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Beyond the Quantity–Quality tradeoff: Population control policy and human capital investment

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ABSTRACT

The quantity–quality tradeoff theory implies that a reduction in fertility would induce more human capital investment per child, and it is widely believed that population control policy could promote human capital levels in developing countries. China's one-child policy (OCP) has significantly reduced the fertility in the country, and popular belief holds that this policy has contributed to the enhancement in China's human capital since 1979. However, the quantity–quality tradeoff dose not present the complete truth—another crucial factor relates to which segment of the population is reduced, a critical issue that has been ignored in the literature. China's OCP is significantly more strictly implemented in urban areas than in rural areas, where human capital investment in children is significantly lower. This two-tier OCP could have significantly increased the rural–urban fertility ratio and brought about important consequences. We first emphasize the importance of such a population compositional effect, which may offset the potentially positive quantity–quality tradeoff effect on human capital. We present a simple analytic framework and quantify the relative sizes of the quantity–quality tradeoff and compositional effects. We find that the former is dominated by the latter, and that the OCP has reduced the average human capital level of China's next generation by approximately 1–2%. This novel evidence indicates that the conventional wisdom on population control may be incomplete and that its policy implications could be misleading.

1. Introduction

In the modern world, high-income countries are characterized by low fertility and high human capital levels, whereas low-income countries are characterized by high fertility and low human capital levels. Although high fertility is usually linked with poverty, the causal relationship is ambiguous and poverty may be the cause rather than the consequence of high fertility (Dasgupta, 1995). However, popular belief holds that a reduction in fertility would increase the human capital investment per child. According to the quantity–quality tradeoff theory introduced by Becker and Lewis (1973), given a family's limited resources, a small family size allows for the allocation of more resources to each child, thereby increasing the average child quality. Human capital accumulation is one of the most fundamental factors that determine the long-term economic growth (Galor and Weil, 2000; Glaeser et al., 2004). Therefore, if the quantity–quality tradeoff exists, it seems rational for the governments to adopt population control policies to reduce family sizes and promote human capital investment in children, particularly in developing countries where low human capital levels usually hinder economic progress. However, the truth is not as simple as it seems at first glance. The one-child policy (OCP) in China provides a perfect natural experiment to study the effect of population control policies on human capital.

The OCP was implemented from 1979. Actually, as shown by Zhang (2017), even before the implementation of this policy, China begun a voluntary yet strong family planning campaign in 1971, with the propaganda theme: “One child isn't too few, two are just fine, and three are too many.” Shortly after that, in the national birth planning conference in 1973, the Chinese government endorsed the slogan: “Later, Longer, and Fewer”, in which “Later” meant the late marriage requirements for women (23 years) and men (25 years), “Longer” meant a birth planning rule of more than three years between the first and second child, and “Fewer” implied that a couple could have two children at most. This family planning campaign was very successful, and China's overall fertility rate was halved between 1971 and 1978. Since 1979, China tightened and made its birth control policy coercive, after which each

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couple was limited to having only one child and those households that exceed this limit would be penalized. It was the first time in human history for a government to control population growth by imposing an extremely strict birth quota on households. At that time, China was experiencing a very difficult economic situation, and implementing the OCP was considered necessary to relieve the great population pressure and facilitate its forthcoming economic takeoff.

The OCP was designed to reduce the population growth rate and promote the population quality of the country. This policy, which promoted "fewer children, higher population quality," effectively reduced fertility in the country (Li et al., 2005; Cai, 2010). Many studies found a tradeoff between the number of children and child quality in China, arriving to the conclusion that China's OCP promoted the human capital level of the next generation (Li et al., 2008; Rosenzweig and Zhang, 2009). Li et al. (2008) further pointed out that such an enhancement of human capital could have contributed to China's economic takeoff over the past decades.

However, the quantity–quality tradeoff does not present the complete truth—another crucial factor relates to which segment of the population is reduced. In an extreme example, assume that urban and rural women would each bear 10 children without the OCP, and that the human capital investment per child in urban areas was substantially higher than that in rural areas. Further, assume that the OCP would reduce rural and urban households by one child and nine children, respectively (leaving nine children and one child, respectively). Although the OCP reduced fertility in both areas and we observe that human capital investment in both rural and urban areas increased, the human capital level of the whole country decreased because the country lost almost all of its urban children, in whom human capital investments are highest. Therefore, to fully evaluate the effect of China's OCP, we must consider not only the children that were allowed to be born, but also the reduced population. Specifically, if the foregone population is precisely among those who would potentially have gained the most valuable human capital if their birth had been allowed, then the human capital level of the whole country may well decline.

This situation is observed in China. The OCP is much more strictly implemented in urban areas than in rural ones (Zhang and Spencer, 1992; Ahn, 1994). Such a rural–urban difference does not result from the original intention of the government but from the difficulty of controlling the birth behavior of rural residents. In fact, in the initial period, the OCP was strictly implemented in both rural and urban areas. However, it was extremely difficult to implement such a policy in rural areas, and many rural families, particularly those with only one female child, strongly resisted the policy (Zhang, 2017). Given the difficulty of strictly implementing the one-child policy in rural areas in reality, the government relaxed the policy in 1984 and allowed rural Han women to have a second child if the first child was female (Scharping, 2003). Later, a second child was generally allowed in many rural areas (Rosenzweig and Zhang, 2009).

Such a two-tier population control policy is closely related to the rural–urban divide in China. Zhang (2017) argued that Chinese urban residents usually enjoy a high level of social welfare over a long period and are thus closely linked with the government and can be more closely and directly affected by its policies and measures. Specifically, if urban residents have more than one child, they will not only have to pay a high fine but also may lose their jobs and all related social welfare. Therefore, failure to abide by the OCP is costly for urban residents. By contrast, Zhang (2017) pointed out that because rural residents receive few benefits from the government, they have nothing or little to lose. In reality, rural residents only have to pay a one-time fine for exceeding the birth quota, and this penalty is typically ineffective because many rural families are too poor to pay the fine. In addition, the traditional idea that having more children would bring more happiness is prevalent in rural areas and the rural households are therefore more willing to pay the price for having more children. Therefore, these situations have resulted in urban families facing an extremely tight birth control and rural families dealing with a relatively soft constraint.

This two-tier OCP may induce a significantly higher rural–urban fertility ratio. The rural–urban gap in China is huge. Specifically, compared with rural areas, urban areas have much better health, medical facilities and education systems, all of which are crucial to new-born babies. Therefore, given an increase in population concentrated in backward rural areas, the OCP may spur an adverse selection in terms of population quality.

This problem presents a classic case of adverse selection. China's rural–urban divide, along with its unique two-tier population control policy, actually facilitate such adverse selection. The OCP was designed to reduce the country's population. However, the policymakers could not control how people respond to the policy. Given that it was extremely difficult to control rural families' birth behavior, Chinese government adopted a two-tie OCP in reality. Although the implementation of this policy was already relaxed in rural areas and the maximum birth quota for each family was set to two instead of one, many rural couples still managed to have more than two children at a relatively lower cost. By contrast, given the extremely high price of disobeying the OCP in urban areas, having more than one child was almost impossible for urban couples. Therefore, the urban population was sharply reduced, whereas rural residents, who usually have fewer resources to invest in their children, were less affected by the policy; this may be completely contrary to the policymakers' goal.

In sum, the OCP reduced the size of rural and urban families but increased their human capital through the quantity–quality tradeoff. However, if urban fertility is reduced much more than the rural one, then the quantity–quality tradeoff effect may be dominated by a population compositional effect and the overall average human capital level of the country may well decline as a result of the adverse selection through the two-tier OCP.

We can draw important general lessons from such a compositional effect caused by the OCP. Specifically, even if a policy is perfectly designed and uniformly implemented across the entire population, heterogeneous responses across population to such policy may still play an important role and produce unsatisfactory outcomes that completely contradict the goal of policymakers. Given that the willingness and cost of breaching the policy greatly differ across heterogeneous population, the effects of such policy on these population may also greatly differ. Specifically, those people who are the primary targets of the policy may be able to violate such policy at a relatively low cost, whereas the non-targeted population may be coerced into fully abiding by this policy. Given that policymakers could not control how people respond to such a policy, it may bring about very unsatisfactory outcomes. Thus, policymakers should always take into account the potential heterogeneous responses of the targeted population when making and implementing any public policy. Although extremely challenging, this step is crucial in making an effective policy.

In this paper, we first emphasize the importance of the population compositional effect to human capital investment across the entire country. To facilitate our analysis, we present a simple analytic framework, in which we derive the mathematical expressions for both the compositional and quantity–quality tradeoff effects. We subsequently use this framework to investigate the effect of the OCP on the human capital level of the next generation. Our empirical results indicate that China's OCP did induce a much higher rural–urban fertility ratio, which implies a negative compositional effect that would counteract the potentially positive quantity–quality tradeoff effect on human capital. Finally, we quantify the relative sizes of these two effects and find that China's OCP reduced the average human capital level of the next generation in the country by approximately 1–2%.

2. Analytic framework

In this section, we present a simple framework to analyze the effect of the OCP on human capital. We first clarify the channels through which the OCP may affect the human capital investment decisions of families. This policy reduced the number of the children in families, thereby affecting the human capital investment in children. We assume this path is the only channel through which the policy can affect human capital accumulation. If a couple decided to have one child regardless of the existence of such a policy, then the OCP could not affect their number of children, and we would have no reason to expect their human capital investment decision to differ under the presence or absence of the policy. By contrast, if a family decided to have three children without the OCP and could have only one child under the policy, then the OCP could affect the average human capital level of the children in this family through the quantity–quality tradeoff channel. The mechanism is very clear and simple: the OCP reduced the number of children and thus affected their average human capital level for a given family budget.

We divide the population into two groups: "rural population" (G1) and "urban population" (G2). G1 has N_1 women of childbearing age, and G2 has N_2 such women. Suppose that the fertility levels of each group are denoted by n_1 and n_2, respectively. Hence, the number of children of G1 and G2 becomes n_1N_1 and n_2N_2. If the average levels of human capital investment per child of G1 and G2 are h_1 and h_2, respectively,[1] then we can obtain the average human capital level of the next generation as follows:

$$h = \frac{N_1 n_1 h_1 + N_2 n_2 h_2}{N_1 n_1 + N_2 n_2} \tag{1}$$

We assume that $h_1 < h_2$, that is, the average level of human capital investment per child in rural areas is lower than that in urban areas. This assumption captures the basic reality in China. Indeed, Chinese rural–urban disparity is considerable. Urban areas are generally much more developed than rural areas. The former have much better health, medical facilities and education systems than the latter, and urban families have more resources to invest in children. Therefore, urban children enjoy a considerably higher human capital investment than their rural counterparts.

China's OCP has significantly reduced the rural and urban fertility rates ($dn_1 < 0,\ dn_2 < 0$). We now examine how such a decline in fertility affects the human capital level of the entire population.

If within families, a tradeoff exists between the number of children and child quality in China, a decrease in n_1 (orn_2) will induce h_1 (or h_2) to increase, or $\frac{\partial h_1}{\partial n_1} < 0,\ \frac{\partial h_2}{\partial n_2} < 0$. However, it is not enough to conclude from this finding that China's OCP induces more human capital investment in the country. As we have emphasized earlier, another crucial factor relates to which segment of the population is reduced. We intend to emphasize that the policy reduces the fertility rate of the country but has less of an effect in rural areas, where the human capital investment in children is low compared with urban areas. Such a consequence can negatively affect the average human capital of the country. We define this process and consequence as the population compositional effect and put forward the following Proposition.

Proposition. *The human capital level of the next generation is determined by both the population compositional and quantity–quality tradeoff effects.*

Let $\alpha = \frac{N_1 n_1}{N_1 n_1 + N_2 n_2}$ be the rural share of the new population in the whole country. Thus, $1-\alpha$ is the corresponding urban share. In Appendix A, we show that:

$$dh = \underbrace{\alpha(1-\alpha)(h_2 - h_1)\left(\frac{dn_2}{n_2} - \frac{dn_1}{n_1}\right)}_{Compositional\ \ effect} + \underbrace{\left[\alpha \frac{\partial h_1}{\partial n_1} dn_1 + (1-\alpha)\frac{\partial h_2}{\partial n_2} dn_2\right]}_{Quantity-quality\ \ tradeoff\ \ effect}. \tag{2}$$

Thus, if $dh > 0$, then the average human capital level h will rise. Note that the second part of Equation (2) denotes the quantity–quality tradeoff effect on the average human capital level. Meanwhile, in the first part of Equation (2), $\frac{dn_2}{n_2} - \frac{dn_1}{n_1}$ denotes the difference in relative fertility reduction of the rural and urban areas, and thus its product with $h_2 - h_1$ represents a population compositional effect on human capital. In this framework, we can interpret the quantity–quality tradeoff as the within-family effect, which is the effect of reallocation of resources within rural and urban families on human capital. Meanwhile, the compositional effect can be interpreted as the inter-family effect (or more specifically, the inter-area effect), which is the effect of the differential fertility of heterogeneous families with different human capital investment levels on the average human capital of the entire population.

Define $x = \frac{n_1}{n_2}$, *which* is the rural–urban fertility ratio

(i) If $x = \frac{n_1}{n_2} \uparrow \Rightarrow \frac{dn_1}{n_1} > \frac{dn_2}{n_2}\left(or \left|\frac{dn_2}{n_2}\right| > \left|\frac{dn_1}{n_1}\right|\right)$, then the urban fertility was reduced more than the rural one and thus the rural–urban fertility ratio increased, the first part of Equation (2) is negative.

(ii) If $\frac{\partial h_1}{\partial n_1} < 0$ and $\frac{\partial h_2}{\partial n_2} < 0$, then a tradeoff exists between the number of children and child quality, and given $dn_1 < 0,\ dn_2 < 0$, the second part of Equation (2) is positive.

The human capital level will increase only if the sum of the two terms is positive. We cannot reach this conclusion merely because the policy has reduced fertility, resulting in a positive effect on human capital.

Equation (2) demonstrates the effect of the OCP on human capital at the margin. To evaluate the policy effect more generally, we need to determine the general form of Equation (2).

We rewrite the average human capital level of the next generation under the OCP as follows:

$$h = \frac{N_1 n_1 h_1 + N_2 n_2 h_2}{N_1 n_1 + N_2 n_2} = \alpha h_1 + (1-\alpha)h_2, \tag{1a}$$

where n_1, n_2,h_1 and h_2 are the fertility and average human capital levels of rural and urban areas under the OCP, respectively.

Similarly, if there were no OCP, the average human capital level would be:

$$h' = \frac{N_1 n_1' h_1' + N_2 n_2' h_2'}{N_1 n_1' + N_2 n_2'} = \alpha' h_1' + \left(1-\alpha'\right)h_2', \tag{1b}$$

where n_1', n_2', h_1' and h_2' are the fertility and average human capital levels of rural and urban areas if there were no OCP, respectively.

By comparing these two situations, we can observe that the OCP has reduced the rural and urban fertility from n_1' and n_2' to n_1 and n_2, respectively. Such fertility reduction increases the rural share of the new population from α' to α, and promotes the rural and urban human capital levels from h_1' and h_2' to h_1 and h_2, respectively.

In Appendix A, we show that:

$$\Delta h = h - h' = \underbrace{\left(\alpha - \alpha'\right)(h_1 - h_2)}_{Compositional\ \ effect} + \underbrace{\left[\alpha'\left(h_1 - h_1'\right) + \left(1-\alpha'\right)\left(h_2 - h_2'\right)\right]}_{Quantity-quality\ \ tradeoff\ \ effect}. \tag{2a}$$

Equation (2a) presents the general form of Equation (2), which we can use to evaluate the effect of the OCP on human capital in the empirical part.

In the next section, we empirically show that the OCP induced a much higher rural–urban fertility ratio (or a much higher rural share of the new population) and thus exerted a negative compositional effect on human capital. Finally, we use Equation (2a) to quantify the relative sizes of these two effects to check whether the OCP promoted or reduced the human capital level of the next generation.

[1] Equivalently, we can assume that the average human capital levels of the children within the representative families in rural and urban areas are h_1 and h_2, respectively.

3. Effect of the OCP on the population structure

In this part, we empirically investigate the effect of the OCP on China's population structure, particularly on its rural–urban population structure. Based on the proposed analytic framework, we now check whether China's OCP induced a much higher rural–urban fertility ratio (x).

The analytic framework clearly indicates that if x increases, then the population compositional change negatively affects human capital.

Although the OCP is more strictly implemented in urban areas than in rural areas, no empirical study has examined the effect of the policy on the population structure or more specifically on the rural–urban population structure. We empirically test whether this policy induced a much higher rural–urban fertility ratio.

We use the rural–urban age cohort cumulative fertility (CCF) ratio to measure x. CCF is the average number of children of a certain birth cohort in the census year. Intuitively, we can deduce that if rural women of the same age have more children than urban women have, then the total fertility rate (TFR) in rural areas will also be higher than that in urban areas. Therefore, the CCF ratio is an appropriate measurement of the relative fertility rate in rural and urban areas.[2]

It is reasonable to use the rural–urban fertility ratio to measure the effect of China's OCP on the population structure. The basic logic is as follows. If before the policy was introduced the rural and urban fertility rates were the same and equal to 4 (the rural–urban fertility ratio being 1), and if after the policy was introduced, the fertility rate decreased to 3 in rural areas and 1 in urban areas (the rural–urban fertility ratio being 3), then the policy not only reduced the fertility rate of the whole country but also changed the population structure evolution pattern, with the birth rate in rural areas becoming much higher than that in urban areas.

By adopting a Difference-in-Differences (DID) strategy, with the ethnic minorities serving as the control group for the Han and using the 1% sample of the 1990 Chinese Population Census, it is not difficult to test whether the policy has induced a rural–urban fertility ratio of the Han that is significantly higher than that of the minorities.

3.1. Difference-in-differences estimation strategy

China's OCP is special in that its implementation differs for the Han Chinese and ethnic minorities. Extremely tight control is imposed on Han women, whereas minority women face less strict restrictions. Specifically, Han women are generally allowed to have only one child, whereas minority women are normally allowed to have two or more children (Park and Han, 1990; Anderson and Silver, 1995; Qian, 1997). Although the government announced in April 1984 that birth control policies should also be in place for ethnic minorities, minority women were allowed to have more than one child for most of the 1980s (Li et al., 2005). Given that the OCP is strictly applied to only Han women, we can use the DID method to capture the policy effect on the population structure, with the Han serving as the treatment group and the ethnic minorities serving as the control group.

We use the following DID regression model to estimate the effect of the OCP on fertility and the population structure:

$$Y_{iHT} = \phi_0 + \phi_1 H_i + \phi_2 T_i + \phi_3 H_i T_i + \varepsilon_i, \tag{3}$$

where Y_{iHT} is the rural–urban fertility ratio of group i at either the country, province or prefecture level. H_i is the Han dummy, which equals 1 when Y_{iHT} is a variable for Han women. T_i is the policy timing dummy, which equals 1 if Y_{iHT} is a variable for women in the post-treatment group. ϕ_3 is the DID estimator of interest. If we assume that the Han and minorities are identical except for their exposure to different birth control policies, then ϕ_3 identifies the policy effect.

This DID strategy carries a strong underlying assumption that the Han and minorities are similar in many ways and share a common trend in fertility if the OCP was not implemented. As argued in Li et al. (2005), this key assumption of the DID method is that the changes in the fertility of the Han and minorities would have been the same if the OCP does not exist. However, other policy shocks or changes in the social–economic variables had occurred during the period may affect the fertility behavior of the Han and the minorities differently, then the DID method might pick up these effects. Thus, this assumption is not always true in reality. Specifically, the minorities, especially those who live in remote areas, may differ greatly from the Han in many ways.

We adopt a strategy similar to the matching method to resolve this problem. As we show later, the difference between the Han and minorities could make our estimates less significant, and thus the DID estimate at the national level actually provides a lower bound of the policy effect. Furthermore, as we gradually reduce the difference between the Han and minorities by restricting our samples to those where the Han and minorities are increasingly similar, and finally obtain a sample in which the Han and the minorities are nearly identical, we find that our estimates become larger and more significant, which presents strong evidence of the treatment effect.

We examine the effects of the OCP on the rural-urban fertility ratio at the national, provincial, and prefectural levels, respectively. We find that even at the national level, in which the differences between the Han and minorities are significant, the DID estimates remain not negligible. We further find that at the provincial and prefectural levels, the estimates for the restricted samples, in which the Han and minorities have been living together for many years and are therefore similar in many ways, become much larger and more significant. We discuss these results in details in Section 3.4.

3.2. Data

We use the 1% sample of the 1990 Chinese Population Census from the Chinese National Bureau of Statistics as our dataset. The data cover 2,832,103 households, with a record for each household. Each record includes information on demographic characteristics, occupation, education levels, ethnicity, household type (rural or urban) and the fertility of each individual living in the household.

For the purpose of our analysis, and following Li et al. (2005), we restrict our sample to women aged between 20 and 64 in the census year. We further exclude individuals whose "marital status" is "never married," "widowed," or "divorced" and include only "married" women. The OCP does not affect those women who are not married.[3] It is impossible to capture the full effect of the OCP on the fertility of those who are widowed or divorced; thus, we also exclude them. The married women in our sample are the primary targets of the OCP. We also exclude a few women of unknown household type (rural or urban) or ethnicity (Han or minority). We ultimately obtain a sample of 2,759,794 women. We summarize the major variables in Table 1.

Table 1 shows that, on average, rural women bear more children than do urban women, whereas the minority women bear more children than Han women, whether in rural or urban areas. Examining the standard deviation (SD) of the number of children, the rural SD is larger than the urban SD, whereas the minority SD is significantly larger than the Han SD. These findings may partly reflect that the birth control policy was more strictly implemented in urban areas and over the Han than in rural

[2] Rural women may marry and bear children earlier than urban women. We show later that such rural-urban difference does not present a problem for our DID strategy. In fact, if we select the minorities as the control group for the Han, we control for all of the rural-urban differences if there is no significant difference between the Han and minorities except their exposure to different birth control policies. Of course, we must confirm whether there is really no difference between the Han and minorities.

[3] We also exclude the very few women who bore children before marriage, as their acts were illegal; these women are "outliers" in the sample.

Table 1
Summary statistics.

Variables	Whole sample	Rural-Han	Rural-Minority	Urban-Han	Urban-Minority
	Mean (S.D)	Mean (S.D)	Mean (S.D)	Mean (S.D)	Mean (S.D)
Observations	2,759,794	1,955,654	160,462	611,421	32,257
Age	37.16	36.86	36.44	38.31	37.03
	(11.50)	(11.58)	(11.6)	(11.34)	(10.99)
Number of children	2.49	2.62	2.89	1.96	2.35
	(1.67)	(1.68)	(1.88)	(1.47)	(1.82)
Number of children by birth cohort					
1963–1970	1.11	1.17	1.28	0.78	0.92
	(0.80)	(0.81)	(0.92)	(0.55)	(0.73)
1952–1962	2.00	2.21	2.65	1.24	1.75
	(1.00)	(0.95)	(1.24)	(0.61)	(1.08)
1944–1951	3.01	3.19	3.80	2.26	2.76
	(1.27)	(1.19)	(1.60)	(1.04)	(1.44)
1925–1943	4.24	4.46	4.54	3.57	3.85
	(1.72)	(1.71)	(1.91)	(1.52)	(1.70)

Note: All sampled women are aged from 20 years to 64 years and are married in the census year.

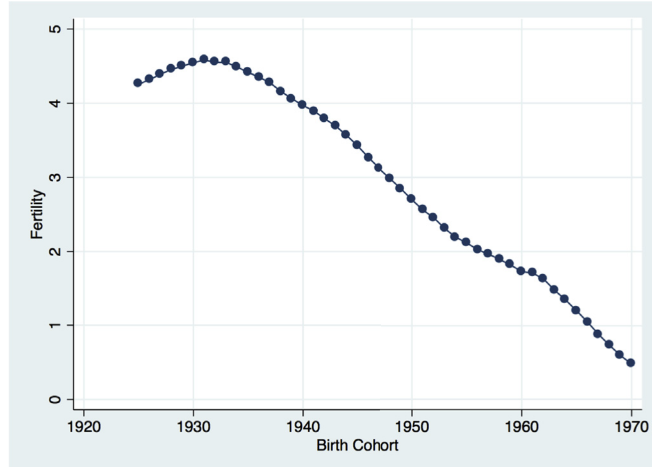

Fig. 1. Age cohort cumulative fertility by birth cohort (whole sample).

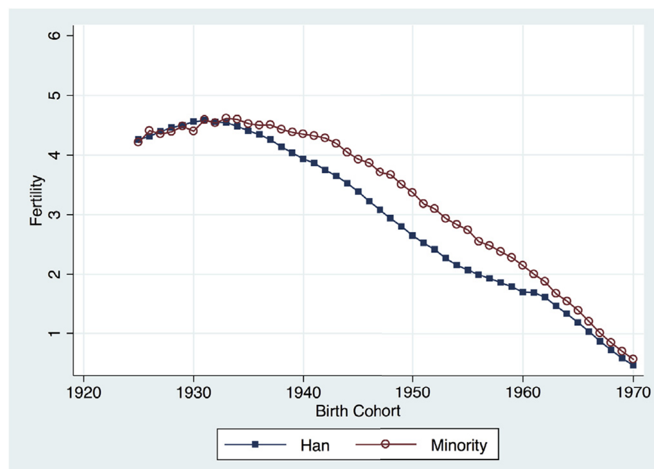

Fig. 2. Han and minority fertility by birth cohort.

areas and over the minorities.[4] These findings are discussed in detail in this paper.

Table 1 also shows that the fertility of the rural minority decreases more than that of the rural Han from the 1944–1951 to 1952–1962 birth cohorts. This result seems strange at first glance. Specifically, if the OCP applies only to the Han, then why does the fertility of the rural minority decrease more than that of the rural Han? The fertility of the rural minorities who live in remote areas is initially much higher than that of the rural Han, and with economic development and social progress, these minorities are increasingly integrated with the Han; thus, their fertility declines more sharply. Therefore, aside from the OCP, other social factors also contribute to the decline in Chinese fertility. To identify the treatment effect, we must select the sample in which the Han and minorities are nearly identical despite their exposure to different birth control policies.

3.3. Pre- and post-treatment groups

The DID framework requires a classification of pre- and post-treatment groups. We have only the cross-sectional census data for 1990, with all women affected by the OCP in that census year. Therefore, no obvious pre- or post-treatment groups are present. Following Li et al. (2005), we divide the entire sample into pre- and post-treatment groups based on women's age in the census year. Li et al. argued that a woman who was 25 years old in 1979 was more affected by the OCP than a woman who was 50 years old in the same year, because older women had fewer remaining childbearing years. Here, we adopt a similar strategy to identify the pre- and post-treatment groups. Specifically, we include those older women who are less affected by the policy in the pre-treatment group, and include those younger women in the post-treatment group.

We need to determine the cutoff age for the pre-treatment and post-treatment groups based on the information provided by the data. We start by plotting some figures based on the data.

Fig. 1 shows the CCF of the whole sample by birth cohort. Except for the initial 1925–1931 birth cohorts, the CCF decreases continuously over time. Such a decrease may partly reflect households' decreasing demands for children within the developing economy and partly the effect of the OCP implemented in 1979.[5] Fig. 2 plots the CCF of the Han and minority women by birth cohort. For the initial birth cohorts, the fertility rate of the minorities is nearly the same as that of the Han. The fertility gap between the minorities and Han is then expanded, which may be an effect of the OCP on Han Chinese. Finally, the gap shrinks to near 0, which may indicate that the women who belong to the later birth cohorts are too young to be fully affected by the OCP in the census year; this point is discussed further below.

Figs. 3 and 4 show the rural–urban CCF ratio of the whole sample and the Han and minority samples, respectively. Fig. 3 shows that the rural–urban fertility ratio for the whole sample keeps increasing initially, perhaps due in part to the stricter implementation of the OCP in urban areas.[6] Fig. 3 also shows that, from around the 1960 birth cohort, the rural–urban fertility ratio begins to decrease. Perhaps because women under 30 years old have not usually finished their childbearing history, and many do not even have a child; thus, both rural and urban women belonging to these cohorts have fewer children, causing the rural–urban fertility ratio decrease closer to 1. In brief, the policy effect on these cohorts has not yet been fully captured up to the census year. Fig. 4 shows

[4] A stricter policy results in a smaller SD. In an extreme case, the policy is so strict that each woman bears only one child and the SD equals 0.

[5] Another obvious point here is that younger women have not finished their childbearing history and may therefore currently have fewer children.

[6] We certainly cannot exclude other possibilities, such as an expanded rural–urban gap and a sharper decrease in the demands of urban households for their children compared with those of rural households. However, by taking the minorities as the control group for the Han, we can control these rural–urban differences to a large degree.

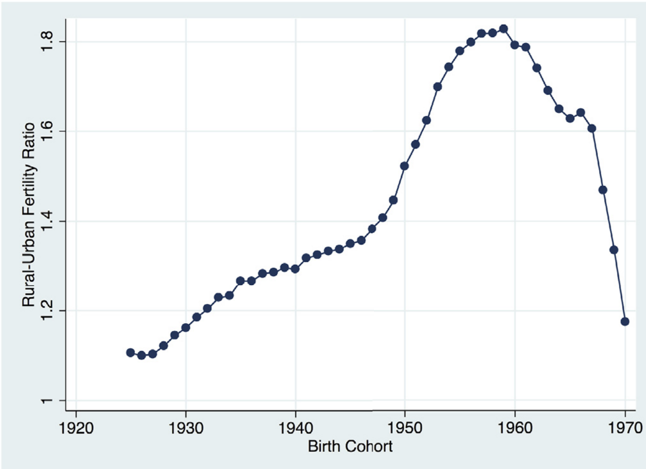

Fig. 3. Rural–urban fertility ratio by birth cohort (whole sample).

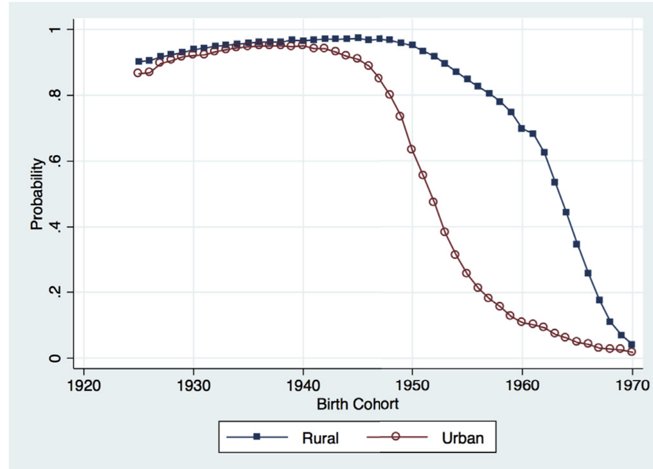

Fig. 5. Probability of having a second child by birth cohort.

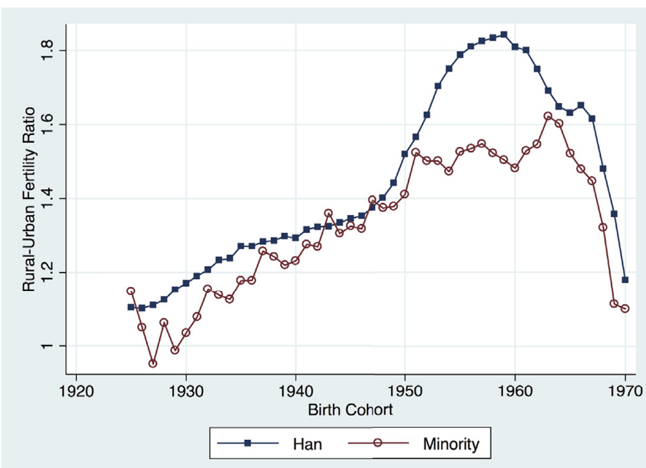

Fig. 4. Rural–urban fertility ratio by birth cohort.

a similar pattern. For the 1952–1962 birth cohorts, the rural–urban fertility ratio of the Han is significantly higher than that of the minorities, from which we can deduce that these women are probably the most affected by the OCP. Older women are less affected by the policy because they already have more than one child, whereas younger women are not fully affected by the policy because they have not yet finished their childbearing history.[7]

Fig. 4 shows that the difference between the Han and minorities decreases to 0 around the 1943 birth year. Therefore, we take the 1943 birth year as the cutoff age for the pre-treatment group, as it marks a turning point before which the women are less affected by the OCP and after which the policy effect becomes increasingly evident. Similar information can be deduced from Fig. 5, which shows the probability of rural and urban Han women to have a second child by birth cohort. These two figures nearly coincide at the beginning, and an increasingly evident rural–urban gap subsequently appears, in which the rural women show a much higher probability of having a second child than urban women, probably due to the stricter implementation of the OCP in urban areas. For the urban Han Chinese women of the 1943 birth cohort, the probability of having a second child is still almost 95%, after which it gradually decreases. The OCP is strictly implemented among the urban Han women. However, that almost all of the urban Han women of the 1943 and earlier cohorts have a second child by 1990 indicates that they probably have already had their second child before the implementation of the OCP, and thus they are hardly affected by the policy. By contrast, women born after 1943 are increasingly affected by the policy.[8] Therefore, the birth year of 1943 can reasonably be used as the cutoff age for the pre- and post-treatment groups. Although the women of the 1943 and earlier cohorts are included in the pre-treatment group, they are not completely unaffected by the OCP, and are only less affected than the younger women. Similarly, although the later cohorts belong to the post-treatment group, many of these women had already borne more than two children when the policy was implemented; thus, they are not fully affected by the policy.[9] This makes our DID estimate less significant. Therefore, a significant DID estimate would indicate a potentially larger policy effect.

The difference between rural and urban women in terms of their probability of having a second child may not be induced by the OCP alone. Fig. 6 provides additional information on this issue. Although the minorities are generally allowed to have a second child, rural minority women are more likely than urban minority women to have a second child after the 1943 birth cohort. Such a rural–urban difference may partly reflect that urban households' demand for children decreases more sharply than that of rural households. To identify the effect of the OCP, we should choose the minorities as the control group for the Han to control for the factors such as rural–urban differences, which may also induce the effect that our DID estimate aims to pick up. Therefore, we plot the Han and minority rural–urban differences in the probability of having a second child in Fig. 7. Even compared with the minorities, the Han rural–urban difference is significantly higher, which may be the result of the effect of the OCP for the Han. Again, if we select 1943 as the cutoff birth year, then the Han-minority difference for the 1943–1951 birth cohorts is not very significant, whereas that for the 1952–1962 birth cohorts reaches its peak. These results are unsurprising; as mentioned earlier, the 1952–1962 birth cohorts are most affected by the OCP.

Although we select 1943 as the cutoff birth year between the pre- and

[7] Fig. 4 is also critical for confirming whether the common trend assumption holds at the national level. We discuss this further in Appendix B.

[8] Fig. 5 is drawn on the basis of the 1990 census data. The figure shows that most urban Han women of the 1943 and earlier cohorts have a second child by 1990. However, we also find that for most of these women of the 1925–1943 birth cohorts who have more than 2 children in 1990, their youngest child is already older than 11 years old in 1990, implying that they have already had more than 2 children by 1979.

[9] Fig. 5 shows that even for the 1951 birth cohort, nearly 60% of the Han Chinese urban women have had a second child.

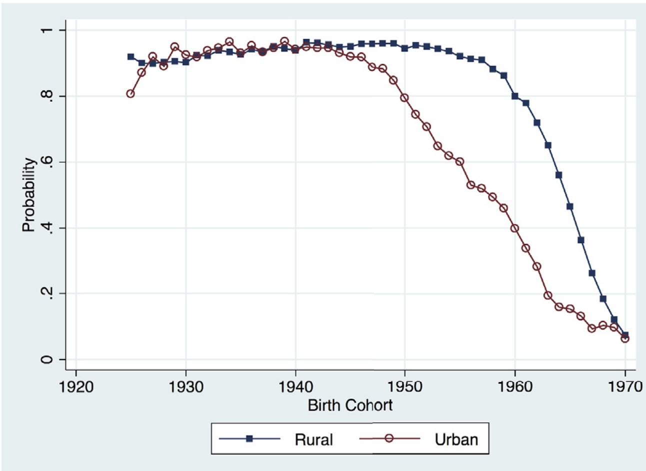

Fig. 6. Probability of having a second child by birth cohort.

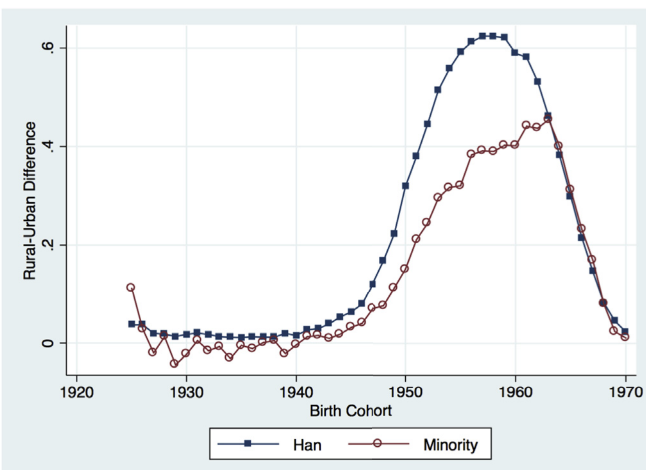

Fig. 7. Probability of having a second child by birth cohort.

post-treatment groups, the dividing line is evidently not unique. We can also select other cutoff birth years, such as 1942 or 1944, as the dividing birth year. The results are not sensitive to the cutoff point. The essential point is that earlier birth cohorts are less affected by the OCP than the later birth cohorts and we can obtain the treatment effect through such a divide.

3.4. Empirical results

The preceding analysis reveals that the OCP probably induces a significantly higher rural–urban fertility ratio for the Han than for the minorities. We now empirically test whether this finding is actually the case.

First, we use the DID framework to check whether the rural–urban fertility ratio of the Han is significantly higher than that of the minority at the national level after the implementation of the OCP. As previously discussed, we take the 1925–1943 birth cohorts as the pre-treatment group and the 1944–1970 birth cohorts as the post-treatment group. The basic process involves calculating the Han and minority rural–urban fertility ratio of each birth cohort and determining whether the rural–urban fertility ratio of the Han increases more than that of the minority after the introduction of the OCP.

We use the following regression model:

$$Y_i = \phi_0 + \phi_1 H_i + \phi_2 T_i + \phi_3 H_i T_i + \varepsilon_i, \tag{4}$$

where Y_i is the (Han or minority) rural–urban fertility ratio of the i year birth cohort. H_i is the Han dummy, which equals 1 when Y_i is the Han rural–urban fertility ratio of the i year birth cohort. T_i is the policy-timing dummy, which equals 1 if birth year i is in the post-treatment birth cohorts ($1944 \le i \le 1970$). ϕ_3 is the DID estimator, which is likely to capture the effect of the OCP.

We expect the DID estimator (ϕ_3) to be positive, indicating that the OCP induces a rural–urban fertility ratio of the Han Chinese that is significantly higher than that of the minority. However, the results of the first column in Table 2 contradict our expectations, indicating that our DID estimate for the whole post-treatment group is only slightly larger than 0 and not statistically significant. However, the insignificant overall estimate does not imply that the policy effect does not exist. As mentioned earlier, the 1952–1962 birth cohorts are most affected by the OCP, whereas the 1944–1951 birth cohorts are less affected by the policy (because many of them have already had more than one child by the time of the policy implementation), and the 1963–1970 birth cohorts are also not fully affected (because they usually have not finished their fertility history up to the census year). Therefore, a policy effect is found if the estimate for the most affected 1952–1962 birth cohorts is significant.

Thus, we divide the post-treatment group into three subgroups: the 1944–1951, 1952–1962 and 1963–1970 birth cohorts. Such a division is meaningful. As shown in Fig. 4, the difference in the rural–urban fertility ratio between the Han and minorities for the pre-treatment group (1925–1943 birth cohorts) is actually larger than 0, and it decreases to around 0 for the 1944 birth cohort. This difference is expected to increase after 1944 because women are increasingly affected by the OCP. However, it takes time for the difference to gradually exceed the previous level, during which the rural–urban fertility ratio of the Han will not be significantly higher than that of the minorities. Therefore, we take the 1944–1951 birth cohorts as the transition group and the 1952–1962 birth cohorts as the crucial post-treatment group that fully reflects the effect of the OCP. We should also specify the 1963–1970 birth cohorts, as in the census year the women of these cohorts are only 20–27 years old; many of them have only recently been married and are still childless, indicating that they are not fully affected by the policy.

As shown in Table 2, for the 1944–1951 birth cohorts, the DID estimate is slightly smaller than 0 and is not significant, which we explain as the result of a transition process. For the 1952–1962 birth cohorts, the DID estimate is 0.190 and significant at the 1% level, which is consistent with our expectations. For the 1963–1970 birth cohorts, the DID estimate becomes smaller and not significant, which is unsurprising because the women of this group are too young to be fully affected by the policy in the census year.

Table 2 presents the first evidence of the effect of the OCP on the

Table 2
Difference-in-differences estimates of the effect of the OCP on the rural–urban fertility ratio (national level).

Variables	Post-treatment group (birth cohorts)			
	1944–1970 (1)	1944–1951 (2)	1952–1962 (3)	1963–1970 (4)
Han	0.071	0.071**	0.071***	0.071*
	(0.045)	(0.029)	(0.026)	(0.042)
Time	0.286***	0.224***	0.360***	0.246***
	(0.042)	(0.038)	(0.031)	(0.055)
Han × Time	0.085	−0.033	0.190***	0.060
	(0.059)	(0.054)	(0.044)	(0.077)
Constant	1.16***	1.16***	1.16***	1.16***
	(0.032)	(0.021)	(0.019)	(0.030)
N	46	27	30	27

Notes: Standard errors are shown in parentheses. ***, **, and * represent $p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively. The dependent variable is the rural–urban fertility ratio of each birth cohort. The pre-treatment group of all four regressions is the 1925–1943 birth cohorts. N denotes the total number of birth cohorts involved in the regression.

rural–urban fertility ratio. However, such effect warrants further investigation. Despite its convenience, merely checking the effect of the OCP at the national level is far from sufficient. For more accurate and robust results, we examine the effect of the policy on smaller units.

China is a vast and substantially diverse country. The Han and minorities from various areas of the country may differ in many aspects. Therefore, at the national level, the minorities may not be an appropriate control group for the Han. In such a case, the DID method can provide only rough estimates of the policy effect. More importantly, the key assumption of the DID method is that without the OCP, the changes in the fertility of the Han and minorities would have been the same. If other policy shocks or changes in the socio–economic variables occurred during the period that affected the fertility behavior of the Han and the minorities differently, then the DID method might pick up these effects (Li et al., 2005). At the national level, other shocks are likely to affect the Han and minorities in various regions differently. However, the Han and the minorities within the same prefecture or county are not only more similar, but also more likely to be affected symmetrically by other shocks.

We first investigate the effect of the policy on the rural–urban fertility ratio at the provincial level. The difference between the Han and minorities within the same province is usually much smaller than that at the national level. Furthermore, although a national OCP was applied throughout the whole country, local birth control policies, such as penalties for above-quota births, could vary across regions (e.g., provinces and prefectures) (Li et al., 2005). Therefore, at the provincial or prefectural level, we can specify the effect of the OCP more accurately, and the DID estimate becomes more robust.

Thirty provinces and municipalities were included in the census year. We calculate the rural–urban fertility ratios of four groups (Han or minority, pre-treatment or post-treatment) in each province or municipality, and check whether the rural–urban fertility ratio of the Han Chinese increased more than that of the minority after the implementation of the OCP.

We use DID regression model (3) to capture the policy effect. Here, Y_{iHT} is the rural–urban fertility ratio of province i. H_i is the Han dummy, which equals 1 if Y_{iHT} is the Han rural–urban fertility ratio of province i. T_i is the policy-timing dummy, which equals 1 if Y_{iHT} is the rural–urban fertility ratio of the post-treatment cohorts of province i. Again, ϕ_3 is the DID estimator of interest.

We expect the DID estimate to be significantly positive, implying that, at the provincial level, the OCP induces a rural–urban fertility ratio of the Han that is notably higher than that of the minorities. However, as shown in the first column of Table 3, the DID estimate for the whole sample is only slightly larger than 0 and not significant, which seems strange yet can be easily explained. China consists of 30 provinces that considerably differ in many ways. We can roughly divide China into three regions: the western, central, and eastern regions. Provinces in the western region are economically backward, with special minority groups living in remote mountainous areas cut off from the Han. Therefore, the minorities in these regions, particularly those living in the rural areas, may differ significantly from the Han in various ways. In this sense, they do not constitute a proper control group for the Han and may render our DID estimate inconsistent with our expectation. By contrast, the eastern region provinces are always developed areas in which the Han and minorities have been living together for many years and are therefore similar in many ways. The provinces in the central region are between the eastern and western regions in terms of development level.

Columns 2–4 of Table 3 show the estimates for the eastern, central, and western regions, respectively. As expected, our DID estimate for the eastern region is significantly positive, indicating that the minorities are a proper control group for the Han in these areas; thus, the DID estimate accurately captures the effect of the OCP. In the central region, the minorities are not a perfect control group for the Han and the DID estimate is smaller and insignificant. In the western region, the minorities are very different from the Han and our DID estimate yields a negative value.

Although we obtain a rough estimate of the policy effect at the provincial level, the sample size is too small and thus the results may not be sufficiently convincing. We then investigate the effect of the policy on the rural–urban fertility ratio at the prefectural level. Similar to the investigation at the provincial level, we use regression model (3) and perform the same analysis for each prefecture.

Table 3
Difference-in-Differences Estimates of the Effect of the OCP on the Rural–Urban Fertility Ratio (Provincial Level).

Variables	Dependent variable: Rural–urban fertility ratio (of each province)			
	Whole sample (1)	Eastern region (2)	Central region (3)	Western region (4)
Han	0.066*	−0.017	0.079	0.133**
	(0.038)	(0.061)	(0.058)	(0.064)
Time	0.175***	−0.007	0.201***	0.324***
	(0.038)	(0.061)	(0.058)	(0.064)
Han × Time	0.054	0.170*	0.075	−0.066
	(0.054)	(0.087)	(0.082)	(0.090)
Constant	1.20***	1.31***	1.14***	1.14***
	(0.027)	(0.043)	(0.041)	(0.045)
N	28	10	7	11

Notes: Standard errors are shown in parentheses. ***, **, and * represent $p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively. N denotes the number of provinces involved in the regression. Given that Shanghai has no rural minority sample and Tibet has no rural Han sample, we exclude both provinces in the analysis, thereby leaving us with 28 provinces. Our classification of the three regions is similar to that of the Chinese government, which is roughly based on the location and level of economic development of each province in the census year. The eastern region comprises 11 provinces and municipalities, including Heilongjiang, Jilin, Liaoning, Beijing, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, and Guangdong. The central region comprises seven provinces, including Hebei, Shanxi, Henan, Anhui, Hubei, Hunan, and Jiangxi. The western region comprises 12 provinces, including Shanxi, Gansu, Inner Mongolia, Ningxia, Qinghai, Xinjiang, Sichuan, Guizhou, Yunnan, Guangxi, and Hainan.

We have 347 prefectures in all. We first restrict our sample to those prefectures that with at least 10 women for all 8 groups (Han Chinese or minority, rural or urban, pre- or post-treatment), as too few observations may not represent the population accurately and thus such observations may need to be dropped.[10] In this way, we eventually identify 95 qualified prefecture-level cities. We continue using regression model (3), with the only difference of designating i to represent each prefecture instead of each province.

For these 95 prefectures, the empirical results are shown in the first column of Table 4. Our DID estimate is slightly larger than 0 and significant at the 10% level. It seems that the policy effect on the rural–urban fertility ratio at the prefectural level is modest at most. However, re-examining these 95 prefectures, we discover that many are autonomous or have at least one autonomous county. These prefectures are generally residential areas of the minorities and, as mentioned earlier, usually have special minority groups living in remote mountainous areas cut off from the Han. Therefore, the minorities in these prefectures, specifically those in rural areas, may be different from the Han in many ways. In this sense, these minorities are not a proper control group; thus, it is not surprising that we obtain only a small DID estimate for the whole sample.

We further restrict our sample to prefectures wherein the Han and minorities are already well integrated and assimilated. As stated, in the eastern region the Han and minorities are usually living together and similar in many ways. By contrast, the differences between the two groups in the western and central regions are not negligible, particularly in those residential areas of the minorities. Therefore, we exclude the

[10] Another critical point here concerns the exact dividing line of a small sample size. We take 10 as the lower bound, which may still seem small. Fortunately, we do not have to struggle with this problem. Even when we take 20 or more as the lower bound of the sample size, we obtain similar results, indicating that our strategy is robust, only at the price of having fewer prefectures left.

Table 4
Difference-in-differences estimates of the effect of the OCP on the rural–urban fertility ratio (prefectural level).

Variables	Dependent variable: Rural-urban fertility ratio (of each prefecture)	
	Whole sample (1)	Restricted sample (2)
Han	0.013	−0.037
	(0.027)	(0.030)
Time	0.120***	0.028
	(0.027)	(0.030)
Han × Time	0.064*	0.156***
	(0.038)	(0.042)
Constant	1.22***	1.27***
	(0.019)	(0.021)
N	95	64

Notes: Standard errors are shown in parentheses. ***, **, and * represent $p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively. The whole sample contains all of the prefectures that include at least 10 women aged from 20 years to 64 years for each of the 8 groups (Han or minority, rural or urban, pre-treatment or post-treatment). The restricted sample is obtained from the whole sample by excluding the autonomous prefectures and those prefectures with at least one autonomous county in the western and central regions. N denotes the number of prefectures involved in the regression.

autonomous prefectures and those prefectures with at least one autonomous county in the western and central regions. Sixty-four prefectures remain, most of them within the central and eastern regions. In these prefectures, the Han and minorities usually exhibit no significant difference. Therefore, if we consider only these 64 prefectures, the minorities may serve as a good control group for the Han, and our DID estimate may accurately capture the effect of the OCP. In Appendix C, we examine the education levels of the Han and minorities to confirm that the differences between them at the national level and at the prefectural level are consistent with our previous discussion.

The regression results for the restricted 64-prefecture sample are shown in the second column of Table 4. The DID estimate becomes considerably larger and significant at the 1% level, suggesting that for those prefectures without significant difference between the Han and minorities, the OCP renders the rural–urban fertility ratio of the Han significantly higher than that of the minorities.

The policy effect is most significant for the 1952–1962 birth cohorts in the post-treatment group. In Appendix D we discuss the corresponding empirical results by birth cohort and verify that this finding is also observed at the prefectural level.

These empirical results reveal that the increasing gap in the rural–urban fertility ratio between the Han and minorities is not negligible and can be explained by the OCP. When the minorities are taken as the control group for the Han, our empirical results specifically demonstrate that the OCP induced a much higher rural–urban fertility ratio.

The robustness of our empirical results is achieved by gradually reducing the differences between the Han and minorities. The minorities who live in remote or mountainous areas and are cut off from the outside world differ greatly from the Han, thereby rendering our DID estimate insignificant. However, even when these minorities are included in the whole sample at the national level, the DID estimate remains not negligible. After gradually excluding the effect of these inappropriate observations, the DID estimate becomes increasingly more significant, presenting strong evidence of the policy effect.

4. Effect of the OCP on human capital

We now use Equation (2a) to quantify the relative sizes of the quantity–quality tradeoff and compositional effects to examine whether China's two-tier OCP has enhanced or reduced the human capital level of the next generation. Equation (2a) shows that a larger rural–urban human capital gap ($h_2 - h_1$) induces a larger compositional effect. In addition, a higher increase in the rural share of the new population ($\alpha - \alpha'$) also generates a more significant compositional effect on human capital.

Another crucial factor is the size of the quantity–quality tradeoff effect. If the size is considerable, then we can reasonably infer that population reduction may promote the human capital level of the next generation. Many studies have investigated the tradeoff between family size and child quality. Early research found evidence of such a tradeoff (Rosenzweig and Wolpin, 1980; Hanushek, 1992), but later studies revealed the tradeoff to be not significant (Angrist et al., 2005; Black et al., 2005; Qian, 2009).

Li et al. (2008) studied the situation of China and revealed that family size is negatively correlated with children's education. Specifically, the tradeoff is more evident in rural China, but the effect diminishes or even vanishes in urban China. They argued that the quantity–quality tradeoff might not be obvious in developed countries. However, for developing countries such as China where excellent in the public education system and support for childbearing and childcare are non-existent, parents predominantly bear the cost of child quality. Therefore, a quantity–quality tradeoff is more probable, specifically in rural areas. Rosenzweig and Zhang (2009) revealed that in one area of China (Kunming), an extra child decreases the schooling progress, expected college enrolment, school grades, and assessed health of all of the children in the family, and that the effect in rural areas is more significant than that in urban areas.

Based on real data of 2010 and several reasonable assumptions, we estimate the rural and urban fertility and human capital levels if there were no OCP. We use Equation (2a) to estimate the effect of the OCP on human capital investment in the next generation.

During 1979, 2010, China's fertility declined considerably. The OCP contributed to this fertility decline. Cai (2010) and Wang et al. (2013) demonstrated that rapid economic development and social progress over the decades also contributed to the decline. As we do not know exactly how much of the fertility reduction after 1979 is caused by the policy, we consider several plausible and typical situations to arrive at an estimation. Among these situations, we include the extreme case that all fertility reduction during this period is caused by the policy and other more realistic cases in which only part of the fertility reduction is caused by the policy. For each situation, we use Equation (2a) to calculate the magnitudes of the compositional and quantity–quality tradeoff effects to evaluate the effect of the OCP on human capital. In almost all of the situations examined, the quantity–quality tradeoff effect is dominated by the compositional effect; thus, we conclude that the OCP has a high tendency to reduce the human capital level of the next generation in the country.

The preceding conclusion is obtained as follows. For convenience of analysis, we consider the situation without the OCP as the benchmark. We first estimate the rural and urban TFRs (n_1' and n_2') in 2010 if the OCP was non-existent. Using the recorded rural and urban TFRs (n_1 and n_2) in 2010, 30 years after the implementation of the OCP, we estimate n_1' and n_2'.

We first need to determine the extent to which the OCP has increased the rural–urban fertility ratio. We must estimate the change in the rural–urban fertility ratio because of the OCP $\Delta\left(\frac{n_1'}{n_2'}\right)$, or at least the lower bound of $\Delta\left(\frac{n_1'}{n_2'}\right)$. As mentioned, the minorities are not a perfect control group for the Han at the national level. Therefore, to estimate how much the rural–urban fertility ratio increased due to the OCP, we use the 1990 census data and take the eastern region, where the Han and minorities are nearly identical, as a relevant sample. Then we compute the rural–urban fertility ratios of the four groups (Han or minority, pre-treatment or post-treatment) in Table 5.

For the pre-treatment group, the rural–urban fertility ratios of the Han and minorities are nearly the same. By contrast, for the post-treatment group, the rural–urban fertility ratio of the Han is signifi-

Table 5
Rural–urban fertility ratio (eastern region).

	Han	Minority	Differences
Post-Treatment Group	1.476	1.302	0.174
Pre-Treatment Group	1.243	1.304	−0.061
Difference-in-Differences	0.235		

Notes: We take the eastern region sample as a whole and compute the rural-urban fertility ratio of each group. The post-treatment group includes the 1944–1970 birth cohorts, while the pre-treatment group includes the 1925–1943 birth cohorts.

cantly higher than that of the minorities, probably because of the OCP. As shown in Table 5, the DID value of the rural–urban fertility ratio is 0.235. As discussed in Section 3.3, given that the women in the pre-treatment group are not unaffected but only less affected by the OCP and that the women in the post-treatment group are not fully affected by the policy, the actual effect of the policy on the rural–urban fertility ratio may be even larger. Therefore, we select 0.235, a relatively conservative value, as the lower bound of $\Delta\left(\frac{n_1'}{n_2'}\right)$.[11]

One concern lies in whether or to what extent the eastern region can represent the whole country. The implementation intensity of the OCP varies greatly across the country, and it is extremely difficult to accurately estimate the effect of the policy at the national level. However, the estimate of the policy effect for the eastern region sample provides a safe lower bound of the policy effect for the whole country. As shown in Zhang (2017), the OCP was more strictly implemented in the more developed eastern region than in the central and western regions, particularly in rural areas. Given that the OCP was generally strictly executed in urban areas across the country, a less stringent implementation policy in the rural areas of the central and western regions would induce higher rural-urban fertility ratios in these regions than the said ratio from the eastern region. Thus, the above estimate based on the eastern region sample is actually the lower bound of the effect of the OCP on the rural–urban fertility ratio of the country.

Another concern arises from our use of the 1990 census data to identify the effect of the OCP on the rural–urban fertility ratio, as it may be inaccurate, given that various changes transpired between 1990 and 2010. However, this may not be a problem. Using the 1990 census data is reasonable to identify the lower bound of the extent to which the OCP increased the rural–urban fertility ratio ($\Delta\left(\frac{n_1'}{n_2'}\right)$). The OCP was implemented for a long time after 1990, potentially increasing the rural–urban fertility ratio. Furthermore, after 1990, the policy was relaxed in many rural areas, and Han women were allowed to have a second child if their first child was female (Li et al., 2005). Later, a second child was more generally allowed in many rural areas (Rosenzweig and Zhang, 2009), whereas the OCP was always strictly implemented in urban areas. This also might have induced an even higher rural–urban fertility ratio after 1990. Our identification of the lower bound of $\Delta\left(\frac{n_1'}{n_2'}\right)$ is therefore safe.

Given the value of $\Delta\left(\frac{n_1'}{n_2'}\right)$, we can obtain the rural–urban fertility ratio without the OCP as $\frac{n_1'}{n_2'} = \frac{n_1}{n_2} - \Delta\left(\frac{n_1'}{n_2'}\right)$, which we can use to further identify all of the possible combinations of n_1' and n_2'. We first estimate the plausible values of n_2'. We know the urban TFR in 1978 (n_{20}) before the OCP was implemented and the urban TFR in 2010 (n_2) under the OCP; thus, we calculate the total urban fertility reduction during 1978 and 2010 as $\Delta n_2 = n_{20} - n_2$. As discussed, such fertility reduction is due partly to the OCP and partly to other social factors. Here, we define $\Delta n_2' = n_2' - n_2$, which represents the urban fertility reduction caused by the OCP over the decades. As we do not know exactly how much of the fertility reduction over the decades is caused by the OCP, we consider several plausible situations. To begin, we select $\Delta n_2' = 100\% \times \Delta n_2$ (row 1 of column 7 in Table 6), which posits that 100% of the urban fertility reduction over the decades is caused by the OCP. Given the value of $\Delta n_2'$, we calculate the urban fertility without the OCP, i.e., $n_2' = n_2 + \Delta n_2'$, and further obtain the corresponding n_1' based on the preceding expression. In this case, without the OCP, the urban fertility in 2010 would be the same as that in 1978, indicating that socioeconomic development contributed nothing to the fertility decline during 1978 and 2010. In other words, all of the urban fertility reduction witnessed during the past decades is caused by the OCP. We then gradually decrease the share of fertility reduction attributed to the OCP (using $\Delta n_2' = \Delta n_2 \times$ the share due to the OCP) and obtain other combinations of n_1' and n_2' (columns 5 and 6 of Table 6).

Given the huge rural–urban gap in China, we further assume that the level of human capital investment per child in urban areas is twice as high as that in rural areas, i.e.,

$$h_2 = 2h_1. \tag{5}$$

This assumption is a conservative one, and the actual rural–urban human capital gap may be much larger. According to the 1990 Census data, rural and urban youths receive approximately five and nine schooling years on average, respectively. Furthermore, more than 53% of urban youths receive an education beyond the secondary level, whereas only 9% of their rural cohorts are admitted to high school or college. Given that the quality of education in urban areas is also much higher than that in rural areas, the actual rural–urban human capital gap is undoubtedly much larger. Such gap also widened over the past few decades (Zhang et al., 2015). In brief, the human capital disparity between the rural and urban areas is always considerable, and the rural–urban human capital gap ($h_2 - h_1$) has increased over the last few decades.[12] Therefore, the assumption in Expression (5) is rather conservative.

We also need to estimate h_1' and h_2', which represent the human capital levels of rural and urban areas if there were no OCP. We define the following:

[11] As shown in Table 4 and A3, the DID estimates based on a prefecture-level regression are smaller than this overall estimate at the national level. For the most affected 1952–1962 birth cohorts, the DID estimate at the prefectural level is only 0.193 (column 2 of Table A3), which is smaller than 0.235. However, many prefectures in the eastern region present relatively few rural or urban minority observations. Thus, to obtain a robust estimate of the policy effect at the prefecture level, we drop those prefectures in these regressions, leaving us with only about 60 prefectures. Although the OCP might have also significantly increased the rural–urban fertility ratio of these dropped prefectures, they are excluded in these regressions. Given that the eastern region sample is much larger than the sample in the prefecture-level regression and is a better sample to represent the whole country, we choose this sample to estimate the effect of the OCP on the rural-urban fertility ratio at the national level. However, even if we take 0.193 (the DID estimate for the most affected 1952–1962 birth cohorts from the prefecture level regression) as an alternative estimate of $\Delta\left(\frac{n_1'}{n_2'}\right)$ and conduct the same analysis, our result only becomes slightly less strong, but the essential point remains the same.

[12] As Li (2015) reported, in 1985, the real human capital values per capita in urban and rural areas were 76,000 and 31,000 Yuan, respectively. The human capital level in urban areas was roughly 2.5 times as high as that in rural areas. The said human capital level in both areas increased rapidly over the subsequent decades, but urban areas have enjoyed a higher growth rate. Consequently, the rural–urban human capital gap has also widened. In 2012, the human capital per capita in the urban and rural areas reached 298,000 and 96,000 Yuan, respectively, with the former reaching three times that of the latter.

Table 6
Estimation of the effect of the OCP on human capital.

Actual fertility in 2010 (under OCP)			Hypothetical fertility in 2010 (if no OCP) No policy			Urban fertility reduced by OCP		Hypothetical HC in 2010	Relative sizes of the two effects		Actual HC in 2010
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
n_1	n_2	$\frac{n_1}{n_2}$	$\frac{n_1'}{n_2'}$	n_1'	n_2'	$\Delta n_2'$	*percent*	h'	*q-q*	*com*	*h*
1.438	0.984	1.461	1.226	1.902	1.551	0.567	100%	100	3.1	−3.1	100.0
				1.832	1.494	0.510	90%		2.9	−3.1	99.8
				1.763	1.438	0.454	80%		2.5	−3.1	99.4
				1.693	1.381	0.397	70%		2.3	−3.1	99.2
				1.623	1.324	0.340	60%		1.9	−3.1	98.8
				1.555	1.268	0.284	50%		1.4	−3.1	98.3

Notes: (i) See the text and Appendix E for the interpretation of this table. (ii) The number of rural and urban women of childbearing age in 2010: $N_1 = 16652855,\ N_2 = 19072626$. (iii) Given that $\Delta\left(\frac{n_1'}{n_2'}\right) = 0.235, \frac{n_1'}{n_2'} = \frac{n_1}{n_2} - \Delta\left(\frac{n_1'}{n_2'}\right) = 1.461–0.235 = 1.226$ (column 4). (iv) Given that the urban TFR in 1978 (n_{20}) is 1.551 and that in 2010 (n_2) is 0.984, $\Delta n_2 = n_{20} - n_2 = 1.551 - 0.984 = 0.567$, which is the total urban fertility reduction during 1978 and 2010. Such reduction is due partly to the OCP and partly to other social factors. Furthermore, $\Delta n_2' = n_2' - n_2$, which represents the urban fertility reduction caused by the OCP over the decades. In the first row, $\Delta n_2' = 100\% \times \Delta n_2 = 0.567$ (column 7), which indicates that 100% of the urban fertility reduction over the decades is caused by the OCP. Under this situation, we calculate the urban fertility without the OCP as $n_2' = n_2 + \Delta n_2' = 1.551$. We also further obtain the value of n_1'. (v) The fertility data for 1978 are cited from Yao and Yin (1994). The other data for 2010 are cited from the Population Census Office of the State Council (2012). (vi) “HC” (columns 9 and 12) denotes human capital, while “q-q” and “com” (columns 11 and 12) denote the quantity–quality tradeoff and compositional effects, respectively.

$$\gamma_1 = \frac{\frac{\Delta h_1'}{h_1'}}{\frac{\Delta n_1'}{n_1'}},\quad \gamma_2 = \frac{\frac{\Delta h_2'}{h_2'}}{\frac{\Delta n_2'}{n_2'}}, \tag{6}$$

where γ_1 and γ_2 are the elasticities of human capital with respect to family size in the rural and urban areas, respectively, which measure the sizes of the rural and urban quantity–quality tradeoff effect, respectively. Studies have shown that although the quantity–quality tradeoff relationship is more evident in rural China, it diminishes or even vanishes in urban China, where the resource constraint is less severe (Li et al., 2008; Rosenzweig and Zhang, 2009). We thus select the upper bound of the quantity–quality tradeoff effect identified by these studies, i.e., $\gamma_1 = 0.26$ and $\gamma_2 = 0.041$, to examine whether such a considerable quantity–quality effect can dominate the compositional effect and thus result in that the OCP promoted China's human capital level. Given $n_1, n_2, n_1', n_2', \gamma_1$ and γ_2, we can calculate h_1' and h_2' based on Equation (6).

Given the fertility and human capital levels of rural and urban areas with and without OCP, we combine Equations (1a) and (5) to calculate the human capital level of the next generation under the OCP (in terms of h_1). We then calculate the compositional effect and the quantity–quality tradeoff effect based on Equation (2a) and finally obtain the value of h'. For convenience of analysis, we normalize h' to 100.

Appendix B provides the detailed steps for our estimation results in Table 6 for different combinations of n_1' and n_2'. The last three columns of Table 6 present the main results. The compositional effect is constant under all of these situations. The rural–urban fertility ratio without the OCP ($\frac{n_1'}{n_2'}$) is identified; thus, the rural share of the new population α' is also fixed, and Equation (2a) demonstrates that the compositional effect is also constant. By contrast, as the share of fertility reduction caused by the OCP decreases, the quantity–quality tradeoff effect induced by the policy also diminishes. As shown in Table 6, in the first situation, i.e., where all of the reduction in urban fertility during 1978 and 2010 were caused by the OCP (row 1 of column 8), the quantity–quality tradeoff effect approximately equals the compositional effect, and the human capital level without OCP h' is nearly the same as that under the OCP (h). Obviously, the policy could not have caused all of the fertility reduction over the past several decades. Other social factors, such as economic development and social progress, also contributed to the decline in Chinese fertility. As the share of fertility reduction caused by the OCP decreases, the quantity–quality effect also decreases and is dominated by the compositional effect. If we accept that 80% or even 50% of the urban fertility reduction is caused by the OCP over the last few decades (row 3 or 6 of column 8 in Table 6), then the quantity–quality tradeoff effect is significantly smaller than the compositional effect, and the overall human capital level decreases by about 1% or 2%. Therefore, it is very likely that China's OCP reduced the human capital level of the next generation.

Although the magnitude of the negative effect of the OCP on human capital seems modest, it is still surprising that the policy has reduced rather than promoted the human capital level of the next generation in China. Furthermore, our estimation is based on several very conservative assumptions—the real policy effect may be much larger.

The vital role of the negative compositional effect in this case is easily understood. The wide Chinese rural–urban disparity implies a large value of $h_2 - h_1$ and a considerable resource gap between rural and urban families. The quantity–quality tradeoff, which is the effect of the reallocation of resources within a family, is too small to cover the resource gap between the rural–urban divide. In particular, the OCP is much more strictly implemented in urban than in rural areas, thus inducing a significant population compositional change and a considerable negative effect on the average human capital investment.

As highlighted previously, although the quantity–quality tradeoff is considerable in rural areas, it is much smaller in urban areas. Cameron et al. (2013) even argued that the OCP produced significantly less trusting, less trustworthy, more risk-averse, less competitive, more pessimistic and less conscientious “little emperors” in urban China. Their study suggested that bearing fewer children could result in an even lower average child quality (at least in urban areas). If these arguments are credible, the quantity–quality tradeoff would be even smaller than expected, and our conclusion that the OCP reduced the average human capital level of the next generation would be strengthened.

One concern is that the OCP may also affect the sex composition of children and further affect the marriage market and average human capital level of the next generation. As shown in the literature (e.g., Ebenstein, 2010), given that son preference is more prevalent in rural areas than in urban areas, the sex ratio is much more distorted in rural areas (having more boys than girls) due to sex selection under the OCP. Such distortion may also affect the marriage market and the average human capital level of the next generation. Specifically, if rural families have more boys than girls and if parents have a boy preference, or if they expect that their sons will face a tight competition in the marriage market in the future, then they may invest more in their male children, thereby increasing the average human capital level in rural areas and mitigate the negative effect of the OCP on overall human capital. However, this may not be the case in reality. Previous studies (e.g., Hannum et al., 2009) show that there is little evidence of a gender gap in economic investments in education, and girls rival or even outperform boys in terms of their academic performance and engagement in rural China. These findings are also consistent with the latest 2010 census data, which shows that the education attainment of males and females who were born after 1980 (after the OCP was implemented) are nearly the same.

Given that the sex ratio in rural areas is more distorted than that in urban areas, there seems an incentive for rural males and urban females to migrate to urban areas and rural areas to get married, respectively. However, given the huge rural–urban gap in China, rural residents have strong incentives to migrate to urban areas and most urban residents are unwilling to migrate to rural areas over the past several decades, thereby resulting in a one-way migration flow in China. As will be shown later, even if we consider the potential effect of rural–urban migration and marriage market on human capital, we still obtain the same or even stronger conclusions.

Another concern is that the rural–urban migration may also affect the robustness of our conclusion. Specifically, China has a steady inflow of migrants from rural to urban areas, and this migration may counteract some of the negative effect of being born in rural areas on human capital investment.

However, this potential effect of migration may not be realized. First, although rural residents have always had strong incentives to migrate to urban areas, it was extremely difficult for most rural households to receive urban hukou (a Chinese household-registration certificate) and migrate to urban areas permanently. For most of the past few decades, rural children were refused admission to urban regular local schools if their parents took them to the cities. Although the government gradually relaxed these restrictions in recent years, rural children are typically admitted to migrant schools with very low education quality. In reality, a large number of rural couples migrate to cities for work and leave their children at home. Although few of these so-called “left-behind” children are left alone in their homes (most are left in the custody of their grandparents), the separation from their parents inevitably affects their development adversely. These children usually encounter many problems, such as the absence of family education, poor academic performance, and psychological difficulties. Therefore, such patterns of migration have further reduced human capital investment in children in rural areas.

Second, as another pattern of rural–urban migration, the most promising rural youths could either be admitted to colleges or seize other opportunities in the cities, such as marrying an urban resident, gain a permanent hukou status, and bear and raise children there. Therefore, their children will enjoy a high human capital investment, consequently increasing the average human capital level of the next generation in the country. However, the OCP actually mitigates such positive effect of migration on human capital. Under this policy, rural migrants could only have one child after migrating to the city permanently, but without the OCP, these migrants could bear more children who can enjoy a high human capital investment in urban areas. Obviously, the OCP makes things worse. In summary, this pattern of rural–urban migration itself could increase the average human capital level of the country, but the OCP mitigates such positive effect on human capital.

Therefore, even if we consider the potential effect of rural–urban migration on human capital, the compositional effect induced by the OCP would be strengthened and our conclusion would also be stronger.

Although we divide our sample into rural and urban subsamples to investigate the adverse selection problem resulting from the OCP, we only do so to facilitate our analysis. Further classification may reveal more details of the effect of the OCP on human capital. Evidence indicates that better-educated women are more affected by the OCP in both rural and urban areas (Li et al., 2005). Adverse selection problems can be observed within both areas. If we further classify our sample within rural and urban areas, then deeper levels of adverse selection can be revealed, which would strengthen the conclusion that the OCP reduced the human capital level of the next generation.

Our research shows that China's OCP reduced both the population size and average human capital level of the next generation. Therefore, concluding that the policy also decreased the human capital stock of the country is within reason.

5. Concluding remarks

High population growth rates are constantly linked with poverty and underdevelopment. Although no strong evidence has shown that population growth is the cause of poverty, a high population growth rate has usually been considered detrimental to a developing economy. Specific population control policies are considered necessary and rational choices for governments, particularly in underdeveloped countries that typically face significant population pressure. In addition, according to the quantity–quality tradeoff theory, it has often been argued that a reduction in fertility will promote the human capital level of the next generation, thereby benefiting developing countries in which a low human capital level is always the main obstacle to further economic growth.

However, such reasoning ignores a potential adverse selection problem. Even though we concur that it is generally beneficial to reduce a developing country's fertility rate, we cannot conclude that such population control policies will achieve the goals of policymakers, who cannot control which segment of the population is reduced.

The adverse selection problem that we examine operates through the rural–urban divide and is facilitated by the two-tier OCP in China. Such adverse selection problem is highly prevalent in other dimensions in China or elsewhere. For example, a population control policy may reduce the fertility of highly educated women more than that of their less educated counterparts. This may decrease the average human capital level of the next generation despite the favorable yet often overemphasized effect of the quantity–quality tradeoff.

The fertility decisions of households are endogenous. Even through coercive measures, birth control policies can reduce only a seemingly undesirable high fertility; they can do nothing to improve the more essential factors (such as a low education level among women) that lead to high fertility. In this sense, the benefits of population control policies can easily be overestimated, whereas their costs, which are usually less perceivable, tend to be underestimated. This study reveals that the usually neglected costs of the adverse selection induced by the OCP may be considerable and may counteract the benefits of fertility reduction.

Although China's two-tier OCP may have reduced the human capital level of the country, we cannot conclude that this policy was a bad solution implemented by China to address its great population pressure in the late 1970s. China might have benefited from its fertility reduction over the past decades. This research indicates only that the costs of the adverse selection induced by the two-tier OCP may be considerable. Implementing proper population control policies may still be necessary for developing countries with extremely high fertility rates. However, designing better policies for minimizing the costs of fertility reduction, specifically those of adverse selections, remains a challenge for both governments and scholars.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jdeveco.2018.04.007.

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