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ABSTRACT

Sex Ratios and Crime: Evidence from China's One-Child Policy*

Sex ratios (males to females) rose markedly in China in the last two decades, and crime rates nearly doubled. This paper examines whether the two are causally linked. High sex ratios imply fewer married men, and marriage has been conjectured to be a socializing force. Our paper exploits the quasi-natural experiment generated by the Chinese one-child policy, a policy which is widely held to be behind the surplus of sons. While a national policy, its implementation was local. We show that the provincial level implementation was unrelated to contemporaneous economic characteristics of the province. Instead, individual characteristics of the provincial party secretary influenced the timing. Moreover, leaders were systematically rotated such that 10 years on, leader characteristics were serially uncorrelated. Using annual province-level data for the period 1988-2004, we show that a 0.01 increase in the sex ratio raised violent and property crime rates by some 3%, suggesting that the rise in excess males may account for up to one-seventh of the overall rise in crime.

JEL Classification: J12, J13, K42

Keywords: male-biased sex ratios, crime, one-child policy, China

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1 Introduction

Does marriage tame men? Unmarried young men are arguably the most crime-prone demographic (Steffensmeier & Allan (1996); Hurwitz & Smithey (1998)), an association that has often been construed as causal (Messner & Sampson (1991); Posner (1992); Barber (2000); Hudson & Den Boer (2002)). However, the treatment is hardly random, and any claim linking marriage to commendable behavior or outcome needs to contend with positive selection: unmarried men are thus for a reason, and this reason may exert an independent effect on the outcome at hand (e.g., Korenman & Neumark (1991)). For instance, violent and property crimes require few skills and may thus be more prevalent among economically disadvantaged groups – groups who face conditions (other than crime) that affect both marriage rates (Wilson (1987)) and crime. While longitudinal data on individuals seemingly offers a solution (e.g., Sampson *et al.* (2006)), the decision to enter into marriage is likely to be influenced by (to the econometrician) unobservable factors that also influence criminality, such as idiosyncratic employment or promotion prospects.

In this paper, we exploit the natural experiment generated by the Chinese one-child policy officially launched in 1979. The one-child policy, combined with a strong preference for at least one son and lowered cost of sex selection in the form of prenatal sex determination technology (chiefly ultrasound B machines), led to a surplus of sons at birth (Zeng *et al.* (1993); Miller

(2001); Chu (2001); Li (2002); Yang & Chen (2004); Das Gupta (2005)), and as these cohorts enter adulthood, a shortage of brides. The sex ratio (men to women) for the 16-25 year old cohort went from 1.053 in 1988 to 1.095 in 2004 (Figure 1), implying an almost doubling of "surplus" men. While it was a national policy, its implementation was delegated to the provinces, generating substantial cross-province variation in the roll-out from the late 1970s through the early 1990s.

The rise in the sex ratio coincided with a dramatic increase in crime. Between 1988 and 2004, criminal offenses rose at an annual rate of 13.6% (or 12.5%, population adjusted) (Hu (2006)), and arrest rates were up by 82.4% (Figure 2).[1] The overwhelming majority (70%) of perpetrators of violent and property crimes in China are between 16 and 25 years old (Hu (2006)). While we do not have the gender composition of arrestees by age, in 2000, 90% of all arrestees were men (*Law Yearbook of China* (2001)).

This paper investigates the impact of rising sex ratios on crimes. Our identification strategy exploits that: (i) sex ratios moved in response to the one-child policy; (ii) there was cross-province variation in the timing of the implementation; and that (iii) this variation was orthogonal to factors that may have a bearing on the crime rate. Specifically, we present evidence that the implementation of the policies were unrelated to province characteristics. Instead, <u>individual</u> characteristics of provincial political leaders – their

[1] We will focus on arrest rates in our empirical analysis, since we do not have offence rates at the province level.

age, education level, and central party connection – influenced the timing. Because leaders were systematically rotated, leader characteristics were orthogonal to province characteristics, thus leading to exogenous variation in the policy implementation and consequently the sex ratio.

The fact that higher sex ratios were in response to family planning programs is attractive for our purposes for a number of reasons. First, it seems reasonable that children born as a result of these programs were positively selected and could therefore be expected to have better adult outcomes (Kane & Staiger (1996); Donohue & Levitt (2001); Pop-Eleches (2006)). Second, falling fertility meant that younger cohorts were also smaller, which could reduce crime rates directly, assuming that younger cohorts are more crime-prone, and indirectly, via more favorable labor market conditions and the quantity-quality tradeoff (Li *et al.* (2008)). Third, sex-selective abortion (Edlund (1999)) and the incentive structure of the one-child policy (Short & Zhai (1998)) are likely to have strengthened the positive selection of sons that is naturally occurring (see Trivers & Willard (1973) and Almond & Edlund (2007)).

Our empirical analysis focuses on the sex ratio rather than marriage itself for the following reasons. First, data on cohort marital status are unavailable. Second, even if we had those data, marriage is endogenous both to factors likely to influence criminality, and criminality itself. The cohort sex ratio (at birth), on the other hand, has straightforward implications for the marriage market as the cohort comes of age, but is plausibly exogenous to factors affecting criminality of this cohort (other than marriage).

Employing province-level annual data covering the period 1988-2004, we estimate (by OLS and instrumenting using policy timing) that a 0.01 increase in the sex ratio of the 16-25 year age group raised the violent and property crime rates by some 3%, suggesting that the increasing maleness of the young adult population may account for as much as one seventh of the overall rise in crime.

A higher sex ratio would trivially raise the crime rate without the need to invoke the role of marriage if men are more crime-prone than women. However, by decomposing the elasticity of the crime rate we show that the estimated magnitude of the effect is consistent with the interpretation that criminality rose not only because of more men, but because of more unmarried men (derivation in Appendix A).

Our paper is related to the literature linking the absence of stable marriage to male violence and criminality. In the Asian context, the focus has been on *male* sex ratios (Dreze & Khera (2000) and Hudson & Den Boer

(2004) and references therein).[2] For the United States, in contrast, a surplus of women has been considered the problem (Messner & Sampson (1991); Barber (2000); Posner (1992)).[3] However, none of these studies has established causality plausibly. Our paper is also related to the vast literature linking marriage to health, wealth, and labor market outcomes (too extensive to do justice here).

The remainder of the paper proceeds as follows. Sections 2 and 3 describe the one-child policy, its impact on the sex ratio at birth, and its likely exogeneity to factors influencing criminality in the cohorts 16 to 25 years thereon. Section 4 describes the data. Section 5 presents the regression results and section 6 concludes. Appendix A presents a decomposition of the elasticity of the crime rate with respect to the sex ratio.

[2]Based on cross-sectional data, Dreze & Khera (2000) found the elasticity of the murder rate with respect to the sex ratio to be greater than eight. They conjectured that cultural variations across regions may account for the pattern that was found. Specifically, a patriarchal culture may result in both higher sex ratios and more violent crime. Another possibility, advanced by Oldenburg (1992), is that high crime rates drive the demand for sons for physical protection. For a critique, see Mitra (1993).

[3]In the U.S., homicides and incarceration (of males) have resulted in female-biased sex ratios among the underclass. In other developed countries, the upward mobility of females means that male-biased or balanced sex ratios prevail among the underclass. For a theoretical treatment of the link between female-biased sex ratios and unstable marriages, see Willis (1999).

2 One-child Policy – Background

The one-child policy was formally launched by the Chinese government in 1979. Initially a literal one-child per couple policy, it was soon amended and today, most provinces allow rural couples a second child if the first is a girl (Gu *et al.* , 2007). Households were given birth quotas, and "above-quota births" were penalized. Although there were variations at the sub-provincial level, e.g., the counties, the main variation of the policy was at the provincial level (Greenhalgh *et al.* (1994); Banister (1987); Li (1995); Short & Zhai (1998)), with the provincial party secretary (the top political leader at the provincial level) heading the local birth control committee.

The one-child policy was a radical departure from policies then in place and its implementation posed a number of challenges. Local governments were given the brief to fine tune the policy to local conditions (e.g., determination of fines for above-quota births), provide the necessary health infrastructure, and initiate a massive educational campaign.

The policy clashed with deeply held values and met with more or less open resistance (sometimes even by local leaders). Chinese culture traces lineage solely through males. Households that do not have a son are reproved by friends and relatives – failure to carry on the family name is a serious sign of disrespect to ancestors.[4] Moreover, old age support remains the

[4]A sentiment vividly described by the saying: "Of the three ways we could disrespect our ancestors, not carrying on the family name is the most serious" (*bu xiao you san, wu hou wei da*). The seriousness of the infraction is further illustrated by expressions such

responsibility of sons, rendering at least one son economically opportune if not a necessity (e.g., Das Gupta *et al.* (2003)).

The one-child policy was politically charged, figuring prominently in the power struggles of the Communist Party. As described in Scharping (2004, page 160), in the late 1970s, the promulgations of the one-child policy was directly chaired by the then General-Secretary of the Chinese Communist Party, Hu Yaobang. A reformist who closely followed Deng Xiaoping, Hu used the policy as a weapon to combat the leftists, who followed the doctrine of Mao's population policy of "more people, more power ('ren duo li liang da' in Chinese)". Consequently, provinces with reformist party secretaries and/or with party secretaries who were closely associated with the central government implemented the policy earlier.[5]

2.1 One-child Policies

The one-child policy is an umbrella term for a raft of policies (see Peng (1996)). Although officially launched in 1979, it covers programs with an earlier start date. We focus on the following three programs established between 1976 and 1992:[6]

as "extinction of descendants" (*duan zi jue sun*).

[5]Also for political consideration, minority women were generally not subject to the one-child policy in the 1980s (Peng (1996)). Hence, provinces with relative large minority populations generally lagged behind other provinces in implementing the one-child policy.

[6]The full set of programs are described in Appendix B. The omitted programs either did not exhibit variation in timing or were not statistically significant in the first stage

1. *Family Planning Science and Technology Research Institutes* are medical and research facilities present at all government levels. These institutes provide birth control services and collect data on the cost effectiveness of various birth control methods (chiefly intra uterine devices [IUDs], sterilizations, and abortions). They also distribute free contraceptives to households.

2. *Family Planning Education Centers* promote family planning through movies, pictures, books, and posters. These centers educate people on the use and usefulness of contraceptives and extol the virtues of a small family.

3. *Family Planning Associations* hold academic exchange activities on local population issues, conduct socioeconomic research on family planning, and make recommendations concerning population policy and planning.

As is clear from Figure A1, there was substantial variation in the rollout of the three programs across provinces. This was especially the case for the *Family Planning Science and Technology Research Institutes* – the first program was established already in 1976 (in Jiangsu) and the last in 1992 (Inner Mongolia).

in the IV analysis.

3 One-child Policies as IVs

This section shows that the provincial variation in the timing of the implementation of the various policy programs is related to personal characteristics of provincial level political leaders – not the economic environment – and that these leaders were rotated on a regular basis such that after 10 years and beyond leader characteristics were serially uncorrelated.

3.1 Determinants of One-child Policies

To examine the hypothesis that the roll-out of the one-child policy programs was in response to local party leaders characteristics rather than the local socio-economic conditions, we regressed the number of (above-described) one-child policy programs (0, 1, 2 or 3) in place in a province in a year over the period 1978-1992 on the provincial party secretary's characteristics (described below) and provincial per capita GDP and secondary school enrollment rate, the latter two proxying for provincial social and economic status. We also include province and year dummies to control for unobserved province and year fixed effects.

The province party secretary is the the top political leader in the province, and we have information on his (her) age, education (college graduate dummy) and central connections (coming from the central government). The data on leader characteristics and tenure was collected from two books published in Chinese: *Who's Who in the Chinese Communist Party* (1997) and *the*

Documentation and Administration in the People's Republic of China (1996) (for further details, the reader is referred to Li & Zhou (2005)).

Estimation results reported in Table 1 show that the one-child policy program roll-out depended crucially on leader characteristics. In particular, provincial party secretaries with college degrees and/or central connections were more likely to start the programs earlier, whether other variables are included (Column 3) or not (Column 1). Interestingly, the program roll-out is not correlated with provincial per capita GDP or secondary school enrollment. In other words, controlling for province and year fixed effects, the roll-out of one-child policy programs depended on who the top provincial leaders were, but not on the provincial social economic status.

3.2 Are One-child Policies Suitable Instruments?

As shown above, the implementation of the one-child policy was highly politicized and the roll-out was associated with provincial leader characteristics but not other social economic variables. To be valid instrumental variables for the sex ratio in our crime equation, we need that the factors associated with the roll-out of these programs, i.e., provincial leader characteristics, do not affect crimes 16 years later. There are two potential channels by which leader characteristics could affect future crime rates. First, leaders who pushed the one child policy may also be tough on crimes, and leader characteristics are serially correlated. In this case, both the implementation and crime rates are determined by leader preference. As we will show below, this is not likely to be the case as leader characteristics are not serially correlated. Second, some policies may have a lagged or long-lasting effect, such that a policy could affect crime rates 16 years later. We are not aware of any such policies *a priori*, but we will control many socioeconomic variables that are potential determinants of crimes, as well as a full set of provincial dummies, to fully deal with this issue. Also, because of the high turnover of provincial leaders, it is difficult to imagine a provincial policy that could have such a long-lasting effect (not captured by province fixed effects).

Normally, the term of provincial party secretaries lasts five years. After one term ends, most provincial party secretaries move laterally from one province to another, or to a ministry at the center at the same rank, or retire (only a few are promoted to the top positions in the country).[7] It is very rare for a party secretary to stay in the same province for more than two terms (Li & Zhou (2005)).

To check whether leader characteristics were serially correlated, we regress the characteristics of party secretaries on the 10-year or 16-year lags of these

[7] China is a unitary state, and its political system is broadly composed of five layers of state administration: the center (zhongyang), provinces (sheng), prefectures (diqu), counties (xian), and townships (xiang). The Central Committee of the Chinese Communist Party (CCP) ultimately controls the mobility of government officials within the political system. Provinces are the second level of the political hierarchy. The top position at the provincial level is that of the provincial party secretary.

same variables. Regressions reported in Table 2 show that none of these characteristics were serially correlated for a time span of 10 years or longer.

Obviously, to be valid instruments, it must also be that the policies moved the sex ratios (i.e. instrument relevance). In Section 5.2, we will test and confirm this. Furthermore, if sex ratios varied mainly in response to the one-child policies, this would also suggest there is no endogenous variation in the sex ratio to be purged, and instrumenting for the sex ratio is unnecessary (absent measurement error).

4 Data

To investigate the hypothesis that increasingly male sex ratios have contributed to the rise in criminality, we analyze annual province-level data from China's 26 provinces,[8] covering the period 1988-2004.[9] Our main data sources are published data from various yearbooks and the 1990 census.

[8]The four municipalities directly under the central government – Beijing, Shanghai, Tianjin, and Chongqing – are excluded, as they are governed by a different judicial system and are not comparable to other provinces. Guangdong is also excluded because of the substantial changes affecting comparability of data over the period. Hainan was spun off and Guangdong's proximity to Hong Kong meant that it was particularly affected by the 1997 return of Hong Kong to Chinese rule.

[9]Recall that 1988 was the first year for annual province-level crime statistics.

4.1 Variable Description

Crime Our focus is on violent and property crimes. These are low-skill crimes with young perpetrators likely to have had their marriage market affected by the rise in the sex ratio.

While we cannot distinguish between violent crimes and property crimes, they may be similarly motivated (e.g., robbery). Property crimes made up between 77.3% and 90.7% of all criminal cases between 1981 and 2004.[10] Among property crimes, larceny is by far the most common (86.7% in the same period) (Hu (2006)).

We define the crime rate to be arrests per 10,000 population. Thus measured, criminality almost doubled in the study period, from 3.71 in 1988 to 6.77 in 2004 (Figure 2); and there was considerable variation, arrest rates ranged from 0.81 (Tibet, 1988) to 13.1 (Zhejiang, 2004). Our data are from the *China Law Yearbook* (Supreme People's Court, 1989-2005) and the *Procuratorial Yearbook of China* (Supreme People's Procuratorate, 1989-2005).

Sex ratio The one-child policy impacted the sex ratio around birth. This is also the sex ratio that frames the marriage market conditions for cohorts as they age. For want of natality data, we proxy the sex ratio for each birth year and province using the 1990 census. For instance, the sex ratio of the cohort 16-25 years old, henceforth the 16-25 ratio,

[10]At the national level, publicly available data go back to 1981.

for Zhejiang, in 1989, is calculated as the sex ratio of those in Zhejiang who were 17-26 years old in 1990. Migration may make this figure different from the actual sex ratio at birth for this cohort. However, inter-provincial migration was very limited until 1991 (the first year of the *de facto* lifting of the household registration system in many provinces). A more serious concern is the possibility of gender differential mortality. If present, it would introduce measurement error. Therefore, we will also instrument for the sex ratio using the one-child policy variables.

The 16-25 sex ratio rose dramatically during the study period, from 1.053 in 1988 to 1.095 in 2004, a rise of four percentage points in 16 years (Figure 1), and there was substantial variation across provinces. We focus on the 16-25 age group for two reasons. First, 16 is the age of full criminal responsibility, and 25 is the upper age for "juvenile crime." Second, these are the most crime-prone ages, accounting for more than 70% of the total number of criminal offenders since the mid-1980s. For example, the share of homicides, rapes, robberies, and larcenies committed by this age group in 1993 was 46.73%, 55.31%, 78.77%, and 66.16%, respectively (Hu (2006)).

Additional controls Provincial level per capita income, employment rate, secondary school enrolment rate, income inequality (urban over rural household income), urbanization rate, age structure, welfare expenditures, police expenditures (as a share of provincial government expenditures), share of (out-of-province) immigrants, and population structure variables are included as additional controls. These data are from the *Comprehensive Statistical Data and Materials on 55 Years of New China* (National Bureau of Statistics (2005)), and the *China Statistical Yearbooks*, 1989-2005.[11]

As a descriptive start, Figure 3 plots the crime rate against the sex ratio (both variables are demeaned of province and year fixed effects). A positive correlation is evident. The fitted line has a slope of 3.140, suggesting that an increase in the sex ratio by 0.01 raised the crime rate by 3.14%. This result, qualitatively and quantitatively, will hold up in the regression analysis, to which we now turn.

5 Regression Analysis

We estimate the following regression model:

$$\ln c_{it} = \alpha r_{it} + X_{it}\beta + \delta_i + \tau_t + \varepsilon_{it}, \tag{1}$$

where c_{it} is the crime rate in province i, year t, and r_{it} is the corresponding sex ratio among 16-25 year olds (males to females). We expect $\hat{\alpha} > 0$. Since the sex ratio is close to 1, α can be interpreted as approximately the

[11]Further variable descriptions and summary statistics are in Table A1.

elasticity of crime with respect to the sex ratio. Making that approximation, $\hat{\alpha} > f$ (shown in Appendix A) is consistent with crime having increased in response to higher sex ratios not only from there being more men, but more unmarried men.

X_{it} is a vector of province-year level controls. We expect income inequality to increase crime rates (Ehrlich (1973); Kelly (2000); Bourguignon (1999)). The influence of per capita income is *a priori* ambiguous. On the one hand, it can magnify the returns to illegal activities relative to legal ones. One the other, as incomes rise, possessions may be better protected.

We expect urbanization to be positively related to crime rates (Glaeser & Sacerdote (1999)). By contrast, we expect employment rate (the fraction of the working age population who are employed), secondary school enrollment, and welfare expenditure (the ratio of pension and social welfare expenditure to total government expenditure) to be negatively related to crime rates (Zhang (1997)). Moreover, we expect police expenditures to have a negative effect on crime rates (Becker (1968)). However, since police expenditures may be high in response to high crime rates, reverse causality may bias the estimates (Levitt (1997, 1998)). For want of a suitable instrument, we estimate Eq. 1 with and without police expenditures, thus allowing us to gauge the sensitivity of our results to the inclusion of this variable.

δ_i and τ_t are vectors of the province and year dummies. These control for pre-existing differences between provinces and year-specific effects that are common to all provinces. The residual ε_{it} is assumed to be $i.i.d$ with zero mean.

5.1 OLS

We estimate Eq. 1 by OLS, using heteroskedasticity robust standard errors. We start by including only the sex ratio (in addition to the province and year dummies) in Column 1 of Table 3 (equivalent to the fitted line in Figure 3). Additional controls are added sequentially in Columns 2-4. Throughout, the estimated coefficient on the sex ratio variable is positive and statistically significant at the 1% level, and neither the point estimates nor the standard errors are much affected by the inclusion of the additional controls. In our preferred specification (Table 3, Column 4), our estimate of α is 3.474, that is, a rise in the sex ratio of 0.01 increased the crime rate by 3.5%. Since the 16-25 sex ratio rose by 0.04 (from 1.053 in 1988 to 1.095 in 2004), this suggests that increasingly male sex ratios can account for 14% of the overall rise in criminality during the sample period (crime rates rose by 82.4% from 1988 to 2004).

Our estimate imply an elasticity of crime with respect to the sex ratio of around three, an order of magnitude consistent with marriage having a crime-reducing effect on men (see Appendix A).

As for the control variables, the estimated coefficient on log per capita income is not significant. The employment rate has the expected negative effect, albeit borderline significant. Inequality and urbanization have positive and statistically significant effects, suggesting that the rise in crime rates may be partly attributable to rapid urbanization and rising inequality. Neither secondary school enrollment nor welfare expenditures are statistically significant.

5.2 IV

While it is reasonable to believe the sex ratio at birth to be exogenous to crime rates 16-25 years into the future, our measure of this sex ratio may suffer from measurement error. Therefore, we now turn to our instrumental variables estimation where we use the family-planning policy variables in place the year prior to the birth year as instruments. These instruments are *a priori* suitable because they plausibly influenced the sex ratio, and, as shown in Section 3, they are unlikely to be contemporaneously correlated with the crime rate (other than through the posited channel).

To match the policies to the crime-prone cohorts, we compute the weighted policy variable P_t^* in year t and province i as follows:

$$P_t^* = \frac{\sum_{g=16}^{25} C_g P_{t-g-1}}{\sum_{g=16}^{25} C_g}, \tag{2}$$

where C_g is the number of people who are g-years old in year t (and province i, subscripts suppressed for clarity of exposition), and P_{t-g-1} is a policy dummy $g+1$ years ago, i.e., the year preceding the g-year-old's birth. In other words, P^* is the proportion of the 16-25 age cohort whose mothers were subject to the one-child policy in question the year before they were born. We construct the instruments by calculating P_t^* for our three policy programs (Family Planning Science and Technology Research Institutes, Family Planning Education Centers, and Family Planning Associations).

The first-stage estimates are presented in Table 4. In addition to the three IVs, we also include all of the other control variables. The IVs are jointly significant at the 1% level in all four cases (as well as individually significant).

The results from the IV estimations confirm our OLS results: increasingly male-biased sex ratios have had an economically and statistically significant impact on crime. First, we report the results of a regression that only includes the (instrumented) 16-25 sex ratio (in addition to the province and year dummies) (Table 5, Column 1). The 16-25 sex ratio has a positive and significant (1%) effect on the crime rate. As before, our key result is robust to the inclusion of other variables (Columns 2-6). The signs of the estimated coefficients for the control variables remain mainly the same as in the OLS estimations.

Overall, the IV estimates of the effect of the sex ratio are similar to the OLS estimates. This is not surprising given the influence of the one-child policy on sex ratios. The estimated coefficient on the 16-25 sex ratio variable ranges from 1.94 to 3.05. In our preferred specification (Table 5, Column

4), α is estimated at 3.04, or about 90% of the estimate obtained in the equivalent OLS specification (Table 3, Column 4).

5.3 Robustness

In our first set of robustness checks, we add control variables to address potential omitted variable bias. (Since these additional variables may be endogenous, we did not include them in our baseline regressions in Tables 3 and 5.)

We first include log police expenditure (Table 6) in our IV specifications to capture its potential impact on crime. However, reverse causality – rising police expenditure as a result of rising crime – is a concern (Levitt (1997)). Since we do not have a suitable instrument to identify the causal effect of police expenditure, its inclusion may be viewed as a sensitivity test. Consistent with reverse causality, the coefficient on the police expenditure variable is positive. With log police expenditure included, our main result remains.

As another robustness test, we include (out-of-province) immigration in the regression equation (Columns 2-4). The estimated coefficient on the share of immigrants is positive in all of the specifications, which is consistent with the theoretical prediction of the standard crime model (Becker (1968); Ehrlich (1973)).[12] Still, the magnitude and significance of the estimated

[12] High population mobility presumably reduces the probability of being caught. Alternatively, a high immigrant share may reflect the economic climate (not captured by the income measures).

coefficient on the sex ratio remain essentially unchanged.

In the last two columns of Table 6, we include variables capturing the age composition of the population. As expected, the estimated coefficient on the proportion of the population that is between 16 and 25 years old is positive and statistically significant (1%). This is due to the mechanical impact of the relative size of the crime-prone cohort on the crime rate. Unexpectedly, the proportion of the population that is older than 65 also has a positive and significant coefficient. Still, the estimated effect of the sex ratio remains positive and significant.

5.3.1 Falsification Tests

A possible concern is that the sex ratio may be correlated with policies or socioeconomic changes likely to exert an independent effect on the crime rate. To address this issue, we conduct two falsification tests.

If the hypothesized relationship holds – marriage makes men less crime prone – then we would expect lower or little impact on high-skill or white-collar crime, such as corruption, because the men likely to engage in this type of crime have largely been insulated from the shortage of women (they are older and more skilled). Figure 4 plots the corruption rate against the sex ratio (both variables are demeaned of province and year effects). The fitted line has a slightly negative slope and is not significant (p-value 0.273). The IV estimates confirm this conclusion (Table 7, Column 2). That is, we find no evidence that the 16-25 sex ratio has raised corruption rates. In other words, the effect of the 16-25 sex ratio is specific to low-skill crime and does not pick up an overall increase in criminality.

Our second falsification test examines whether the sex ratios for the 10-15 year old age group (too young to commit crimes) impact the crime rate. The IV estimates (Table 7, Columns 3-4) show that the 10-15 sex ratio has no impact on the crime rate, whether we control for the 16-25 sex ratio or not. The coefficient on the 10-15 sex ratio is negative in Column 3, but is not significantly different from zero. When we also include the 16-25 sex ratio, the coefficient on the 10-15 sex ratio remains negative and insignificant. Moreover, the 16-25 sex ratio continues to have a large and significant impact on the crime rate (Column 4).

These results suggest that our main findings are not likely to be driven by unobserved time-varying confounders.

5.3.2 Sex Crimes?

One possibility is that the rise in violent and property crimes is driven by "sex related" crimes: rape and abduction of women and children.[13] While a breakdown does not exist at the provincial level, we can examine the patterns at the national level. These data do not indicate the rise in violent and property crimes to be driven by sex related crimes. Figure 5a shows that the rape rate rose between 1985 and 1992. However, this was probably

[13] There is only one "rape" category (attempted rape and sexual assault are either not crimes or subsumed under rape).

not related to the sex ratio, as the 16-25 sex ratio during this period (Figure 1) was rather flat (the first cohorts of the one-child policy were still young in 1992). More interestingly, the rape rate began to drop in 1992 (as did the abduction of women and children; not shown), which is in stark contrast to the overall rise in property and violent crime rates in the same period (Figure 5b).[14] Thus, our findings are likely driven by "non-sex related" crimes.

6 Summary and Discussion

In 2000, 120 boys were born for every 100 girls in China, a development that has raised a number of concerns, ranging from human rights issues surrounding the fate of the "missing females" to the social impact of surplus men. Who are these men going to marry, and, if they do not, what are the consequences (e.g., Hesketh & Xing (2006) and references therein)?[15] High sex ratios are not unique to China, but, unlike India, where population

[14] A possible explanation for the decline in sex related crimes is that prostitution (illegal, but not included among violent and property crimes) has increased rapidly in the last two decades (Jeffreys (2004)). In his article "Surfeit of boys could spread AIDS in China's cities" published in *Nature* 434, 425 (24 March 2005), David Cyranoski said "...it [China] has admitted that there are now between 4 million and 6 million [prostitutes], compared with only 25,000 in 1985." doi:10.1038/434425b; Published online 23 March 2005. http://www.nature.com/nature/journal/v434/n7032/full/434425b.html

[15] Also see "Missing sisters", *The Economist*, April 17, 2003 and "China: Too Many Men", *CBS 60 Minutes*, April 16, 2006,

http://www.cbsnews.com/stories/2006/04/13/60minutes/main1496589.shtml.

growth has buffered some of the impact, the shortage of brides is likely to be felt more acutely. Also, whereas South Korean men have been able to turn to poorer neighbors to source brides, China's bachelors (the poorest in a still poor country) are unlikely to be in a position to do so.

The rise in the sex ratio has coincided with a dramatic increase in crime. Although the notion that unbalanced sex ratios may raise crime is a long-standing hypothesis, a causal link has been difficult to establish. This paper has taken a step in that direction by exploiting the natural experiment created by the one-child policy which, in combination with a traditional preference for sons and the arrival of prenatal sex determination, have raised sex ratios (males to females) at birth substantially. We find that the sex ratio among those 16 to 25 years old has had a large and statistically significant impact on crime. We estimate that male-biased sex ratios may account for about a one-seventh of the overall rise in violent and property crime during the period 1988-2004. Moreover, our estimates suggest that marriage reduces male criminality, a finding of particular salience given China's demographics. Increasingly male sex ratios among children imply that another 10 percentage point increase in the 16-25 sex ratio is likely in the offing.

Granted, China has seen other dramatic changes during the study period. Although the state tightened its grip on fertility, its influence over virtually all other spheres of life diminished markedly. The introduction of a *de facto* market economy, rapid economic growth, and reduced state control over most facets of life are factors that may have contributed to the rise in crime rates. However, the fact that our results are robust to the inclusion of many province-level variables that proxy for these developments (including provincial fixed-effects) and that the sex ratio for a younger cohort (10-15 years old, young to commit crimes) has no impact on the crime rate suggest that our estimate is unlikely to be caused by unobserved time-varying factors. Furthermore, the effect of the sex ratio is not evident in a type of crime that we would not expect to be influenced by the sex ratio – corruption – further supports our hypothesis that the surplus of young men has had a causal and economically important effect on low-skill crimes.

Appendix A. Male-biased Sex Ratios and Crime – A Decomposition

This section decomposes the crime rate into changes due to more men, changes due to more unmarried men, and the residual. The residual could be interpreted as being due to changes in the criminal propensity of men, conditional on marital status.

Consider a population of measure 1 with m men and $f = 1 - m$ women. Men can be unmarried, m^0, or married, m^1, and $m = m^0 + m^1$. Similarly for women, $f = f^0 + f^1$. We denote each demographic group's crime rate as c_m^0, c_f^0, c_m^1, and c_f^1, respectively. The crime rate, c, can then be expressed as

$$c = c_m^0 m^0 + c_m^1 m^1 + c_f^0 f^0 + c_f^1 f^1.$$

We restrict our attention to the case of male-biased sex ratios, and assume that men marry with probability $f/m(< 1)$ and women marry with certainty. Furthermore, we assume that

$$c_m^0 \geq c_m^1 > 0,$$

$$c_f^0 = c_f^1 = c_f, c_f \in [0, c_m^1).$$

To assume that married and unmarried females are equally crime-prone is innocuous, as all women will be married by assumption.

A higher sex ratio increases the fraction of males and the fraction of males who are unmarried, both of which may raise the crime rate. To focus on the first mechanism, we assume for now that

$$c_m^0 = c_m^1 (= c_m). \tag{3}$$

In this case, the crime rate, c, is simply

$$c = c_m m + c_f (1 - m).$$

Let r denote the sex ratio:

$$r = \frac{m}{f} = \frac{m}{1 - m}. \tag{4}$$

We can write the elasticity of the crime rate with respect to the sex ratio, conditional on Eq. 3, as

$$\begin{aligned}
\epsilon(c,r)|_{c_m^0=c_m^1=c_m} &= (\frac{dc}{dm}\cdot\frac{m}{c})\cdot(\frac{dm}{dr}\cdot\frac{r}{m}) \\
&= \frac{c_m m - c_f m}{c_m m + c_f(1-m)}\cdot f \\
&\leq f. \qquad (5)
\end{aligned}$$

That is, if the estimated elasticity of crime with respect to the sex ratio is greater than the fraction of females, then higher criminality cannot be due simply to more males.

Next, we consider the possibility that marital status has an impact on the propensity to commit crime. Specifically, an increase in the sex ratio, r, not only increases m, but also raises the fraction of unmarried males, which, assuming that $c_m^0 > c_m^1$, further raises criminality.

In this case, the ratio of all males to unmarried males gives an upper bound on the elasticity of the crime rate with respect to the sex ratio, because

$$\begin{aligned}
\epsilon(c,r) &< (\frac{dc}{dm^0}\frac{m^0}{c})\cdot(\frac{dm^0}{dr}\frac{r}{m^0}) \\
&< (\frac{dc}{dm^0}\frac{m^0}{c})\cdot\frac{m}{m^o} \\
&\leq \frac{m}{m^o}. \qquad (6)
\end{aligned}$$

The first inequality in 6 follows from the fact that higher sex ratios result in an increase in unmarried males and a decrease in married males (and females). For the second inequality, we obviously need

$$\begin{aligned}
\frac{dm^0}{dr}\frac{r}{m^0} &< \frac{m}{m^0}, \\
&\Leftrightarrow \\
\frac{dm^0}{dr} &< f.
\end{aligned}$$

To see that this is the case, note that since $m^1 = f$, it follows that

$$f = (1 - m^0)/2$$

and that

$$\frac{dm^0}{dr} = \frac{1}{dr/dm^0} = \frac{(1-m^0)^2}{2} < \frac{1-m^0}{2}, m^0 \in (0, 1).$$

For the last inequality in 6, we note that $\frac{dc}{dm^0}\frac{m^0}{c} < 1$, because a percentage change in the fraction of unmarried men can at most bring about an equal change in the crime rate.

Since $m^0 = 2m - 1$, we can rewrite inequality 6 as

$$\epsilon(c, r) \leq \frac{r}{r-1},$$

which for a sex ratio of 1.10 translates into 11 (threshold values are plotted in Figure A2), well above our estimated elasticity in the neighborhood of three.

Appendix B. One-Child Policies

All the three programs used as instruments are subsidiaries of the *Family Planning Commissions*, which were established at all government levels in China. They are in charge of implementing the one-child policy. They were all established at about the same time (reflecting direct control by the central government).

The one-child policy also included the programs below. They were not included as instruments because there was either little variation in the timing of their implementation or they were not found to impact the sex ratios.

- Population Information Agent: conducts research on population trend and socio-economic impacts of population change. Present only in a few provinces.
- Press Agent: runs local newspapers for birth control news (little variation; established in the mid-1980s).
- Cadre Training Center: trains family planning cadres (little variation; established in the mid-1980s).
- Medicine and Medical Equipment Management Center: provides medicine and equipment for birth control; equipment maintenance (little variation; established in the mid-1980s).

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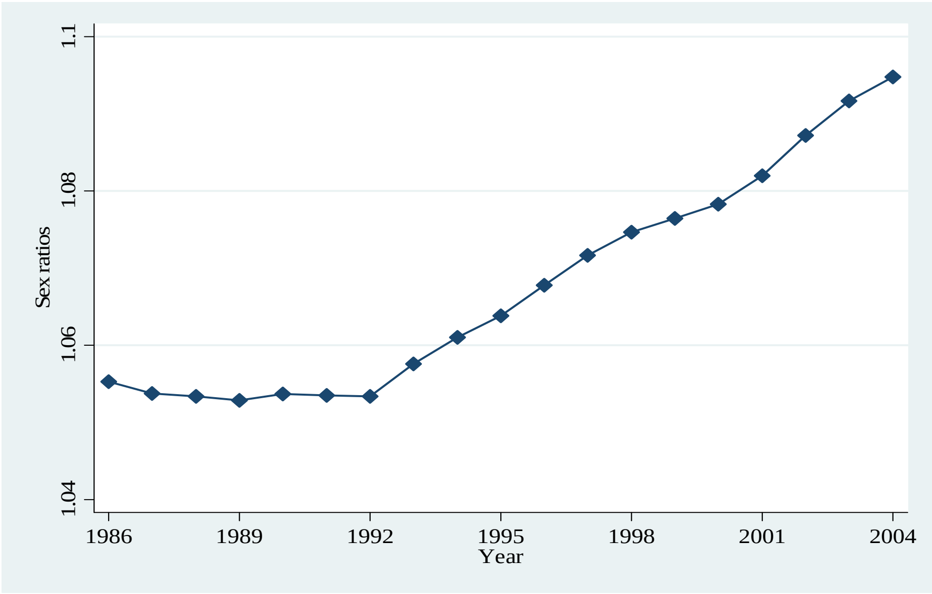
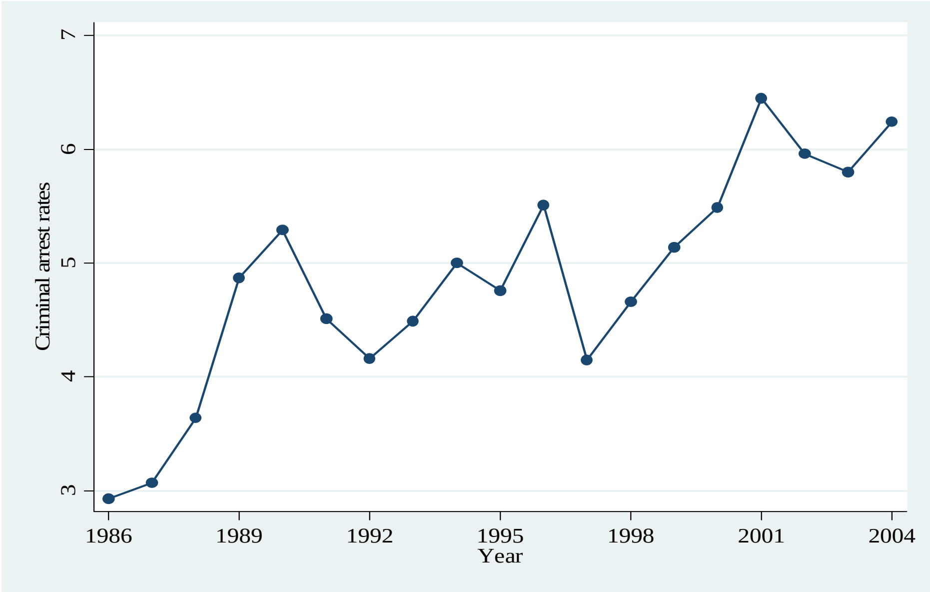
Figure 1: Sex ratios of the 16-25 age cohort, by year



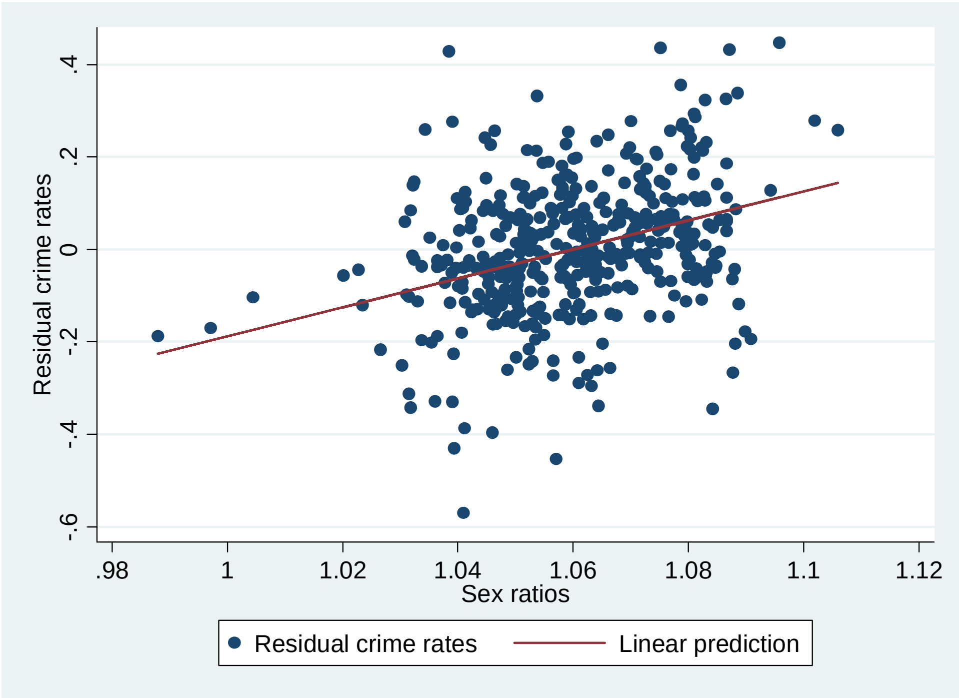
Note: Calculation is based on the 1990 Chinese population census (1% sample).

Figure 2: Criminal arrest rates (property and violent crimes): 1986-2004



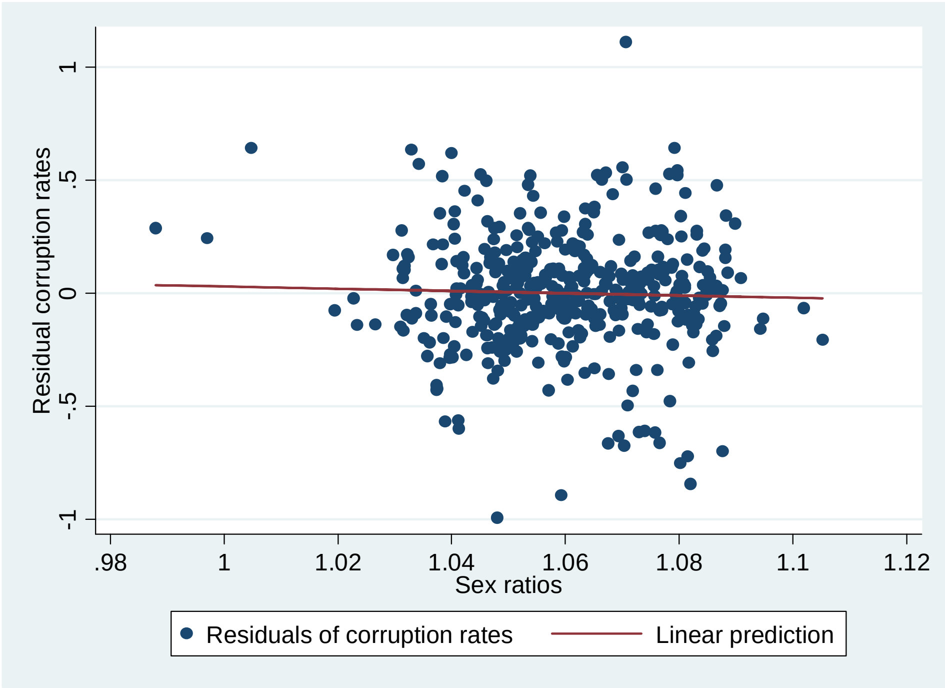
Notes: (i) data sources: Chinese Supreme People's Procuratorate (1986-2005), *Procuratorial yearbook of China*, Beijing, The Publishing House of Law; (ii) two structural breaks of the criminal arrest rates in China deserve noting. First, in 1989-1990, there is a marked increase in violent and property offenses, possibly due to weakened government and social control in the aftermath of the *Tiananmen Square Protests of 1989*. Second, in 1997, the 5th session of the 8th NPC passed the new amended *Criminal Law* and *Criminal Procedure Law*, which considerably modified the preceding 1979 *Criminal Law* and *Criminal Procedure Law*, leading to a structural break in 1997. (The regression analysis will control for year fixed effects.)

Figure 3: (Residual) crime rates by sex ratios, 1998-2004



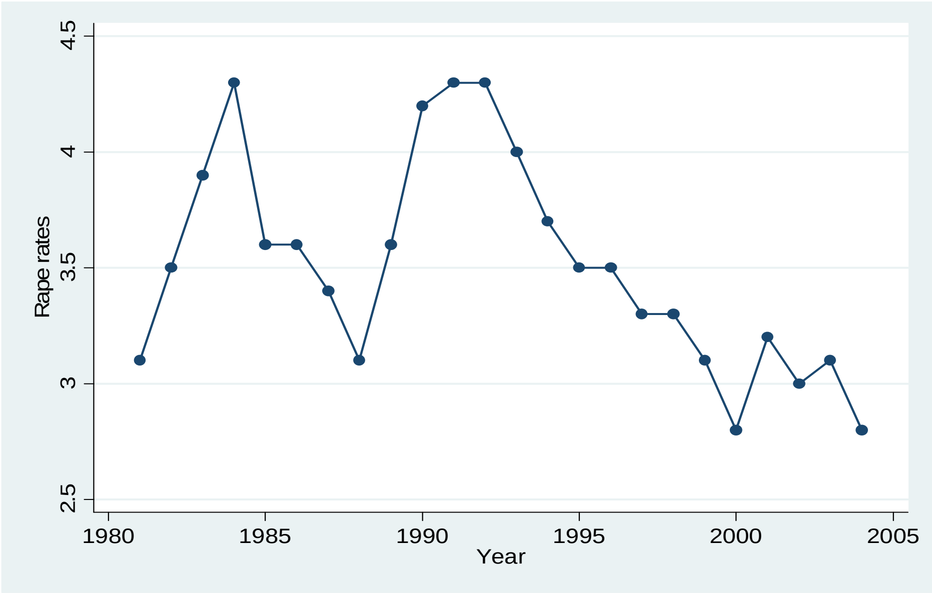
Note: Crime refers to property and violent crimes. Crime rates and sex ratios are purged of province and year fixed effects; coefficient: 3.140; *t*-statistic: 6.96. Crime rates are in log form.

Figure 4: (Residual) corruption rates by sex ratios, 1988-2004



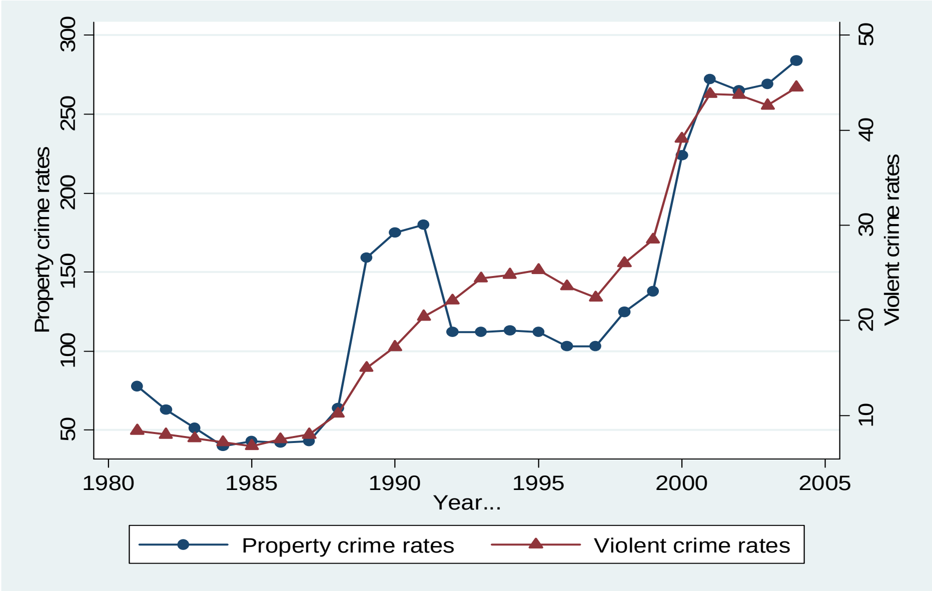
Note: Corruption rates and sex ratios are purged of province and year fixed effects estimation; coefficient: -0.507; *t*-statistic: -0.64. Corruption rates are in log form.

Figure 5a: Rape rates by year



Notes: (i) data sources: Chinese Supreme People's Court (1985-2005), *Law Yearbook of China*, Beijing, The Publishing House of Law; (2) Rape rates are defined as the number of cases registered by the police per 10,000 population.

Figure 5b: Property crime rates and violent crime rates by year



Notes: (i) data sources: Chinese Supreme People's Court (1985-2005), *Law Yearbook of China*, Beijing, The Publishing House of Law; (2) both the property and violent crime rates are defined as the number of offense cases registered by the police per 10,000 population

Table 1: Determinants of the One-Child Policy Programs Roll-out in 1978-1992

	Number of one-child policy programs (0,1,2 or 3)		
	(1)	(2)	(3)
Characteristics of provincial party secretary			
Age	0.014		0.010
	(0.009)		(0.009)
College graduate	0.215*		0.267**
	(0.125)		(0.125)
Central connection	0.194**		0.167*
	(0.097)		(0.098)
Provincial variables			
per capita GDP		-0.079	-0.037
		(0.170)	(0.170)
Secondary school enrollment		-0.001	-0.004
		(0.006)	(0.006)
Observations	432	411	409
Number of provinces	29	29	29
R-squared	0.70	0.72	0.72

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The data are provincial panel data. Year- and province-fixed effects are included in all specifications.

Table 2: Serial Correlations of Leader Characteristics

	Dependent variables: Characteristics of provincial party secretary					
	Age	Age	College graduate	College graduate	Central connection	Central connection
	(1)	(2)	(3)	(4)	(5)	(6)
Age						
10 years lagged	-0.044					
	(0.049)					
16 years lagged		-0.037				
		(0.762)				
College graduate						
10 years lagged			0.054			
			(0.045)			
16 years lagged				0.026		
				(0.533)		
Central connection						
10 years lagged					0.026	
					(0.049)	
16 years lagged						0.099
						(0.325)
Observations	225	51	225	51	225	51
R-squared	0.00	0.00	0.01	0.01	0.00	0.02

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: OLS Estimates of the Effect of Sex Ratios on Crime Rates in China, 1988-2004

	Dependent variable: ln(crime rate)			
Variables	(1)	(2)	(3)	(4)
Sex ratio (16-25)	3.140***	3.261***	3.528***	3.474***
	(0.474)	(0.563)	(0.550)	(0.554)
ln(per capita income)		-0.061	0.020	-0.002
		(0.111)	(0.085)	(0.085)
Employment rate (%)		-0.006*	-0.004	-0.004
		(0.003)	(0.003)	(0.003)
Secondary school enrollment (%)		0.003	0.004	0.003
		(0.003)	(0.003)	(0.003)
Inequality			0.139**	0.137**
			(0.056)	(0.056)
Urbanization rate (%)			0.008***	0.008***
			(0.003)	(0.003)
ln(welfare expenditures)				-0.053
				(0.040)
Observations	442	442	442	442
Number of provinces	26	26	26	26
R-squared	0.78	0.79	0.81	0.81

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The data are provincial panel data. Year- and province-fixed effects are included in all specifications. The sex ratio is defined as the ratio of males to females aged 16-25 with a sample mean of 1.06.

Table 4: First Stage Regressions of the IV-Estimations

	Dependent variable: Sex ratio (16-25)			
	(1)	(2)	(3)	(4)
Instrumental variables (lagged 17-26 years)				
Family planning science and technology research institute	0.028***	0.028***	0.029***	0.027***
	(0.007)	(0.006)	(0.006)	(0.006)
Family planning education center	0.040***	0.035**	0.034**	0.035**
	(0.013)	(0.014)	(0.015)	(0.015)
Family planning association	0.046***	0.036***	0.035***	0.036***
	(0.008)	(0.009)	(0.009)	(0.009)
Control variables				
ln(per capita income)		0.031***	0.032***	0.028***
		(0.008)	(0.008)	(0.008)
Employment rate (%)		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Secondary school enrollment (%)		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Inequality			0.000	-0.000
			(0.004)	(0.004)
Urbanization rate (%)			-0.000	-0.000
			(0.000)	(0.000)
ln(welfare expenditures)				-0.008*
				(0.005)
Joint F test of IVs				
F-statistics	44.87	32.38	28.82	27.65
p-values	<0.001	<0.001	<0.001	<0.001
Observations	442	442	442	442
Number of provinces	26	26	26	26
R-squared	0.76	0.76	0.76	0.77

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The dependent variable in all specifications is the 16-25 sex ratio (males to females) with a sample mean of 1.06. Year- and province-fixed effects are included in all specifications. See Figure A1 for the distributions of the three instrumental variables.

Table 5: IV Estimates of the Effect of Sex Ratios on Crime Rates in China, 1988-2004

	Dependent variable: ln(crime rate)			
	(1)	(2)	(3)	(4)
Sex ratio (16-25)	2.174***	1.939*	3.047***	3.041***
	(0.828)	(1.002)	(1.010)	(1.023)
ln(per capita income)		0.005	0.043	0.017
		(0.119)	(0.101)	(0.099)
Employment rate (%)		-0.007**	-0.004	-0.005
		(0.003)	(0.003)	(0.003)
Secondary school enrollment (%)		0.002	0.003	0.003
		(0.003)	(0.003)	(0.003)
Inequality			0.138**	0.135**
			(0.056)	(0.056)
Urbanization rate (%)			0.008***	0.007***
			(0.003)	(0.003)
ln(welfare expenditures)				-0.058
				(0.041)
Hausman overidentification test:				
Test statistics (chi-squared)	1.365	1.647	0.176	0.178
Critical value (5%)	5.99	5.99	5.99	5.99
Observations	442	442	442	442
Number of provinces	26	26	26	26

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The sex ratio variable is defined as the ratio of males to females aged 16-25 with a sample mean of 1.06. Year- and province-fixed effects are included in all specifications. See Figure A1 for the distributions of the three instrumental variables.

Table 6: IV Estimates of the Effect of Sex Ratios on Crime Rates in China, 1988-2004 (robustness tests)

	Dependent variable: ln(crime rate)			
	(1)	(2)	(3)	(4)
Sex ratio (16-25)	2.924***	3.325***	3.062***	3.365***
	(1.071)	(1.018)	(0.970)	(1.127)
ln(per capita income)	0.017	-0.007	-0.010	-0.028
	(0.100)	(0.097)	(0.095)	(0.103)
Employment rate (%)	-0.005	-0.003	-0.002	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)
Secondary school enrollment (%)	0.003	0.003	0.004	0.003
	(0.003)	(0.003)	(0.003)	(0.002)
Inequality	0.142**	0.134**	0.109**	0.110**
	(0.055)	(0.055)	(0.048)	(0.047)
Urbanization rate (%)	0.007**	0.007**	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
ln(welfare expenditures)	-0.057	-0.061	-0.048	-0.039
	(0.041)	(0.041)	(0.042)	(0.042)
ln(police expenditures)	0.078	0.062	0.084	0.032
	(0.088)	(0.087)	(0.088)	(0.090)
Immigration rate (‰)		0.025*	0.028**	0.031**
		(0.013)	(0.013)	(0.013)
Age 16-25 (%)			0.027***	0.034***
			(0.008)	(0.009)
Age 0-14 (%)				0.009
				(0.009)
Age 65- (%)				0.055***
				(0.021)
Hausman overidentification test:				
Test statistics (chi-squared)	0.178	0.178	0.178	0.089
Critical value (5%)	5.99	5.99	5.99	5.99
Observations	442	442	442	442
Number of provinces	26	26	26	26

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The sex ratio variable is defined as the ratio of males to females aged 16-25 with a sample mean of 1.06. Year- and province-fixed effects are included in all specifications. See Figure A1 for the distributions of the three instrumental variables.

Table 7: IV Estimates of the Effect of Sex Ratios on Crime Rates in China, 1988-2004 (robustness tests)

	Dependent variables		
	ln(corruption rate)	ln (crime rate)	ln (crime rate)
	(1)	(2)	(3)
Sex ratio (16-25)	-0.134		4.638***
	(1.817)		(1.398)
Sex ratio (10-15)		-0.778	-0.901
		(1.561)	(1.451)
ln(per capita income)	0.144	0.219	0.055
	(0.189)	(0.145)	(0.147)
Employment rate (%)	0.006	-0.008*	-0.007*
	(0.004)	(0.004)	(0.004)
Secondary school enrollment (%)	-0.002	0.005	0.006
	(0.003)	(0.004)	(0.004)
Inequality	-0.218***	0.180***	0.155***
	(0.060)	(0.065)	(0.058)
Urbanization rate (%)	0.004	-0.001	0.007
	(0.005)	(0.005)	(0.006)
ln(welfare expenditures)	0.153*	-0.035	0.012
	(0.078)	(0.058)	(0.060)
Hausman overidentification test:			
Test statistics (chi-squared)	1.602	1.088	1.254
Critical value (5%)	5.99	5.99	5.99
Observations	442	338	338
Number of provinces	26	26	26

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The sex ratio (16-25) is defined as the ratio of males to females aged 16-25, and the sex ratio (10-15) is defined as the ratio of males to females aged 10-15. The mean of the sex ratio is 1.06 (for ages 16-25) and 1.08 (for ages 10-15) respectively. Columns 2-3 also have fewer observations because of missing values for the 10-15 sex ratio. See Figure A1 for the distributions of the instrumental variables. Columns 1 uses the three program variables (lagged 17-26 years) as IVs; column 2 uses the three program variables (lagged 11-16 years) as IVs; column 3 uses both sets of variables as IVs.

Table A1: Summary Statistics of Variables (N=442)

Variables	Mean	Standard deviation	Min	Max
Crime rate (number of arrests per 10,000 population)*	5.351	1.653	0.816	13.042
Corruption rate (number of corruption cases per 10,000 population)	0.460	0.215	0.086	1.515
Sex ratio (the ratio of males to females 16-25 projected by the 1990 census)	1.059	0.029	0.984	1.131
Real per capital income (RMB 1,000 at 2000 prices)	2.702	1.093	0.993	8.005
Employment rate (% employed of 16-65 year olds)	67.427	9.060	46.816	97.961
Inequality (the ratio of urban per capita income to rural per capita income)	2.721	0.705	1.528	5.159
Urbanization rate (% of population living in urban areas)	29.934	11.086	13.113	56.011
Secondary school enrollment rate (%)	87.859	11.177	39.6	100
Welfare expenditures share (% of government expenditures)	2.454	0.772	1.032	11.412
Police expenditures share (% of government expenditures)	5.372	1.316	2.588	9.245
Immigration rate (‰ of cross provincial immigrants)	2.196	1.283	0.310	8.680
Age 16-25 years old (% of population)	20.453	3.906	13.948	33.811
Age 0-14 years old (% of population)	25.924	4.655	13.892	36.739
Age 65 and above (% of population)	6.348	1.518	2.967	11.495
Age of provincial party secretary	60.760	4.735	48.5	73
Provincial party secretary was a college graduate	0.515	0.406	0	1
Central connection of provincial party secretary	0.269	0.358	0	1

*Violent and property crimes. A non-exhaustive list includes: homicide, assault, robbery, rape, abduction of women and children, larceny, fraud, and smuggling.

Data sources: *China Population Statistical Yearbooks, 1989-2005; China Statistical Yearbooks, 1989-2005; China Population Statistical Data and Material By Provinces and Cities, 1992-2004; Comprehensive Statistical Data and Materials on 55 Years of New China; Chinese Population Census (1982, 1990), 1% Sample; Law Yearbook of China, 1989-200; Procuratorial Yearbook of China, 1989-2005*

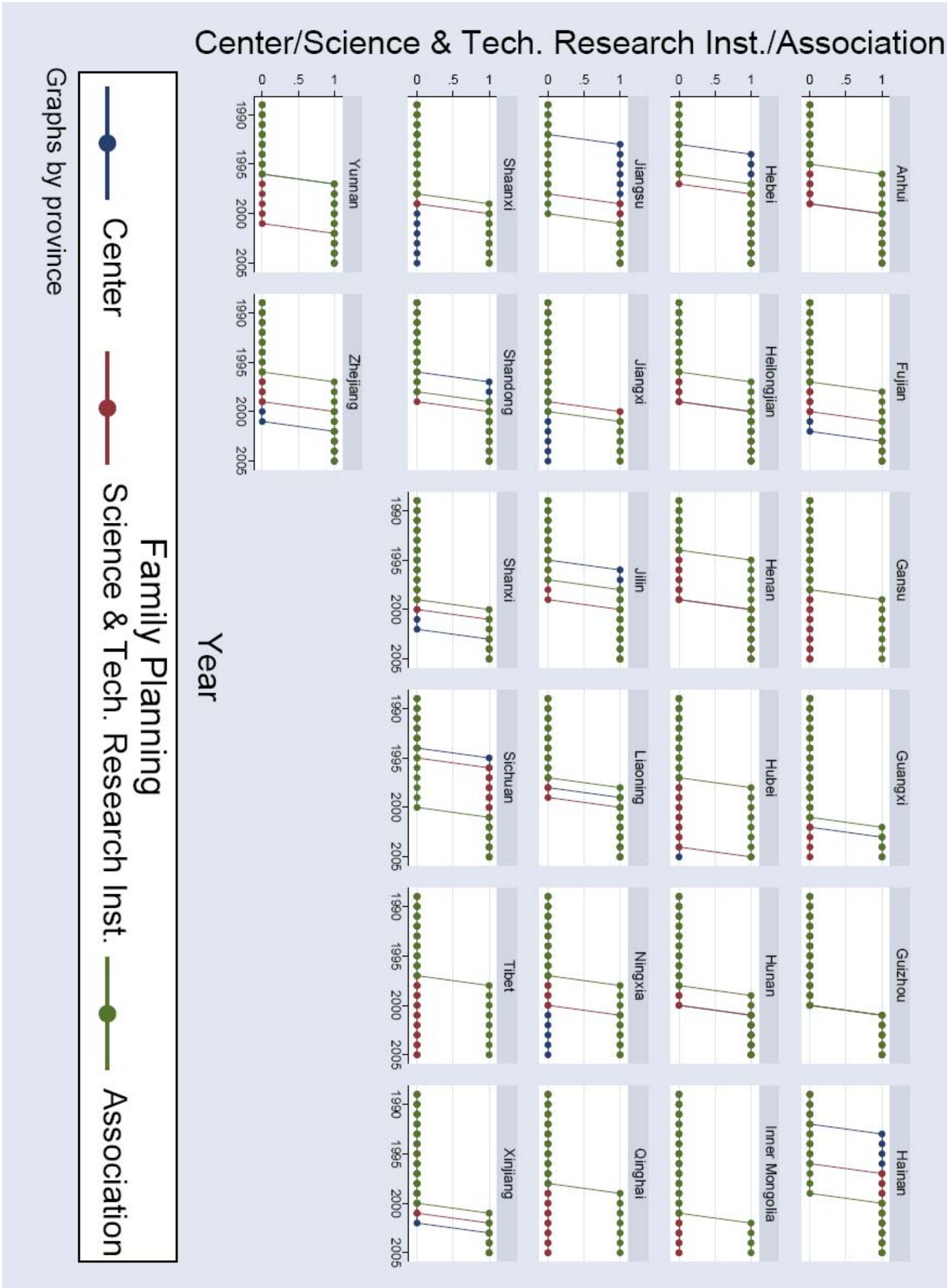


Figure A1: Program roll-out, by Province and Year of Implementation+17

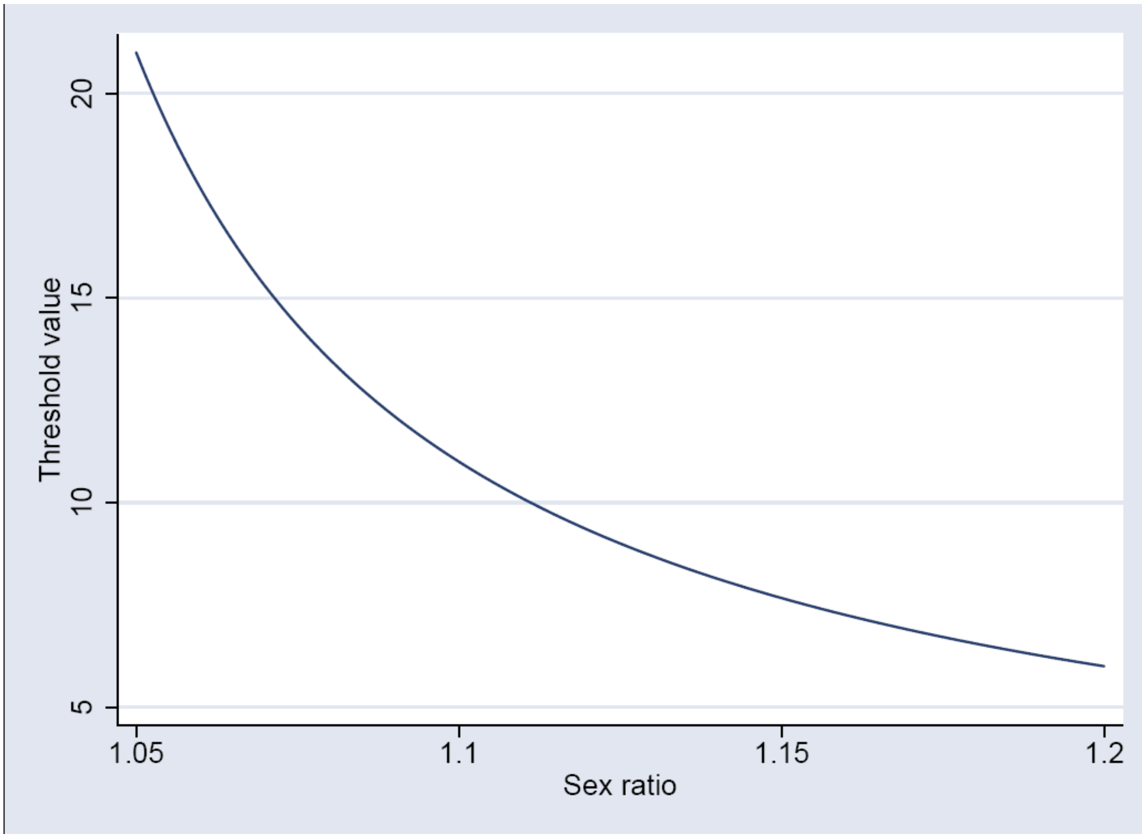


Figure A2: Ratio of males to unmarried males implied by the sex ratio