BANGLADESH
MYANMAR
SRI
LANKA
JAMMU
&
KASHMIR
HIMACHAL
PRADESH
Chandigarh
PUNJAB
UTTARAKHAND
HARYANA
DELHI
UTTAR PRADESH
RAJASTHAN
BIHAR
SIKKIM
ARUNACHAL
PRADESH
ASSAM
(ASSAM)
NAGALAND
MEGHALAYA
MANIPUR
TRIPURA
MIZORAM
JHARKHAND
WEST
BENGAL
GUJARAT
MADHYA PRADESH
CHHATTISGARH
(ODISHA)
ORISSA
Dadra &
Nagar Haveli
DADRA &
NAGAR HAVELI
MAHARASHTRA
ANDHRA
PRADESH
Yanam
(Puducherry)
GOA
KARNATAKA
Mahe
(Puducherry)
Puducherry
Karaikal
(Puducherry)
TAMIL NADU
LAKSHADWEEP
(INDIA)
ANDAMAN & NICOBAR ISLANDS
(INDIA)
ARABIAN
SEA
BAY
OF
BENGAL
I N D I A N
O C E A N
LEGEND
International Boundary
State Boundary
Females Per
1000 Males
less than 800
800-900
900-950
950-1000
above 1000
Map not to Scale
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This map is updated as on July 27, 2011