Original Article

Does daughter deficit promote paternal substance use? Evidence from China

Xi Chen[1,2]

[1]Department of Health Policy and Management, Yale School of Public Health, New Haven, CT, USA; [2]Department of Economics, Yale University, New Haven, CT, USA

Correspondence to: Xi Chen. Department of Health Policy and Management, Yale School of Public Health, Laboratory of Epidemiology and Public Health, 60 College St, New Haven, CT 06510, USA. Email: xi.chen@yale.edu.

Background: China and various other countries have experienced unbalanced sex ratios in the marriage market, which triggers intense competition and pressure to get married. Meanwhile, China has more smokers and drinkers than any other countries in the world. This paper provides evidence on smoking and alcohol use as a stress coping strategy for the competitive marriage market.

Methods: This paper utilizes two household longitudinal datasets from rural China—a national survey and a regional survey—to examine paternal substance use in response to skewed sex ratios of their children's generation. The longitudinal feature of the two datasets enables us to explore within household variation in smoking and alcohol use. Sex ratios are matched using a 1% sample of the 2000 China Population Census.

Results: Strikingly, paternal smoking and alcohol use are more intense for families with a son living in communities with higher sex ratios. In contrast, those with a daughter do not demonstrate this pattern. Coping with the marriage market pressure is a plausible pathway linking the observed skewed sex ratios and intense substance use.

Conclusions: High male-to-female sex ratios promote smoking and alcohol drinking among fathers with sons. Considering the highly competitive marriage market in the coming decade and the prevalent substance use that generates lasting health impacts and large negative externalities to society, policies that address the skewed sex ratios could lead to substantial welfare gains.

Keywords: Skewed sex ratios; marriage market; substance use; smoking, alcohol use

Introduction

Substance use, such as smoking and alcohol use, spreads widely in the world. Such behavior is addictive, imposes long term negative health impacts and even a large number of premature deaths (1,2), impairs labor market performance (3), raises negative externalities within society through accidents (4), increases the use of public health care and addiction treatment services (5), child abuse (6) and partner abuse (7), and violence and crime (8,9).

Some countries in the world have cultural norms that value male children over female children and therefore experience skewed sex ratios, especially in China, Korea,

India, Pakistan, the Caucasus, and Southeast Europe. This paper aims to examine how a large number of excess men in the marriage market affects smoking and alcohol use. We focus on China as it has more smokers and consumes more alcohol than any other countries. Understanding and suppressing the determinants of substance use could lead to substantial health improvement for China and the world.

The widely available ultrasound technology in recent decades and the ingrained culture of son preference, together with one of the most radical birth control policies in history, lead to highly skewed sex ratios favoring women in China. According to the China Population Census, sex ratio at birth (SRB) in China has increased from 106.32 in

1975 to 118.06 in 2010 (10). Moreover, the 2000 population census and a 1% 2005 population census indicate that rural areas possess more skewed sex ratios compared to their urban counterparts (11). The number of excess Chinese men under age 20 exceeded 32 million in 2005, greater than the entire male population of Italy or Canada (12).

Skewed sex ratios widen the dispersion of marriage market rewards. Faced with the pressure to get married, men tend to invest more in education, spend more on positional goods, throw extravagant wedding parties, pay high bride prices and build fancy houses for marriage, which occupy a great proportion of lifetime income. However, almost none of these expenses are incurred by the brides' families (13). To make ends meet, men have to work harder and take riskier jobs (14-16). Meanwhile, the savings rate for grooms' families peak in the year before the wedding, while it is almost always lower for brides' families (17).

Consequently, substance use can be promoted as a stress coping strategy among the grooms' families. In contrast, brighter prospects for marriage among females reduce the occurrence of a number of substance use behaviors (18). For example, nicotine is a psychoactive (mood altering) drug, and tobacco use may make the subjective effects of stress (such as feelings of frustration, anger, and anxiety) less severe (19). Psychological studies link increasing psychosocial strain with more excessive use of alcohol to self-medicate anxiety disorders (20,21).

Built on (22), we study substance use in response to skewed sex ratios in rural China. Compared to (22), this paper further examines alcohol drinking in response to skewed sex ratios. These additional evidence supports our previous findings and suggests that child sex ratios may affect parents to a larger extent and involve more behavior changes.

To the best of our knowledge, the contributions of this paper involve three aspects: this is among the first studies to examine the causal link between sex ratios and substance use as well as its differential gender responses; it is the first time that parental alcohol use in response to skewed sex ratios is investigated; our data are composed of a rich survey distinguishing tobacco products of different visibility, enabling us to explore the potential status signaling mechanism that promotes substance use.

We focus on comparing families with the first child being a son versus being a daughter. Much evidence suggests that there are very few gender selections at the first birth parity in rural China: no strict fertility control policy has been implemented for ethnic minorities in China (23); sex

selections at the first birth are low in rural areas, where more than one child is allowed; sex ratio for the 1st birth parity has been almost constant over time (24); mothers who are faced with different fertility policies at the 1st birth demonstrate similar SRB (24); SRB by parity shows that the availability of ultrasound does not affect the 1st birth but higher parities (25); Chinese parents generally prefer 1 daughter 1 son to 2 sons. Moreover, evidence also suggests that endogenous fertility decisions on the first-born child may not be a concern in our rural sample: regressing the number of children (or whether stopping at the second child) on household minority status finds no significant results, suggesting that both ethnic minorities and the major Han group are not subject to binding fertility control policy; summary statistics indicate that sex ratios at the 1st birth parity are similar to the natural rate (24).

The empirical investigations in this paper focus on paternal smoking and alcohol use for at least three reasons. First, smoking and alcohol use by men is deeply ingrained in Chinese culture, while there have been strong social norms against women smoking and drinking alcohol. In China, men smoke at a much higher rate than women (53% *vs.* 2% in 2010) (26) and drink 13.4 times more than women (27). Second, men are the major income earners in most Chinese families and thus naturally bear much of the financial burden in preparation for children's marriage. Third, substance use among sons tends to be both motivated by the pressure to get married and suppressed due to their weak bargaining power to smoke in the marriage market that favors women. Fortunately, the latter is irrelevant when we investigate paternal substance use, which gives us a cleaner identification of the marriage market pressure.

Our results suggest that fathers with a son in the competitive marriage market favoring females smoke more and consume more alcohol, especially for the poor. In contrast, those with a daughter do not demonstrate this pattern. Compared to income effect and status seeking motives, coping with the marriage market pressure is a more plausible pathway linking the observed unbalanced sex ratios and the intensified substance use. The placebo test using sex ratios of less relevant age cohorts and the growing marginal effects as a son approaches the marriage age all suggest that our identified effect is likely to be causal.

The rest of the paper is organized as follows. Section 2 reviews the investigated consequences of skewed sex ratios in the literature. Section 3 introduces study design and data collection for this paper and documents basic trends from the data. We also lay out the empirical model. Section

4 presents the main results, placebo tests, robustness, and discusses the potential mechanisms. Finally, section 5 concludes.

Skewed sex ratios and marriage: a brief review

The most direct effect of skewed sex ratios is on the marriage market. Empirical results are largely consistent with the theories that high sex ratios increase female bargaining power in the marriage market. High male-to-female sex ratios promote the likelihood of female marriage and discourage their labor force participation (28). The 2005 inter-census China national survey shows sizable surplus Chinese men in the marriage market (12). Using the national census data, a study documents that there were 22 million more men than women in cohorts born between 1980 and 2000 (11). Based on their simulations, about 10.4% of these additional men will fail to marry. Therefore, high male-to-female sex ratios may bear severe consequences through more intense marriage market competition. It induces males to work longer hours, take more risky jobs, and save competitively to amass more assets (16,17,29).

Some studies document the relationship for skewed sex ratios, marital status and intensified psychological distress between the married and unmarried people, while others examine the depressive consequences of economic hardship, social isolation and parental responsibilities that unmarried people are especially vulnerable and exposed to Pearlin and Johnson (30). Barber provides evidence on family conflict and aggression across many countries (31), and Edlund *et al.* offers such evidence from China (32). The economic and physical well-being of men who divorce or fail to marry should be of special concern. The mortality rate of the unmarried males has been higher than unmarried females and all those married, and their excess mortality rate has been increasing in a large number of developed countries over the past decades (33).

Though the impact of skewed sex ratios on stress and stress-related illness is studied, very few studies investigate its impact on stress coping behavior, especially its impact on the behavior and well-being of the parental generation.

Little attention is paid towards gender differential responses to unbalanced sex ratios, the focus of this paper. Compared to the existing literature, different mechanisms, such as income effect, stress, and status signaling, are further distinguished.

Methods

Study design and data

We utilize two household longitudinal datasets from rural China—a census-type survey in Guizhou province between 2004 and 2009 and a national survey in nine provinces between 1991 and 2009—to examine paternal substance use responses, such as tobacco and alcohol use, to skewed sex ratios. The national sample of the China Health and Nutrition Survey (CHNS) covers a wide range of nationally representative counties. We follow the literature to link the survey with sex ratios at the county level based on a 1% sample of the 2000 China Population Census. Though the Guizhou survey only covers villages in one county, its census feature allows us to accurately gauge sex ratios at the village level, which can be an appropriate measure of localized marriage market competition in impoverished rural China[1].

For the purpose of this study, the rural sample of the CHNS is employed. The CHNS covers nine provinces in China that vary substantially in geography and economic development. Each province is drawn following a multistage, random cluster process. Stratified by income, a weighted sampling scheme was used to randomly select four counties in each province. Villages and townships within the counties were selected randomly. There are about 18,000 individuals in some 4,200 rural households surveyed. We utilize the information on cigarette consumption per day and liquor drinks per week in seven waves of the survey between 1991 and 2009. *Table 1* suggests that around half of the fathers smoke, and their smoking rate increases slightly from 49% to 53% in 2004–2009. The average number of cigarettes consumed per day increases from 5.38 to 6.32 between 2004 and 2009, while alcohol consumption rises from 233.5 to 292 gram in the same period.

We merge the survey with sex ratios at the county

---

[1] The marriage market competition can be quite localized. More than half of the marriages in the Guizhou survey are within villages (*Table S1*). It has been well documented that grooms' families build fancy houses and spend lavishly in social events to signal to local matchmakers and improve the relative standing in the local marriage market (Brown *et al*. 2011). More generally, village reference groups are the most salient for residents living in close proximity in rural China (34).

Table 1 Summary statistics for key left-hand side variables

Variables	Mean	Standard deviation
Guizhou sample		
Dummy for paternal smoking in 2004	0.46	0.35
Dummy for paternal smoking in 2006	0.52	0.36
Dummy for paternal smoking in 2009	0.54	0.39
Paternal tobacco consumption expenses in 2004	265.39	293.81
Paternal tobacco consumption expenses in 2006	387.86	540.21
Paternal tobacco consumption expenses in 2009	536.44	709.43
Paternal homemade tobacco consumption in 2004 (in 50 g)	30.96	34.28
Paternal homemade tobacco consumption in 2006 (in 50 g)	26.82	35.47
Paternal homemade tobacco consumption in 2009 (in 50 g)	27.15	37.82
Paternal alcohol consumption expenses in 2004	281.89	327.48
Paternal alcohol consumption expenses in 2006	423.77	613.60
Paternal alcohol consumption expenses in 2009	587.85	764.55
China Health and Nutrition Survey (CHNS) national sample		
Dummy for paternal smoking in 1991–2009	0.52	0.51
Dummy for paternal smoking in 2004	0.49	0.50
Dummy for paternal smoking in 2006	0.51	0.50
Dummy for paternal smoking in 2009	0.53	0.50
Paternal tobacco consumption in 1991–2009 (# cigarettes per day)	5.32	7.42
Paternal tobacco consumption in 2004 (# cigarettes per day)	5.38	8.02
Paternal tobacco consumption in 2006 (# cigarettes per day)	5.66	7.53
Paternal tobacco consumption in 2009 (# cigarettes per day)	6.32	8.25
Paternal alcohol consumption in 1991–2009 (# 50 g per week)	4.54	10.40
Paternal alcohol consumption in 2004 (# 50 g per week)	4.67	10.01
Paternal alcohol consumption in 2006 (# 50 g per week)	5.73	11.54
Paternal alcohol consumption in 2009 (# 50 g per week)	5.84	12.65
Paternal life satisfaction (1= least satisfied, 5= most satisfied)	3.97	0.85
Paternal happiness (1= least happy, 5= most happy)	3.17	0.71

Author's Guizhou household survey data [2004–2009]; CHNS household survey data [1991–2009].

level based on a 1% sample of the 2000 China Population Census. The county level sex ratios increase from 109 to 118 males (per 100 females) between 1991 and 2009 (*Tables 1,2*). Together with the worsening skewed sex ratios, their standard deviations increase as well, suggesting that the gender gap among counties may widen. The population census data suggests that the national average county sex

ratios at the 1st, 2nd and 3rd birth parities are 108.4, 143.2 and 152.9, respectively.

Figure 1 plots the positive relationship between sex ratios and paternal tobacco and alcohol consumption and distinguishes the relationship by child gender composition. Families with one son and no daughter show a positive association between sex ratios and tobacco and alcohol

Table 2 Summary statistics for key right-hand side variables

Variables	Mean	Standard deviation
Sex ratios inferred from a census-type survey in Guizhou		
Sex ratio for the age cohort 5–19 average over 2004–2009	1.16	0.08
Sex ratio at first birth (# males per female)	1.06	0.14
Sex ratio at second birth (# males per female)	1.20	0.15
Sex ratio at third birth (# males per female)	1.39	0.15
Sex ratios inferred from a 1% sample of the 2000 China Population Census		
Sex ratio for the age cohort 10–19 in 1991 (# males per female)	1.09	0.16
Sex ratio for the age cohort 10–19 in 1993 (# males per female)	1.09	0.16
Sex ratio for the age cohort 10–19 in 1997 (# males per female)	1.10	0.16
Sex ratio for the age cohort 10–19 in 2000 (# males per female)	1.12	0.16
Sex ratio for the age cohort 10-19 in 2004 (# males per female)	1.13	0.17
Sex ratio for the age cohort 10–19 in 2006 (# males per female)	1.17	0.20
Sex ratio for the age cohort 10–19 in 2009 (# males per female)	1.18	0.20
Sex ratio at first birth (# males per female)	1.08	0.12
Sex ratio at second birth (# males per female)	1.43	0.12
Sex ratio at third birth (# males per female)	1.53	0.12

The sex ratios for the age cohorts 10–19 in 1991, 1993, 1997, 2004, 2006 and 2009 are respectively inferred from the age cohorts 19–28, 17–26, 13–22, 6–15, 4–13, 1–10 in the 2000 population census. Sex ratios are defined as number of males per female. Author's Guizhou household survey data [2004–2009]; CHNS Data [1991–2009]; a 1% sample of the 2000 China Population Census.

consumption, especially when sex ratios are more biased favoring females. However, no clear association is found for families with one daughter and no son.

Figure 2 compares tobacco and alcohol consumption patterns among households along the income distribution. We distinguish between families with a son and those with a daughter, and families living in high sex ratio counties and those living in low sex ratio counties. The two types of counties are categorized by their sex ratios relative to the median level in our sample. The overall increase in smoking and alcohol consumption in relation to income may capture a positive income effect. The two left figures suggest that poor families with a son living in high sex ratio counties smoke more and drink more alcohol, while the intensity is much lower for their poor counterparts living in counties with low sex ratios. This may suggest that these families are especially stressed and are less capable of coping with the marriage market pressure. However, in the right figures no similar pattern is found for families with a daughter.

Moreover, families living in high sex ratio counties with a son demonstrate significantly higher smoking and alcohol consumption intensity (left figures of *Figure 2*) than those with a daughter (right figures of *Figure 2*), while a comparison between the two types of families in low sex ratio counties generates no distinct pattern. The findings in *Figure 2* consistently suggest that the marriage market pressure can be explicitly distinguished from other factors, such as income and demographic effect.

We also utilize a three-wave Guizhou survey administered between 2004 and 2009. Though the survey has a limited geographic scope, it covers all households and their members in 26 randomly selected villages. The rich information on both manufactured tobacco products and homemade tobacco products (*Table 1*) helps us distinguish other potential motives from status seeking in driving smoking and alcohol use. *Table 2* indicates that the village level sex ratios at the 1st, 2nd and 3rd birth parities in our sample are 106.0, 119.7 and 138.9, respectively.

This study only used secondary data sets and was approved by the Institutional Review Board (IRB) at Yale University (IRB Protocol ID: 2000021280). The IRB examined the project for potential ethics issues and
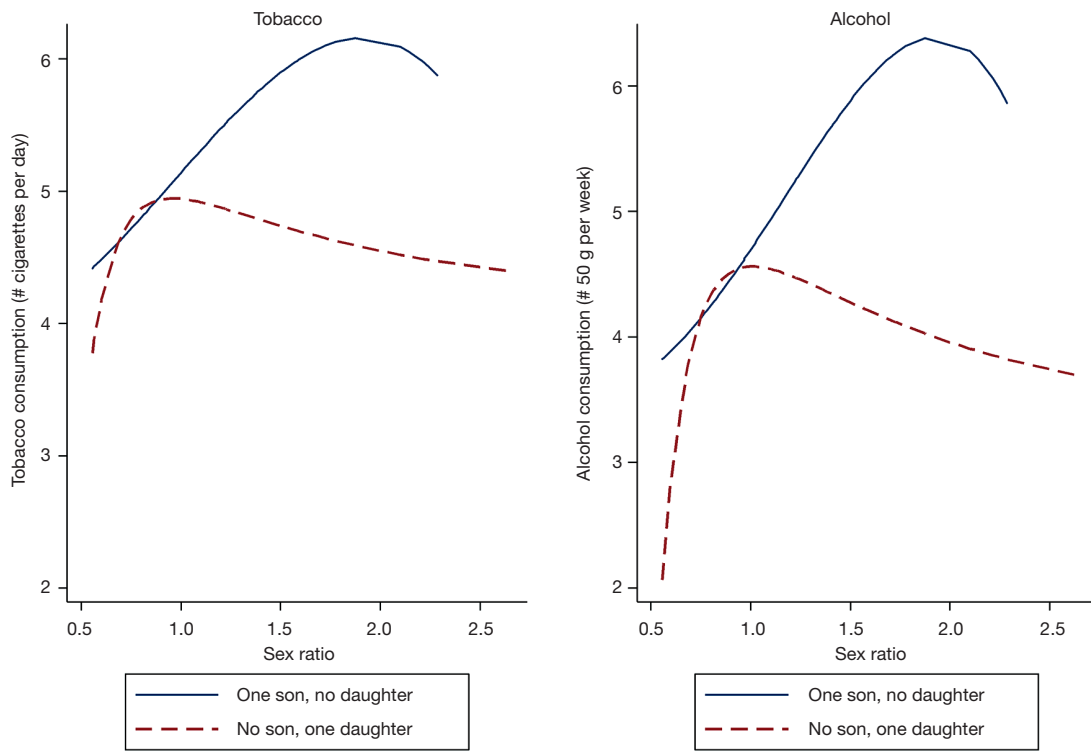
Figure 1 Sex ratios and Tobacco & Alcohol consumption, by child gender composition.
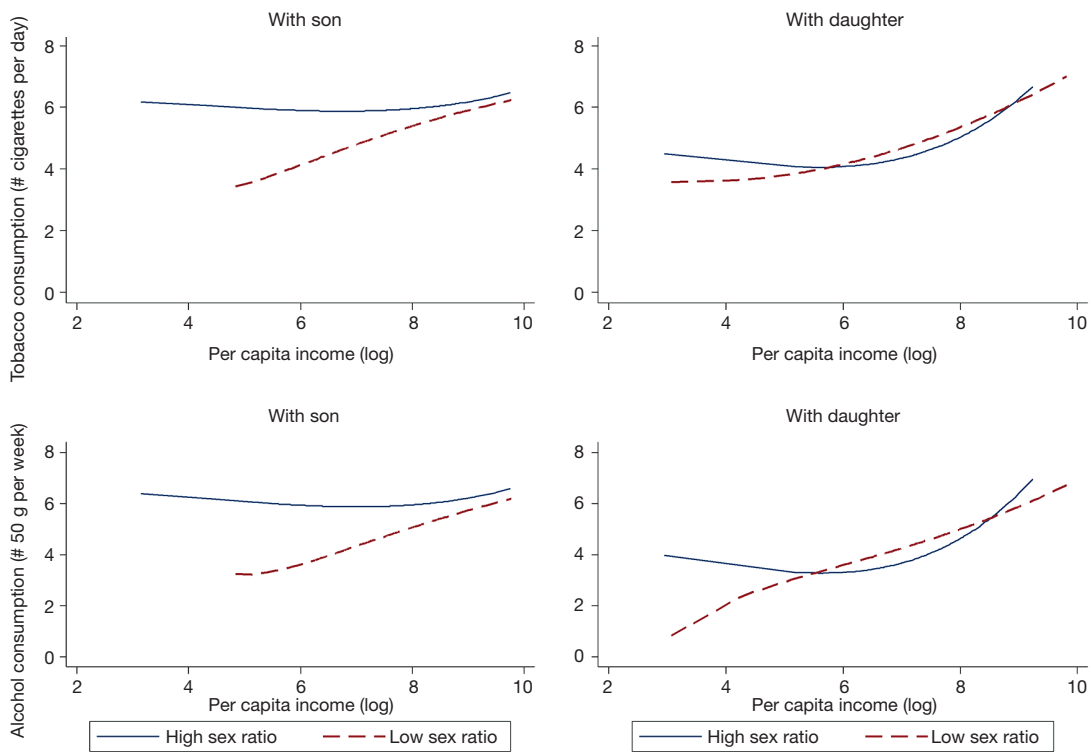

Figure 2 Paternal Tobacco and Alcohol consumption by income.

approved the whole study, including methods and consent.

The empirical model

To maximize comparability, we restrict our analysis to nuclear families with mother younger than 40 and both parents still alive. To distinguish families with a son from those with a daughter and families with a different number of children, the first column for each outcome variable in *Table 3* is estimated as:

$$y_{ijt} = \alpha_1 sexratio_{jt} + \beta_1 son1st_{ij} + \gamma_1 sexratio_{jt} * son1st_{ij} + X_{ijt}\Gamma + \mu_i + \nu_t + e_{ijt} \qquad [1]$$

where i denotes family; j represents county (for the CHNS data) or village (for the Guizhou survey); t is year. $sexratio_{jt}$ is sex ratio at the county level (for the CHNS data) or the village level (for the Guizhou survey), and $son1st_{jt}$ is a dummy variable equals one when the first child of the family is a son. y_{ijt} denotes four outcome variables for fathers, including expenditures on tobacco use and alcohol use in the Guizhou survey and number of cigarettes one smoke per day and grams of liquor drinks per week in the CHNS. Only outcomes that capture the intensive margin of tobacco use and alcohol drinking are investigated since people tend to form the habit of smoking or alcohol drinking at a younger age and thus are less likely to change this decision.

X_{ijt} are covariates, including price of cigarettes at the village level (in USD), household income per capita (in USD), fathers' years of education, household head's gender and age, marital status (dummy), shares of the elderly and the youth (percentage), household size (number of members), major diseases (dummy), and ethnicity (dummy). ν_t denotes year fixed effects, and μ_i represents household fixed effects. Since our main interested variables, i.e., tobacco and alcohol consumption, may reflect individual habit and local norms, our estimations utilizing within-household variation in consumption should mitigate these concerns.

Releasing the assumption that paternal inclination to engage in such behavior is identical regardless of the sex composition of children, we estimate the equation (II) for nuclear families with a son (the second columns) and those with a daughter (the third columns) in *Table 3*.

$$y_{ijt} = \alpha_1 sexratio_{jt} + X_{ijt}\Gamma + \mu_i + \nu_t + e_{ijt} \qquad [2]$$

Results

Main results

The first set of results using the CHNS is reported in *Table 4*. The first column for each outcome variable uses sex ratios of 5–19 age cohorts. The second column through the fourth column for each outcome variable adopt sex ratios of 5–9, 10–14, and 15–19 age cohorts, respectively. Sex ratios of the 15–19 age cohort capture a more significant effect. Because most sampled households have one or two children, most families in the 5–9, 10–14, and 15–19 age cohorts do not overlap, and the marginal effect of the first column (age cohort 5–19) is close to the sum of the effects of the other three age cohorts.

Restricting the sample to households with no more than two children, the first column for each outcome variable in *Table 3* suggests that having a son first does not affect paternal substance use. However, the combination of having a son and living in a community with more skewed sex ratios is associated with more smoking and alcohol drinking among fathers (*Table 3*). The second and third columns for each outcome variable in *Table 3* suggest more substance use among nuclear families with a son, while no such pattern is found for those with a daughter.

The marriage market pressure is expected to exert a bigger impact on households with a son approaching marriage age. Using the CHNS, we estimate the equation (I) with various age cohorts from 1–5 to 26–30 to gauge the heterogeneous effects and draw their marginal effects in *Figure 3*. The growing marginal effects of the interaction term (sex ratio * first child being son) suggest that the marriage market pressure becomes more intensified as a son grows up. Though the small sample size in the Guizhou survey prohibits us from testing heterogeneous effects, a separation into 1–11 and 12–19 age cohorts[2] suggests that the 12–19 cohorts demonstrate a much higher marginal effect than the 1–11 cohorts.

Robustness of the main findings

First, the number of children in a household might be an

---

[2] In rural Guizhou province, families with boy reaching 12 hold a coming-of-age ceremony, signaling to the community that the boy grows up into the marriage age.

Table 3 Main results: sex ratios, family composition and paternal substance use—smoking and alcohol use

| Variables | Guizhou sample | | | | | | China Health and Nutrition Survey (CHNS) national sample | | | | | |
| | Ln (Tobacco consumption expenditure) | | | Ln (Alcohol consumption expenditure) | | | Ln (# cigarettes smokes per day) | | | Ln (# 50 Gms liquor drinks per week) | | |
	One or two children	One son	One daughter	One or two children	One son	One daughter	One or two children	One son	One daughter	One or two children	One son	One daughter
Sex ratio for age cohort 5–19	−0.128	0.763***	0.046	−0.215	1.069**	0.219	−0.211	1.289***	−0.286	0.003	1.082***	0.161
	(0.520)	(0.000)	(0.842)	(0.441)	(0.041)	(0.558)	(0.133)	(0.278)	(0.226)	(0.162)	(0.535)	(0.198)
Sex ratio* first child being a son	0.946*			1.303*			2.335***			2.356***		
	(0.079)			(0.076)			(0.330)			(0.371)		
Year FEs, village/county FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R2	0.123	0.141	0.094	0.102	0.124	0.087	0.465	0.425	0.483	0.307	0.331	0.283
AIC	3,614.98	693.94	500.97	3,943.59	778.78	568.97	2,119.04	6,057.94	2,882.86	2,860.18	8,320.58	2,641.97
N	1,261	310	250	1,261	310	250	15,380	3,407	4,136	14,506	3,821	4,113

*, 10% significance level; **, 5% significance level; ***, 1% significance level. Author's Guizhou household survey data [1991–2009], and 1% sample of the 2000 China Population Census; to facilitate comparison with new findings in columns [1–6] and [10–12], columns [7–9] are drawn from *Table 3 Panel A* (22). (I) All covariates follow *Table 4*; (II) left panel (Guizhou sample): sex ratios are measured at the village level using the 26-village census-type survey. The Cameron-Gelbach-Miller [2011] bootstrapping method is adopted to address the issue of small number of clusters, and adjusted P values are presented in the brackets; (III) right panel (CHNS national sample): sex ratios are measured at the county level using a 1% sample of the 2000 China Population Census data. Robust standard errors, clustered at the county level, are presented in the brackets.

Table 4 Baseline results: sex ratios and paternal substance use—smoking and alcohol use

Variables	Ln (# cigarettes smokes per day)				Ln (# 50 Gms liquor drinks per week)			
	5–19 years	5–9 years	10–14 years	15–19 years	5–19 years	5–9 years	10–14 years	15–19 years
Sex ratio	0.541***	0.090	0.115*	0.104**	0.602***	0.100	0.131*	0.113**
	(0.128)	(0.060)	(0.061)	(0.047)	(0.149)	(0.072)	(0.072)	(0.050)
Adjusted R2	0.443	0.422	0.372	0.328	0.287	0.298	0.273	0.269
AIC	8,310.47	8,282.45	8,300.67	8,340.37	9,006.12	8,970.62	8,991.91	9,034.38
N	21,321	21,321	21,321	21,321	20,088	20,088	20,088	20,088

Sex ratios are measured at the county level using a 1% sample of the 2000 China Population Census data. Sex ratios in columns [1–4] are calculated for 5–19, 5–9, 10–14, 15–19 age cohorts, respectively. A rich set of covariates are controlled for, i.e., price of cigarettes at the village level (in USD), household income per capita (in USD), fathers' years of education, household head's gender and age, marital status (dummy), shares of the elderly and the youth (percentage), household size (number of members), major diseases (dummy), ethnicity (dummy), year fixed effects and household fixed effects. Robust standard errors, clustered at the county level, are presented in the brackets. *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. CHNS household survey data [1991–2009]; to facilitate comparison with new findings in columns [5–8], columns [1–4] are drawn from *Table 4* (22).
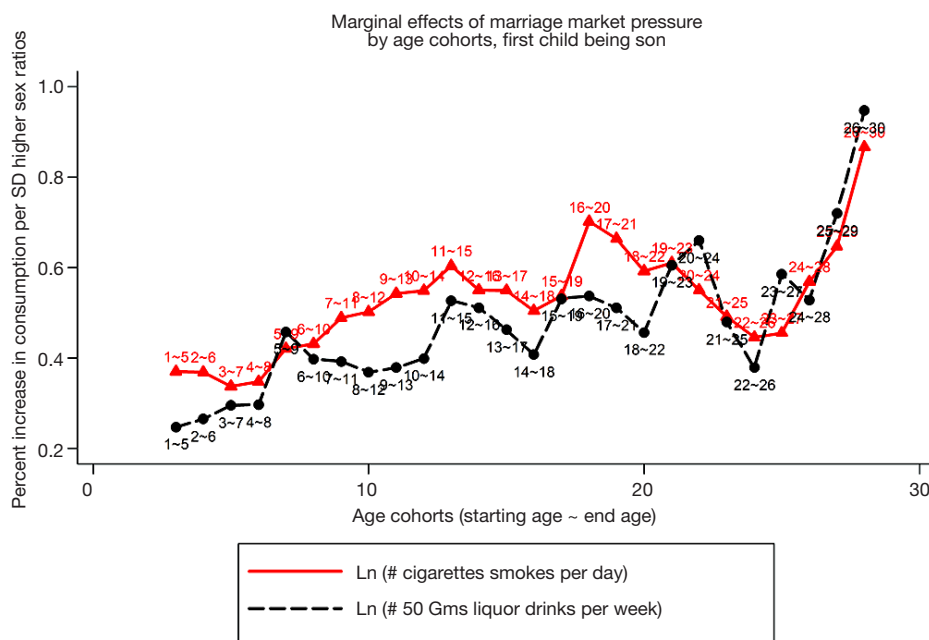
Figure 3 Marginal effects of marriage market pressure.

endogenous choice of the parents. Therefore, in *Table S2* we check using the Heckman two-step estimations that model the parental fertility choice to stop at one child. Following (16), we use the minority status of the household, the age of the first child and whether the first child is disabled or suffers from major diseases as the exclusive variables in the selection equation of whether parents stop at the first child. The main equations for nuclear families

with the first child being a son still maintain statistical significance, while no such result is obtained for nuclear families with first child being daughter.

Second, *Table 5* shows the result of a falsification test that replaces the sex ratios (age cohort 5–19) best capturing the mating competition by sex ratios of less relevant age cohorts [30–40]. The effects disappear and even change signs, indicating that the combination of having an unmarried son

Table 5 Falsification test: using sex ratios for age cohort 30–40

Variables	Ln (# cigarettes smokes per day)			Ln (# 50 Gms liquor drinks per week)		
	One son	One daughter	One or two children	One son	One daughter	One or two children
Sex ratio for age cohort 30–40	–0.330	–0.381	–0.433	–0.126	–0.498	–0.635
	(0.396)	(0.657)	(0.356)	(0.611)	(0.876)	(0.475)
Sex ratio*first child being a son			0.053			0.013
			(0.443)			(0.619)
Adjusted R2	0.178	0.143	0.066	0.155	0.099	0.040
N	3,407	4,136	15,380	3,821	4,113	14,506

Sex ratios are calculated at the county level for the age cohort 30–40. Robust errors are in the brackets. Standard errors clustered at the county level. All covariates follow *Table 4*. CHNS household survey data [1991–2009]; to facilitate comparison with new findings in columns [4–6], columns [1–3] are drawn from *Table 4* Panel B (22).

and living in an area with a skewed sex ratio at marriage age, rather than unobserved potential trend, promote paternal substance use.

Third, all the estimations cluster standard errors at the village level (for our 26-village Guizhou survey) and at the county level (for the CHNS survey). For our Guizhou survey, the Cameron-Gelbach-Miller bootstrapping method is adopted to address the issue of small number of clusters (35), and adjusted p-values are presented in the brackets in *Table 3*.

Fourth, besides following the recent studies to calculate sex ratios at age cohorts 5–19 (16,17,36), our main results are robust to further including the age cohorts 20–30. The results are available upon request.

Moreover, marriage market in the home county may be less relevant to a small proportion of children who migrate for a long period. Since we have no information on the counties/cities to which they migrate, they are dropped from the analysis but the main results persist.

Discussion

Evidence suggests that unbalanced sex ratios stimulate grooms' families to work harder to earn more money (16,17). However, we do not find evidence that sex ratios motivate more substance use through income effect (22).

Coping with stress can be a key motive for intensified smoking and alcohol drinking (19). It is plausible that those who are less able to manage the marriage market pressure tend to consume more such goods. Though stress is not directly measured in the CHNS data or the Guizhou survey, we find suggestive evidence that having a son and living in a community with skewed sex ratios favoring females reduce

paternal life satisfaction and happiness (22).

Since both cigarette smoking and alcohol consumption are positional (37), do poor households consume as a means to signal and improve social status? Though the positional feature of tobacco and alcohol consumption makes it difficult to fully distinguish marriage market pressure from status seeking motive, the rich Guizhou survey data on different types of tobacco consumption enables us to partially distinguish between the two mechanisms. Relative to packed cigarettes with publicly recognizable brands, tobacco pipe smoking generally has little to do with status signaling. If status signaling is the dominant motive, we should find little evidence on tobacco pipe smoking. However, results from *Table 6* shows families with a son living in high sex ratio villages experience more tobacco pipe smoking. In other words, factors other than status signaling should be in effect.

Smoking and alcohol use may also serve to strengthen interpersonal relationship during social ceremonies. Merging the rich information on all ceremonies in the past few years with the Guizhou survey, we estimate the number of ceremonies each household attended and organized on sex ratios, gender of first child and their interactions. There is no evidence that families with a son living in communities with unbalanced sex ratios attended or organized more social events, which goes against the social network hypothesis.

Conclusions

China and various other East Asian countries have experienced increasingly skewed sex ratios. Meanwhile, China has more smokers and alcohol drinkers than any other

Table 6 Testing potential mechanisms—signaling socioeconomic status

Variables	Ln [tobacco pipe consumption (in 50 g)]			
	All families	Families with one or two children	One son	One daughter
Village sex ratio for age cohort 5–19	0.569***	−0.122	0.560***	−0.069
	(0.008)	(0.763)	(0.010)	(0.569)
Sex ratio* first child being a son		0.729**		
		(0.041)		
Adjusted R2	0.046	0.060	0.154	0.124
N	2,591	1,261	310	250

*, sex ratios are calculated at the village level for the age cohort 5–19; **, 5% significance level; ***, 1% significance level. Standard errors are clustered at the village level. Adjusted P values are reported. Covariates follow *Table 4*. Author's Guizhou household survey data [2004–2009].

countries in the world. Utilizing two longitudinal datasets, the CHNS national sample and the Guizhou survey, we find that the marriage market competition promotes substance use. Fathers with a son living in communities with higher sex ratios consume more tobacco and alcohol, while those with a daughter do not demonstrate this pattern. Some evidence suggests that coping with the marriage market pressure is the most plausible pathway connecting the observed skewed sex ratios and the intensified substance use, while there is no solid evidence supporting income effect and status seeking motives. Our results may underestimate the marriage market effect as rural China is subject to less stringent family planning policy. Due to the strong social norms in China that discourage women from substance use, we limit our analysis to the male subsample.

Due to the strong son preference, sex ratios in China will probably stay skewed in the coming decade albeit the recent release of one child policy, investigating the marriage market pressure and behavior consequences could help design effective policies that improve parental well-being through the rebalancing of skewed sex ratios. Moreover, widespread substance use in the world imposes large negative health impacts, affects functioning of the labor market, and brings various negative externalities to society. Therefore, understanding and suppressing the determinants of substance use, such as the skewed sex ratios explored in this paper, could lead to substantial welfare gains.

Acknowledgments

Footnote

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jhmhp.2018.08.04). The author has no conflicts of interest to declare.

Ethical Statement: The author is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study only used secondary data sets and was approved by the Institutional Review Board (IRB) at Yale University (IRB Protocol ID: 2000021280).

Open Access Statement: This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with

References

1. Chatterji P, Dave D, Kaestner R, et al. Alcohol abuse and suicide attempts among youth. Econ Hum Biol 2004;2:159-80.

2. Hu TW, Mao Z, Ong M, et al. China at the crossroads: the economics of tobacco and health. Tob Control 2006;15:i37-41.

3. Balsa AI, French MT. Alcohol Use and the Labor Market in Uruguay. Health Econ 2010;19:833-54.

4. Lovenheim MF, Steefel DP. Do Blue Laws Save Lives? The Effect of Sunday Alcohol Sales Bans on Fatal Vehicle Accidents. J Policy Anal Manage 2011;30:798-820.

5. Balsa AI, French MT, Maclean C, et al. From Pubs to Scrubs: Alcohol Misuse and Health Care Use. Health Serv Res 2009;44:1480-503.

6. Markowitz S, Grossman M. The effects of beer taxes on physical child abuse. J Health Econ 2000;19:271-82.

7. Markowitz S. The price of alcohol, wife abuse, and husband abuse. South Econ J 2000;67:279-303.

8. Carpenter C. Heavy alcohol use and crime: Evidence from underage drunk driving laws. J Law Econ 2007;50:539-57.

9. Corman H, Mocan NH. Alcohol Consumption, Deterrence and Crime in New York City. NBER Working Paper Series. 2013.

10. National Bureau of Statistics of China. China Population Census Data. Available online: http://www.stats.gov.cn/tjsj/pcsj/

11. Ebenstein AY, Sharygin EJ. The consequences of the 'missing girls' of China. World Bank Econ Rev 2009;23:399-425.

12. Zhu WX, Lu L, Hesketh T. China's excess males, sex selective abortion, and one child policy: analysis of data from 2005 national intercensus survey. BMJ 2009;338:b1211.

13. Foreign Policy. Bachelor Padding. September 28, 2012.

14. Robson A. The Evolution of Attitudes to Risk: Lottery Tickets and Relative Wealth. Games Econ Behav 1996;14:190-207.

15. Hopkins E. Inequality and Risk-Taking Behaviour. Available online: https://ideas.repec.org/p/edn/sirdps/270.html

16. Wei S, Zhang X. Sex Ratios, Entrepreneurship, and Economic Growth in the People's Republic of China.

17. NBER Working Papers 16800, 2011.

18. Wei S, Zhang X. The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China. J Polit Econ 2011;119:511-64.

19. Umberson D. Family status and health behaviors: Social control as a dimension of social integration. J Health Soc Behav 1987;28:306-19.

20. Pesko MF. Stress and Smoking: Associations with Terrorism and Causal Impact. Contemp Econ Policy 2014;32:351-71.

21. Kushner MG, Sher KJ, Beitman BD. The relation between alcohol problems and the anxiety disorders. Am J Psychiatry 1990;147:685-95.

22. Shaw BA, Agahi N, Krause N. Are changes in financial strain associated with changes in alcohol use and smoking among older adults? J Stud Alcohol Drugs 2011;72:917-25.

23. Chen X. Do skewed sex ratios among children promote parental smoking? Longitudinal evidence from rural China. J Subst Use 2018;23:366-70.

24. Scharping T. Birth Control in China 1949–2000. New York, NY: Routledge Curzon, 2003.

25. Ebenstein A. The Missing Girls of China and the Unintended Consequences of the One Child Policy. J Hum Resour 2010;45:87-115.

26. Chen Y, Li H, Meng L. Prenatal Sex Selection and Missing Girls in China: Evidence from the Diffusion of Diagnostic Ultrasound. J Hum Resour 2013;48:36-70.

27. The Economist. The Big Smoke. 2012.

28. Cochrane J, Chen H, Conigrave KM, et al. Alcohol Use in China. Alcohol Alcohol 2003;38:537-42.

29. Angrist J. How Do Sex Ratios Affect Marriage and Labor Markets? Evidence from America's Second Generation. Q J Econ 2002;117:997-1038.

30. Chang S, Zhang X. The Economic Consequences of Excess Men: Evidence from a Natural Experiment in Taiwan. IFPRI discussion papers 1203, 2012.

31. Pearlin LI, Johnson J. Marital Status, Life Strains, and Depression. Am Sociol Rev 1977;42:704-15.

32. Barber N. The sex ratio as a predictor of cross-national variation in violent crime. Cross Cult Res 2000;34:264-82.

33. Edlund L, Li H, Yi J, et al. Sex Ratios and Crime: Evidence from China's One-Child Policy. IZA Discussion Papers 3214, 2007.

34. Hu YR, Goldman N. Mortality Differentials by Marital Status: An International Comparison." Demography 1990;27:233-50.

35. Mangyo E, Park A. Relative deprivation and health: Which

reference groups matter? J Hum Resour 2011;46:459-81.

35. Cameron AC, Gelbach JB, Miller DL. Robust Inference with Multi-Way Clustering. J Bus Econ Stat 2011;29:238-49.

36. Wei S, Zhang X, Liu Y. Status Competition and Housing Prices. NBER Working Papers 18000, 2012.

37. Heffetz O. A Test of Conspicuous Consumption: Visibility and Income Elasticities. Rev Econ Stat 2011;93:1101-17.

Table S1 Marriage geographic pattern (The Guizhou Survey)

Years	Stay in the village (%)	Same township different village (%)	Same county different township (%)	Same province different county (%)	Different province (%)
2004	53.5	12.4	24.2	8.9	1.0
2006	54.0	13.4	24.5	7.5	0.6
2009	54.6	10.5	24.9	9.4	0.6

Author's Guizhou household survey data [2004–2009].

Table S2 Heckman two-step estimations on the likelihood of family bearing only one child

Variables	Nuclear family with 1st child a son		Nuclear family with 1st child a daughter		Nuclear family with 1st child a son		Nuclear family with 1st child a daughter	
	Ln (# cigarettes smokes per day)	Stop at 1st child	Ln (# cigarettes smokes per day)	Stop at 1st child	Ln (# 50 Gms liquor drinks per week)	Stop at 1st child	Ln (# 50 Gms liquor drinks per week)	Stop at 1st child
Sex ratio for age cohort 5–19	0.94*** (0.19)	0.04 (0.09)	–0.44 (0.55)	0.03 (0.13)	1.03*** (0.21)	0.04 (0.09)	–0.45 (0.63)	0.03 (0.13)
Ln (per capita income)	0.21 (0.14)	0.06 (0.05)	0.35 (0.25)	0.07 (0.06)	0.24 (0.16)	0.06 (0.05)	0.4 (0.29)	0.07 (0.06)
Year of education	–0.04 (0.04)	–0.01 (0.02)	0.02 (0.05)	0.00 (0.02)	–0.05 (0.05)	–0.01 (0.02)	0.02 (0.05)	0.00 (0.02)
Household head gender	1.34*** (0.44)	–0.38* (0.22)	–0.33 (0.49)	–0.35 (0.25)	1.58*** (0.51)	–0.38* (0.22)	–0.28 (0.55)	–0.35 (0.25)
Marriage status	–0.24 (0.21)	–0.08 (0.15)	0.77 (0.87)	–0.40*** (0.15)	–0.3 (0.24)	–0.08 (0.15)	0.87 (1.01)	–0.40*** (0.15)
Household head age	0.00 (0.01)	0.06*** (0.01)	–0.04*** (0.01)	0.07*** (0.01)	0.00 (0.01)	0.06*** (0.01)	–0.05*** (0.01)	0.07*** (0.01)
Share of the elderly	–0.07 (0.49)	–0.22 (0.21)	1.40** (0.70)	0.25 (0.26)	–0.04 (0.55)	–0.22 (0.21)	1.66** (0.82)	0.25 (0.26)
Share of youth	–0.26 (0.45)	–0.26 (0.25)	–3.05*** (0.70)	–0.57*** (0.16)	–0.32 (0.52)	–0.26 (0.25)	–3.51*** (0.83)	–0.57*** (0.16)
Household size	0.17 (0.11)	–0.21*** (0.04)	0.11 (0.23)	–0.27*** (0.06)	0.19 (0.12)	–0.21*** (0.04)	0.14 (0.26)	–0.27*** (0.06)
Whether parents suffer from major diseases	–0.42** (0.17)	–0.07 (0.09)	0.15 (0.51)	–0.04 (0.15)	–0.48** (0.20)	–0.07 (0.09)	0.23 (0.61)	–0.04 (0.15)
Minority status of the household		0.06 (0.14)		0.06 (0.18)		0.06 (0.14)		0.06 (0.18)
Age of the first child		–0.06*** (0.02)		–0.10*** (0.01)		–0.06*** (0.02)		–0.10*** (0.01)
Whether the 1st child disables or suffers from major diseases		–0.15 (0.09)		–0.16 (0.18)		–0.15 (0.09)		–0.16 (0.18)
Log likelihood	–1,121.91		–638.08		–1,162.73		–659.78	
N	13,183		11,142		13,183		11,142	

*, 10% significance level; **, 5% significance level; ***, 1% significance level. DVs in the main equation = paternal tobacco/alcohol consumption; DV in the selection equation = likelihood that parents stop at the 1st child. Robust errors are in the brackets. Standard errors are clustered at the county level. CHNS household survey data [1991–2009].