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The Effect of China's Two-Child Policy on the Child Sex Ratio: Evidence From Shanghai, China

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Abstract

Objective: The bias towards males at birth has resulted in a major imbalance in the Chinese sex ratio that is often attributed to China's one-child policy. Relaxation of the one-child policy has the potential to reduce the imbalance in the sex ratio away from males. In this study, we assessed whether the bias towards males in the child sex ratio was reduced as a result of the two-child policy in China. Medical records data from one large municipal-level obstetrics hospital in Shanghai, East China. Design: Matching and difference-in-differences (MDID) techniques were used to investigate the effect of the two-child policy on the imbalance in the sex ratio at birth after matching for pregnancy status and socioeconomic factors. Results: Analyzing 133,358 live births suggest that the relaxation of the one-child policy had a small, but statistically significant effect in reducing the imbalance in the male to female sex ratio at birth. Conclusion: The results demonstrate that relaxation of the one-child policy reduced the imbalance in the male to female sex ratio at birth from 1.10 to 1.05 over the study period at one of the major obstetrics and gynecology hospitals in China.

Keywords

gender imbalance, one-child policy, two-child policy, sex ratio at birth

Highlights

- **What do we already know about this topic?**
The bias towards males at birth has resulted in a major imbalance in the Chinese sex ratio that is often attributed to China's one-child policy. Relaxation of the one-child policy has the potential to reduce the imbalance in the sex ratio away from males.
- **How does your research contribute to the field?**
In this study, we assessed whether the bias towards males in the child sex ratio was reduced as a result of the two-child policy in China.
- **What are your research's implications towards theory, practice, or policy?**
Analyzing 133,358 live births suggest that the relaxation of the one-child policy had a small, but statistically significant effect in reducing the imbalance in the male to female sex ratio at birth from 1.10: 1.00 to 1.05: 1.00 over the period from January 1, 2013, to May 31, 2018. Further exploration revealed that the policy effect was driven mainly by first birth parity, migrant status, and maternal age.

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Introduction

Bias in the selection of males at birth has resulted in gender inequality in many Asia regions, especially in China.[1,2] This phenomenon has attracted much attention worldwide. Normally, the SRB consists of between 103 and 106 male births per 100 women.[3] In 2005, the gender balance of male to female at birth surged at 1.20 reaches its peak.[2,4,5] Existing literature has suggested that the increasing sex ratio imbalance may result from China's "unique" one-child policy.[6–8] Under the one-child period, women would often have an abortion if they knew that their future child was to be a girl.[5,9] The consequences of these policies have been a shift towards gender inequality in favor of males at birth with resulting long-term demographic and socioeconomic repercussions.

China stated the one-child policy in 1979 to control a growing population. The policy was strictly enforced in urban centers, including the four municipalities of Shanghai, Beijing, Tianjin, and Chongqing as well as in the two provinces of Jiangsu and Sichuan.[10–12] However, ethnic minorities were excluded from this policy and were generally allowed to have more than one child.[13]

Fear that a low fertility rate might hazard economic growth in China has resulted in pressure on the Chinese government to modify the one-child policy. The new family planning policy called the universal two-child policy was executed on January 1, 2016. This fresh policy allowed every couple the option to have a second child. This change had the potential to impact the imbalance in the male sex ratio.[14,15]

The objective of this paper is to estimate the relationship between the relaxation of the one-child policy and the male to female sex ratio at birth by using matching and difference-in-differences (MDID) techniques. The data were drawn from all inpatient births over the period January 1, 2013–May 31, 2018, at the Shanghai First Maternity and Infant Hospital. This hospital is one of the largest obstetrical hospitals in China, with the highest annual number of births (more than 30,000). Our study shows that the "universal two-child policy" was effective in reducing the imbalance in the child sex ratio. Further exploration revealed that the policy effect was driven mainly by first birth parity, migrant status, and maternal age.

In *Background and Literature Review*, we describe the research background, and in *Framework*, we outline the conceptual framework. Data and methods are described in *Empirical Method*. *Empirical Results* reports our results, and various robustness tests are discussed in *Robust Analysis*. Our findings are discussed in *Discussion*. *Conclusion* offers a brief set of conclusions and policy implications.

Background and Literature Review

Family Planning Policy and the Sex Ratio in China

In 1979, China announced the one-child policy, in the belief that population containment was essential to improving the economic conditions of China. This policy was particularly unpopular in rural areas and was considered virtually unenforceable. As a result, in most provinces, rural couples already had a girl were allowed to give a second birth.[10–12] About 9% of the population, ethnic minorities are generally allowed to have more than one child. On October 29, 2015, China stated that the child planning policy would be relaxed to allow all couples to have a second child to help address the issue of the aging of the Chinese population. On December 27, 2015, the fresh child planning policy, the so-called universal two-child policy, was implemented by the Chinese government from January 1, 2016.

Potential Impacts of the One-Child Policy on the Child Sex Ratio

The imbalance in the male to female sex ratio in China reached alarming levels within just 20 years after the original execution of the one-child policy.[5] In 2005, the gender balance of male to female at birth surged at 1.20.[2,4,5] Existing literature has suggested that the one-child policy was a significant factor accounting for this high sex ratio.[6–8] First, son preference is well-rooted in Chinese culture; many households would spare no effort to have "at least one son." Second, in the presence of the one-child policy, improved access to B-ultrasound techniques, and elective abortions, it became possible for parents to select the sex of their child. In addition, in vitro fertilization services also contribute to the male to female sex imbalance at birth because that technology allowed for genetic sex selection.[16] The confluence of these factors has been an essential driver of the skewed distribution towards boys at birth. With the relaxation of the one-child policy, some authors have suggested that the imbalance in the child sex ratio would decline because parents now have the opportunity to have a second birth which may result in a boy if their first child were a girl.[2,5]

Framework

According to prospect theory proposed by Kahneman and Tversky,[17] parents with a preference for boys over girls have an incentive to identify the sex of their child during pregnancy in order to terminate that birth if the child was not of their preferred sex even when sex-selective abortion is illegal in China and poses a potential health risk.[9] These actions are sequential and depend on a comparison of the expected benefits and costs of those actions, including all physiological, psychological, financial, and even, legal costs. Son-preference in China is the norm, and the one-child policy acted as a constraint that catalyzed this phenomenon. Once, the one-child policy was relaxed, parents had the option to let chance prevail for the first birth and be more motivated to consider ultrasound and abortion as strategies for the second pregnancy if their first child were a girl. Relaxation of

one-child policy could diminish the gender imbalance, rather than eliminate it. Consequently, even with a general societal preference for boys, the male to female child sex ratio may fall with the relaxation of the one-child policy. It is this hypothesis that is being tested in this paper.

Empirical Method

Data

This study used inpatient hospitalization admission data on all women who gave birth between January 1, 2013, and May 31, 2018, at the Shanghai First Maternity and Infant Hospital. The data were used to evaluate the sex of the child at birth. The data contain patient demographics and clinical details on 133,358 live births. Physicians and nurses obtained demographic information on the mother by interviewing patients and verifying medical history.

In all analyses, we matched the mother of the Han Chinese and ethnic minority child for demographic and maternal clinical characteristics in order to assess the propensity to be a member of an ethnic minority group. Demographic covariates and relevant health variables were also controlled to minimize potential selection bias associated with them, including maternal age at the child's birth, gravida—which refers to the number of times a woman has been pregnant, birth parity—is the number of pregnancies >20 weeks, gestation week—is a measure of the age of a pregnancy which is taken from the woman's last menstrual period (LMP), migrant status (1 = Shanghai-born women, 0 = Migrants), ethnicity (1 = Han Chinese; 0 = Ethnic Minority), nationality (1 = China; 0 = others), marital status (1 = married; 0 = others), occupation (1 = employed; 0 = not employed), insurance (1= has health insurance; 0 = pay out of pocket), high-risk pregnancy status—refers to a situation when either the mother or the baby were more likely to have health problems during the course of pregnancy (1 = high-risk pregnancy; 0 = otherwise), mode of delivery (1 = cesarean delivery; 0 = natural delivery) and in vitro fertilization (IVF)—which is defined as a women who has undergone in vitro fertilization services (1 = in vitro fertilization; 0 = others).

Matching and Difference-In-Differences Approach

One of the unique features of the one-child policy was that ethnic minorities were never affected by the policy.[15] A previous study that used a difference-in-differences approach where Han Chinese were considered as the treatment group while ethnic minorities (sample size less than 10%) were considered as the comparison group, estimated the relationship between the one-child policy and the male to female sex-ratio imbalance, where the binary dependent variable was equal to 1 if the gender of the child was male and zero otherwise.[13] In light of that work, we have used the same set of methods to assess the effect of the "universal two-child policy" on the sex of children at birth. Here, being a Han Chinese is considered as a treatment variable, and we estimate the likelihood that the birth yields a boy as

$$Male_i = \alpha_0 + \alpha_1 H_i + \alpha_2 TU_i + \alpha_3 H_i \times TU_i + \lambda_i + v_t + \varepsilon_i \quad (1)$$

where $Male_i$ is a binary variable equal to 1 if the gender of the child is male. The binary variables, H_i and TU_i, pick up children who are members of a Han Chinese and time effects due to the period after implementation of the "universal" two-child policy, respectively: $H_i = 1$ for a child who is a Han Chinese and zero otherwise; $TU_i = 1$ if mothers gave birth subsequent to the introduction of the "universal two-child policy," that is, in 2016 or thereafter, otherwise zero. (This time frame was used because when a family elects to have an abortion, it only occurs during the first trimester). The coefficients, α_3, on the interaction term is, in essence, our estimator.

	Han	Not Han	Difference
Before Jan 1, 2016	$\alpha_0 + \alpha_1$	α_0	α_1
After Jan 1, 2016	$\alpha_0 + \alpha_1 + \alpha_2 + \alpha_3$	$\alpha_0 + \alpha_2$	$\alpha_1 + \alpha_3$
Difference	$\alpha_2 + \alpha_3$	α_2	α_3

Hence, the policy effect on the probability of having a boy at birth is

$$\begin{aligned} \text{DID} = &[\Phi(\alpha_0 + \alpha_1 + \alpha_2 + \alpha_3) - \Phi(\alpha_0 + \alpha_1)] \\ &- [\Phi(\alpha_0 + \alpha_2) - \Phi\alpha_0] = \Phi\alpha_3 \end{aligned} \quad (2)$$

There are two statistical challenges to our analysis. First, the choice by a household to have a second child is potentially self-selective, which might differentially depend on the socioeconomic status of the household. Second, our analysis dataset (n = 133,358) comprises a relatively small sample of ethnic minorities (n = 1746 or 1.3% of the full sample). The potential selection bias and small sample size of the control group may limit the formation of definitive conclusions. To handle both of these situations, we conduct matching and difference-in-differences models.[18–20] The use of difference-in-differences methods removes the influence of permanent confounders, while matching is used to capture potential selection bias.[21] Also, after matching, the sample size of both the control and treatment groups are the same. Therefore, the matching method makes the estimation more accurate and reduces the potential statistical bias caused by small samples.[22]

The matching and difference-in-differences models (MDID) were based on a two-stage procedure. In the first stage, a propensity score was estimated in order to identify those characteristics that were associated with the status of the mother who had a Han Chinese child in the dataset. This estimated propensity score was then used to match observations in the whole dataset in such a way that individuals with similar predictive covariate values were grouped together in order to assess the independent effect of ethnic status. Specifically, we use a rich set of control variables X_i related to socioeconomic status and maternal health status in order to avoid endogeneity problems. In

Table 1. Variable Definition and Summary Statistics.

Variable	Definition	Mean/N	SD/%
Continuous Variable		Mean	SD
Age		30.69	3.91
Gestation week		39.97	.68
Gravida		1.81	1.08
Parity	1 = first child; 0 = more than one child	1.25	.46
Binary variable		N	%
Occupation	1 = employ; 0 = no-employ	125076	93.8
Migrant status	1= Shanghai born; 0 = others	83872	62.9
Marriage status	1 =married; 0 = others	133100	99.8
Insurance	1 =insurance; 0 = out of pocket	82038	61.5
Nationality	1 = China; 0 = others	133040	99.8
Han	1 = Han Chinese; 0 = others	1746	1.3
High-risk pregnancy	1 = high risk; 0 = no high risk	71657	53.7
Mode of delivery	1 = cesarean delivery; 0 = natural delivery	54314	40.7
In vitro fertilization	1 = have in vitro fertilization; 0 = others	4684	3.5
Policy	1= for 2016 and thereafter; 0 = others	72389	54.28
Observations		133,358	

Note: Continuous variable including age, gestation weeks, gravida and parity were presented as mean and sd. Binary variables were presented as number and percentage (%).

the second stage, the matching different-in-differences approach was estimated on the common support of the propensity score. This way, matching and difference-in-differences models (MDID) compare the conditional pre-policy and post-policy effects, for ethnic minorities to those of Han Chinese in order to control for remaining unobservable differences.[18,20] In practice, we perform our MDID analysis with the use of Stata "Kernel Propensity Score Diff-in-Diff."[23] All estimates were performed using STATA 14.

Empirical Results

Data Description

Table 1 provides descriptive statistics for the variables used in this study. Migrant status, occupation, marriage status, insurance status, nationality, ethnicity, high-risk pregnancy, mode of delivery, and in vitro fertilization were coded as binary variables. For example, if the mother was employed, married, had health insurance, Shanghai-born, had a Han Chinese child, who was high risk, had a cesarean delivery and in vitro fertilization then the values of each these nine binary variables were set to one.

The average age of the sample of mothers was 30.7 years, with 37% being migrants. Almost all (94%) of the mothers were employed, the overwhelming majority (99%) were married Chinese women, and the majority (62%) had public health insurance. Among the mother, over 41% of the women had a cesarean delivery, and 54% of the children were born after 2016. In terms of ethnicity, most of the children (99%) were Han Chinese.

Matching and Difference-In-Differences Results

We examined the effect of the relaxation of the one-child policy on the male to female sex ratio at birth over the study period through the use of the MDID approach after we had matched observations on the basis of maternal socioeconomic and individual health status as predictors of ethnic minority status. The results are presented in Table 2. The effect of the "universal two-child" policy, identified by comparing the pre-2016 period to that in 2016 and thereafter, on the probability that the birth sex was male was statistically significant and resulted in an absolute decline of .044 ($P < .001$) in the sex ratio at birth.

Table 2. Matching and Difference-in-Differences (MDID) Estimates of the Effect of the Relaxation of the One-Child Policy on the Probability of Born in a Male (2013-2018).

Variable	β	P value
Not Han × policy	−.044***	<.001
	(.005)	
Policy	.033***	<.001
	(.004)	
Not Han	.006	.156
	(.004)	
Constant	.505***	<.001
	(.003)	
Observations	133,358	

Standard errors in parentheses *P < .05, **P < .01, ***P < .001.

Matching and Difference-In-Differences Results by Parity

To test whether the relaxed policy would be more effective at first birth or at second birth, we extended our MDID estimator

Table 3. Matching and Difference-in-Differences (MDID) Estimates of the Effect of the Relaxation of the One-Child Policy on the Probability of Born in a Male by Birth Parity (2013-2018).

	Model 1		Model 2	
	Fist Birth		Higher Birth	
Variable	β	P value	β	P value
Not Han × policy	−.045***	<.001	−.057***	<.001
	(.006)		(.011)	
Policy	.029***	<.001	.057***	<.001
	(.004)		(.008)	
Not Han	.007	.128	.019*	.033
	(.005)		(.009)	
Constant	.505***	<.001	.491***	<.001
	(.003)		(.006)	
Observations	101,236		32,104	

Standard errors in parentheses *P < .05, **P < .01, ***P < .001.
Note: After being stratified by the birth parity, the higher birth subgroup is associated with a slight loss in sample size with the MDID method. Specifically, after matching, the sample size of the higher birth associated with the MDID method is 32,104. There is 18 sample lost after conducted MDID method. There is no sample size lost with the first birth subgroup.

by birth parity. Table 3 reports our results by birth parity. After stratification by the birth parity, the higher birth group is associated with a slight loss in sample size with the MDID estimator due to the smaller sample size after matching. In particular, the number of loss sample sizes was noted at the bottom of Table 3. Model 1 shows that the probability of a male birth at first birth fell in absolute terms by .045 (P < .001), which is robust and statistically significant. In terms of higher birth parity, similarly, the probability of a male birth decreased significantly by .057 (model 2, P < .001). These results suggest that the "universal two-child policy" had a similar effect on the sex of the first and the higher-order births in the household virtually.

Matching and Difference-In-Differences Results by Migrant Status

Because the one-child policy was more strictly enforced in urban centers, we further extended our results by stratifying by maternal migrant status. Table 4 demonstrates that the "universal two-child" policy resulted in a significant absolute decline of .083 (model 1, P < .001) in the probability of a male birth among Shanghai residents. Although the policy had a smaller impact on migrant women, it still reduced their probability of a male birth by .020 (model 2, P < .05). Likewise of the stratification by the birth parity, the stratification by the maternal migrant status also is associated with a slight loss in sample size with the MDID estimator. We also noted the number of loss sample sizes at the bottom of Table 4.

Table 4. Matching and Difference-in-Differences (MDID) Estimates of the Effect of the Relaxation of the One-Child Policy on the Probability of Born in a Male by Migrant Status (2013–2018).

	Model 1		Model 2	
	Locals		Migrants	
Variable	β	P value	β	P value
Not Han × policy	−.083***	<.001	−.020*	.024
	(.007)		(.009)	
Policy	.026***	<.001	.041***	<.001
	(.005)		(.006)	
Not Han	.044***	<.001	−.022**	.001
	(.005)		(.007)	
Constant	.493***	<.001	.512***	<.001
	(.003)		(.005)	
Observations	83,824		49,484	

Standard errors in parentheses *P < .05, **P < .01, ***P < .001.
Note: After being stratified by the migrant status, the locals (Shanghai residents) subgroup is associated with a loss in sample size with the MDID method. Specifically, the sample size of the locals (Shanghai residents) subgroup associated with the MDID method is 83,824. There is 48 sample lost after conducted MDID method. The sample size of the migrants subgroup associated with the MDID method is 49,484. There is 2 sample lost after conducted MDID method.

Table 5. Matching and Difference-in-Differences (MDID) Estimates of the Effect of the Relaxation of the One-Child Policy on the Probability of Born in a Male by Maternal Age (2013-2018).

	Model 1		Model 2	
	Age < 30		Age > 30	
Variable	β	P value	β	P value
Not Han × policy	−.066***	<.001	−.019*	.036
	(.007)		(.009)	
Policy	.026***	<.001	.047***	<.001
	(.005)		(.006)	
Not Han	.025***	<.001	−.022**	.001
	(.005)		(.007)	
Constant	.499***	<.001	.513***	<.001
	(.004)		(.005)	
Observations	82,048		51,218	

Standard errors in parentheses *P < .05, **P < .01, ***P < .001.
Note: After being stratified by the maternal age, the age <30 subgroup is associated with a loss in sample size with the MDID method. Specifically, the sample size of the age <30 subgroup associated with the MDID method is 82,048. There is 92 sample lost after conducted MDID method. There is no sample size lost with the age >30 subgroup.

Matching and Difference-In-Differences Results by Maternal Age

Our results were extended by stratifying by maternal age. Women over the age of 30, particularly middle-to late-thirties, are significantly less likely to become pregnant. Since that time, miscarriage rates have increased and egg quality and quantity

have decreased significantly.[24] Hence, we estimated the women under 30 years of age and over 30 years. Table 5 reports a statistically significant effect of each policy for women less than 30 years of age and for older women. We found that the "universal two-child" policy reduced the probability of a male birth for women under 30 years of age by .066 (model 1, $P < .001$). The effect for older women was smaller at .019 (model 4, $P < .05$) and less significant. Similarly, the loss of sample size with the MDID estimator is reported at the bottom of Table 5.

Robust Analysis

To check the sensitivity of our results, we performed the robustness checks as follows. First, we assessed the mean standardized bias (SB) before and after propensity score matching (PSM) as suggested by.[25] Appendix 1 reports the balancing variables before and after matching. T-tests for equality of means in the treated and non-treated groups, both before and after matching are shown. For proper balancing, these should be non-significance after matching, which is what we found. Comparison before and after PSM shows that matching reduced the mean standardized bias (SB) below the threshold, which should <10%.[26] Hence, the robustness checks ensure that our estimates are not sensitive to the matching approach used. Second, as mentioned, we conducted our study by using the same methods as an earlier study.[13] Third, we also extended our results by stratifying by birth parity, migrant status, and maternal age, and obtained robust and significant results.

Discussion

Key Findings and Implications

The bias towards males at birth has resulted in a major imbalance in the Chinese sex ratio that is often attributed to China's one-child policy. This policy generally constrained every Han Chinese household to only one child, while ethnic minorities were allowed to have at least two children. Under the one-child policy, Han Chinese women would often have an abortion if they knew that their future child was to be a girl. Relaxation of the one-child policy has the potential to reduce the imbalance in the sex ratio away from males. The change in the child planning policy targeted regions, such as Shanghai, where the previous policy had been strictly enforced. There were four key findings regarding the effect of the relaxation of the one-child policy on the male to female sex ratio at birth:

First, our results reveal robust and statistically significant effects of the relaxation of the one-child policy on the male to female sex ratio at birth; the policy change was statistically significant in reducing the male to female sex ratio at birth. The one-child policy has been shown to be a key trigger to the sex ratio imbalance at birth. In the absence of that policy, families would have been able to give birth until eventually their son-preference was attained. Thus, the relaxation of the one-child policy resulted in a tendency to diminish gender imbalance at birth.

Second, once the impact of the policy change was stratified by birth parity, there was a similar reduction in the male sex ratio for first and higher-order births in the household. This finding contrasts with a previous study from the United States[27] that found Asian area mothers were more likely to have an abortion when they had previously given birth to girls. Consequently, gender selection only affected the second birth. In the case of our results, we were unable to reject the hypothesis that the policy had similar effects on the sex ratio irrespective of birth parity.

Third, stratified by migrant status, we found that the policy shift was more likely to affect Shanghai natives when compared to migrants. As mentioned, the one-child policy was restricted in cities, such as Shanghai; therefore, the policy was more likely to impact Shanghai people rather than migrants.

Fourth, our findings also show that younger mothers were more affected by the policy change than women over 30 years. With the increase of women's age, their fertility declines, and this might reduce the chance that they would have a second child, and accordingly, the older mother would be less likely to be affected by the policy.

These findings are consistent with the conceptual framework advanced by Kahneman and Tversky[17] that motivated this study. Moreover, our findings support the assumption of a previous study that argued that relaxation of the one-child policy would reduce the male to female sex ratio at birth.[15] Additionally, our results are also consistent with recent downward trends in the sex ratio at birth in China, Statistical Monitoring Report of the China Children's Development Program (2011–2020).[28]

Our study lends support to an earlier Chinese study[13] that found the one-child policy increased the male to female sex ratio. We report a decline in the male to female sex ratio at birth following the relaxation of the one-child policy and that this effect occurred for both first and second births; Shanghai natives and migrants; and for younger and older mothers. Taken together, our findings suggest that when the constraint on the number of children in a household may have shifted from one to two, parents are more likely not to select their baby's gender. Consequently, the male to female child sex ratio would tend to fall with the relaxation of the one-child policy.

To our knowledge, this is the first paper to directly investigate the effect of the universal two-child policy on the male to female sex ratio at birth. As mentioned, son-preference culture is deeply rooted in many Asia areas regions,[29] even among Asian-American families,[30] and is the root cause for the male to female sex ratio imbalance. The one-child policy triggered this phenomenon by restricting the number of children a household could have, and therefore, relaxation of the one-child policy would improve the imbalance.

Strengths and Limitations

The study used extensive, detailed, and high-quality patient-level medical records data from the Shanghai First Maternity and Infant Hospital. Our findings are robust and statistically significant and suggest that relaxation of the one-child policy reduced the male bias in the sex ratio at birth in China.

However, there is a range of limitations to highlight. First, our study was based on hospital inpatient data from a single hospital in Shanghai, which may limit the generalizability of the findings. While single-center studies pose challenges for generalizability, this hospital is situated in one of the most diverse regions of China and the women included in the study were diverse in clinical, demographic, and ethnic background, which helps to improve generalizability. Moreover, the study hospital is one of the largest obstetrical hospitals in China and is associated with the largest annual number of births nationwide at more than 30,000 births.

Second, while the information used for this study were drawn from hospital administrative data that comprised comprehensive maternal medical diagnostic and demographic data, there were some variables that were not captured in that database. Such as the condition of twins or multiple births variables. And consequently, there are the possibilities of omitted variable and misspecification bias. However, we conducted matching and difference-in-differences techniques to eliminate potential biases. We also extended our results by stratifying by birth parity, migrant status, and maternal age to ensure our results. Consequently, we believe that these concerns, if still present, maybe small.

Finally, we were unable to directly test for the impact of pregnancy decision prior to or during the two-child policy period, and associated trends in such decision. This absence of information may have had consequences for the resulting findings. Further research is needed to garner a more complete picture of pregnancy decision, their trends, and their association with the sex ratio at birth in the presence of the universal two-child policy.

Conclusions

The bias towards males at birth has resulted in a major imbalance in the Chinese sex ratio that is often attributed to China's one-child policy. This policy generally constrained every Han Chinese household to only one child, while ethnic minorities were allowed to have at least two children. This paper assessed the impact of the recently relaxed one-child family planning policy in China on the male to female sex ratio at birth after matching on the basis of demographic and maternal clinical characteristics. We found that the relaxed policy resulted in a statistically significant decline in the male to female sex ratio at birth. Specifically, we found that the policy resulted in a decline in the infant male to female sex ratio from 1.10 to 1.05 over the 5-year study period, 2013–2018. This change meant that relaxation of the one-child policy resulted in an approximate 4.5% decline in the male to female sex ratio. Further exploration revealed that the policy effect was driven mainly by first birth parity, migrant status, and maternal age. The relaxation of the family planning policy in China represents a unique natural experiment in which to estimate the effect of the policy shift on gender imbalance in China. Conducting matching and difference-in-differences analysis to directly investigate the relationship between the policy shift and sex imbalance at birth, revealed that gender inequity has improved as a result of the two-child policy. This paper is the first study to estimate the relationship between China's relaxed family planning policies and gender imbalance. Our results were found to be robust to matching on social-demographic and health factors and also to a range of sensitivity analyses.

Appendix 1

Covariate Balance in Estimating the Average Treatment Effect of Ethnic Status the Word Test Score.

Variable	Unmatched Matched	Mean		%bias	%reduct	t-test		V(T)/ V(C)
		Treated	Control		|bias|	t	p > |t|	
Migrant status	U	.388	.632	−50.30		−20.98	.000	
	M	.385	.394	−1.900	96.30	−.530	.596	
Age	U	31.20	30.69	13		5.470	.000	1.060
	M	31.09	31.01	1.800	86.10	.540	.587	1.16*
Occupation	U	.908	.938	−11.50		−5.250	.000	
	M	.910	.929	−7.200	37.50	−2.020	.043	
Nationality	U	.875	.999	−53		−110.90	.000	
	M	.915	.915	0	100	0	1.000	
Marriage	U	.997	.998	−1.900		−.890	.374	
	M	.998	.998	−.100	93.60	−.0400	.972	
Insurance	U	.597	.615	−3.700		−1.540	.124	
	M	.624	.652	−5.700	−55	−1.680	.093	
Gravida	U	1.875	1.809	6		2.530	.011	1.030
	M	1.864	1.788	7	−15.20	2.030	.043	1.070

(continued)

(continued)

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p > |t|	V(T)/ V(C)
Parity	U	1.257	1.250	1.500		.650	.513	1.13*
	M	1.248	1.237	2.400	−54.10	.670	.505	1
High risk	U	.612	.536	15.30		6.270	.000	
	M	.606	.605	.100	99.60	.0200	.987	
Mod	U	.401	.407	−1.200		−.500	.620	
	M	.400	.380	4	−237.6	1.170	.241	
Gestation week	U	38.98	39.01	−2		−.840	.402	1.11*
	M	38.99	39.10	−7	−257.5	−2.050	.041	1.14*
ivf	U	.0344	.0351	−.400		−.170	.862	
	M	.0318	.0227	4.900	−1078	1.610	.108	

Author Contributions

Di Tang, Xiangdong Gao, Peter. C. Coyte contributed to the design of the study. Di Tang wrote the first draft, Peter. C. Coyte and Jiaoli Cai critically revised the paper for important intellectual content. All authors approved the final version.

Declaration of Conflicting Interests

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Ethical Approval

Our study was approved by the Ethics Committee of the Shanghai First Maternity and Infant Hospital. Date of approve: Jun 13, 2018. Ethical acceptance number: (2018) No. (35).

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