Population Research and Policy Review (2023) 42:94
https://doi.org/10.1007/s11113-023-09834-7

ORIGINAL RESEARCH

The Consequences of Fertility Decline on Educational Attainment in China

Hanzhi Hu[1]

Received: 3 February 2022 / Accepted: 14 October 2023

Abstract

Rapid fertility decline has been witnessed in developing countries during the second half of the twentieth century. However, the consequences of fertility decline on average education and educational inequality at the societal level remain unexplored. Using data from the China General Social Survey (CGSS) and China Family Panel Survey (CFPS) (N=44,918), this study contributes to the literature by answering two questions regarding the educational consequences of fertility decline in China with simulations. First, has the fertility decline improved human capital via declining average sibship size? Results reveal that the fertility decline during the 1950–1993 cohorts in China brought a 9% improvement in the average years of schooling compared to the Vietnamese counterfactual. Second, how does the differential fertility between groups contribute to educational inequality? Counterfactual simulations show that its impact on the educational disparity between males and females is limited. However, it has a marked impact on the rural–urban disparity in education.

Keywords Fertility decline · Sibship size effect · Education · China

Introduction

Several developing countries have witnessed rapid fertility decline during the second half of the twentieth century (Bongaarts, 2008). This demographic process is argued to affect economic outcomes, socioeconomic inequality, and the population's well-being. The consequences of the fertility decline have long been of interest to scholars. Fertility decline is believed to have an impact on economic growth (Cuaresma et al., 2014), poverty reduction (Wietzke, 2020), and gender inequality (Yount et al., 2014). First, scholars argue that fertility decline can boost productivity and benefit economic growth by creating a demographic dividend (Bloom &

✉ Hanzhi Hu
huhz@cass.org.cn

1 Institute of Sociology, Chinese Academy of Social Sciences, No.5 Jianguomennei Avenue, Dongcheng District, Beijing, China

Published online: 07 December 2023

Williamson, 1998), which derives from the beneficial changes in age-dependency ratios with more workers and fewer dependents. Following this argument, the "East Asian Growth Miracle" is attributed to countries' fertility decline and the subsequent changes in age structure (Bloom & Williamson, 1998; Bloom et al., 2003). Moreover, studies found that fertility decline raises income per capita (Ashraf et al., 2013) and positively affects GDP growth (Li & Zhang, 2007). Second, studies on the relationship between fertility rates and poverty emphasize the impact of the heterogeneous trends of fertility decline. Scholars argued that compared with the higher-status group, fertility decline happens later and slower for the lower-status group, which can increase inequality and influence poverty rates (Eastwood & Lipton, 1999). Furthermore, fertility decline can influence gender inequality and intensify gender gaps in societies that prefer male offspring (Yount et al., 2014). For instance, as fertility rates fell in India, girls' excess mortality grew as fertility rates fell in India (Das Gupta & Bhat, 1997). In China, the fertility decline is accompanied by an increasing male-to-female sex ratio at birth (Junhong, 2001; Li et al., 2011).

Improvement in human capital is an often-mentioned mechanism when discussing the impact of fertility decline on economic growth, poverty reduction, and gender inequality (Lee et al., 2000; Wietzke, 2020). Fertility decline can increase educational attainment since, according to the "Quantity-Quality" trade-off thesis coined by Becker and Lewis (1973), parents can offer each child more resources that benefit educational attainment as the number of children in the household decreases. Empirical studies have discussed the variations of the sibship size effect on education over cohorts (Maralani, 2008; Parish & Willis, 1993; Pong, 1997) and across countries (Li et al., 2017; Vogl, 2016). Moreover, scholars investigated the mechanism of the effect (Chen, 2020) and its robustness against unmeasured confounders (Angrist et al., 2010; Black et al., 2005). Though several lines of studies in recent years questioned the robustness of the negative relationship between sibship size and educational attainment (Angrist et al., 2010; Åslund & Grönqvist, 2010; Bagger et al., 2013; Maralani, 2008), numerous empirical studies have reported evidence supporting the "Quantity-Quality" trade-off thesis (Choi et al., 2020; Liu, 2014; Ponczek & Souza, 2012; Rosenzweig & Zhang, 2009).

When studying the relationship between fertility and education, previous studies have disproportionately focused on the relationship between sibship size and education for individuals. However, less is known whether the association between sibship size and education bears any implication at the aggregated level. In the previous studies, the macro-level implications of fertility decline on education are often incorporated in the statistical models predicting the impact of fertility decline on economic growth and calibrated to synthetic cross-countries or cross-regions data. (Ashraf et al., 2013; Mason et al., 2017; for a systematic review, see Bongaarts & Hodgson, 2022, Chapter 6). Findings for a specific country or international comparisons are sparse and reach divergent conclusions. In Nigeria, studies found that a more rapid decline in TFR would lead to 2.47 more years of schooling than observed (Karra et al., 2017). On the contrary, other studies reported a limited contribution of fertility decline to education improvement in Bangladesh (Joshi & Schultz, 2007) and other Latin American and Asian countries (Li et al., 2017). China is not included in the previous comparative studies but provides a unique case to understand the consequences of fertility decline. It experienced a rapid fertility decline since the 1970s; however, its fertility decline did not happen entirely voluntarily like in other countries. The fertility trends in China are affected by multiple governments' birth planning suggestions, campaigns, and regulation policies, among which the "one-child limits" launched in 1979 forcefully set limits to people's fertility behavior. Several studies tried to estimate how birth limits affect human capital in China but reached conflicting conclusions since the methods and underlying assumptions varied greatly. Using the China Twins Survey, Rosenzweig and Zhang (2009) concluded that the birth limits at most increased educational attainment by 4%. Using regional differences in regulation intensity, Li and Zhang (2017) reported that the "one-child limits" only modestly contributed to the country's human capital. However, other studies reached more sizable estimates. Zhu et al. (2014) found that the average schooling would have been 28.9% lower without the "one-child limits." With OLG models, Gu (2022) reported that the birth limits increase human capital by 47%. However, besides policy intervention, socioeconomic development and ideological changes also affect fertility evolvement in China. Focusing solely on policy-induced fertility change cannot reveal how much China's rapid fertility decline translated into human capital improvement. Therefore, the first goal of this study is to examine to what extent the fertility decline observed in China improves its human capital.

Using recent data sources, this study observed the completed education for cohorts born from 1950 to 1993 and used counterfactual simulations to assess the educational consequences of fertility decline. Following the practices in previous studies (Goodkind, 2017), this study uses the Vietnamese pattern as the counterfactual scenario to show what would have happened if the fertility rates in China had not declined so rapidly. Results show that if the fertility decline in China had followed the Vietnamese pattern, the improvement in education would have been 9% less than the observed. As mentioned, the fertility decline in China is driven by multiple factors, and the effects of policy intervention and socioeconomic factors are interwoven. This study focuses on the consequences of the total fertility decline rather than isolating the respective contributions of policy intervention and other factors. Therefore, this study reached higher estimates than the previous studies (Li & Zhang, 2017; Rosenzweig & Zhang, 2009) that focused solely on the contribution of the policy intervention on human capital improvement.

Furthermore, during demographic transitions, fertility rates can decline differently across groups. For instance, the "leader–follower model" suggests that higher socioeconomic groups begin to have fewer births earlier and faster than the lower-status groups (Bongaarts, 2003; Wietzke, 2020). The divergence or convergence in fertility rates between groups over time can lead to long-term changes in between-group educational inequality. For instance, Sen et al. (2023) reported that family size differences between high-caste Hindus and Muslims in India account for 10% of the between-group inequality in education. As the TFR of these two groups converges over time, the educational gap is expected to decline. As in China, fertility rates varied by parental educational level, socioeconomic status, and *hukou* status (urban or rural). Moreover, a series of birth control regulations set different birth limits across groups, which might forcefully alter the differences in fertility between groups and lead to changes in education inequality. For instance, previous studies suggested that the decrease in sibship size for females should promote gender equality, as more women enjoyed the only-child premium and obtained similar attainment as men (Ye & Wu, 2010; Wu et al., 2012). Moreover, during the "one-child limits" era, the relaxation of the regulations for the rural population in 1984 created differences in policy-targeted fertility between urban and rural populations. Only the urban population was strictly forced to limit their fertility, which might have amplified the fertility differences between rural and urban China. However, whether the fertility differences between groups have translated into between-group inequality in education has not been empirically tested.

In this study, the counterfactual simulation analysis let different groups take on the same level of sibship sizes to gauge the contributions of sibship size differences in educational inequalities. Results show that the impact of sibship size on gender inequality is limited. The gender gap in education would have disappeared over cohorts even if there had been no difference between genders in their sibship sizes. However, if rural residents had had the same sibship size as their urban counterparts, it would have significantly reduced the urban/rural educational inequalities.

The rest of the article is organized as follows. The literature review first summarizes relevant previous studies on fertility decline and focuses on the relationship between fertility and educational attainment. Thereafter, it reviews the trends in fertility and educational attainment in China from 1950 to 1990 and discusses why and how we should expect differential fertility to contribute to gender inequality and rural–urban inequality. After that, it introduces the data and empirical strategy and reports the results. The paper ends by discussing the implications of the findings for understanding human capital growth and inequality in Chinese society.

Literature Review

As a feature of demographic transitions, fertility decline and its implications have attracted scholarly interest. Though the causal relationships are still debatable, fertility decline is believed to be at least associated with economic growth (Cuaresma et al., 2014), poverty reduction (Wietzke, 2020), and gender inequality (Yount et al., 2014).

Scholars argue that fertility decline can boost productivity and benefit economic growth by creating a demographic dividend (Bloom & Williamson, 1998), which derives from the beneficial changes in age-dependency ratios. Fertility decline contributed to a fast-growing working-age population and expanding per capita productive capacity during the second half of the twentieth century in East Asian countries, which led to the so-called "East Asian Growth Miracle" (Bloom & Williamson, 1998; Bloom et al., 2003). Moreover, the literature shows that fertility decline increases income per capita (Ashraf et al., 2013) and positively affects GDP growth (Li & Zhang, 2007). When examining the rapid economic development in China, previous studies contend that the fertility decline substantially benefited the economic growth in China (Bloom et al., 2010; Fang, 2018; Wei & Hao, 2010). For instance, Fang and Wang (2005) found that the contribution of the decline in dependency ratio to economic growth was 26.8% in 1982–2000, while Wang and Mason (2008) reached an estimate of 15% for the same period**.** Improvement in human capital is an often-mentioned mechanism that links fertility decline and economic growth (Lee et al., 2000; Wietzke, 2020). As the dependency ratio declines, people can save more and invest more in human capital. For instance, Cuaresma et al. (2014) argued that the demographic dividend of fertility decline is an educational dividend. They pointed out that the improvements in educational attainment explain a substantial portion of productivity and income growth brought by age structure changes after the fertility decline.

In the literature, the relationship between fertility and education is often studied at the individual level. The "Quantity-Quality" trade-off thesis, coined by Becker and Lewis (1973), states that as the number of children in the household decreases, parents can offer each child more resources that benefit educational attainment. Thus, the sibship size should negatively affect individuals' educational attainment. Empirical studies have intensively tested the relationship between sibship size and education over cohorts (Maralani, 2008; Parish & Willis, 1993; Pong, 1997) and across countries (Choi et al., 2020; Li et al., 2017; Vogl, 2016). Scholars have also investigated the mechanism of the sibship size effect on education (Chen, 2020) and its robustness against unmeasured confounders (Angrist et al., 2010; Black et al., 2005). Though numerous empirical studies have reported evidence supporting the "Quantity-Quality" trade-off thesis (Choi et al., 2020; Liu, 2014; Ponczek & Souza, 2012; Rosenzweig & Zhang, 2009), the robustness of the negative relationship between sibship size and educational attainment has been questioned (Maralani, 2008; Angrist et al., 2010; Åslund &Grönqvist, 2010; Bagger et al., 2013).

However, less is known whether the association between sibship size and education bears any implication at the aggregated level. In other words, when the average sibship size of a society increases or decreases, would it translate into changes in the average educational attainment at the societal level? If the negative relationship between sibship size and education holds at the societal level, we should expect that as fertility declines, the benefits of small sibship size lead to improvements in the average educational level of the society. In the previous studies, the macro-level implications of fertility decline on education are often treated as one mechanism that links fertility decline and economic growth (Ashraf et al., 2013; Bongaarts & Hodgson, 2022; Mason et al., 2017). The statistical models usually incorporate parameters indicating the educational changes induced by fertility decline and calibrate the model to synthetic cross-countries or cross-regions data. Findings for a specific country or international comparisons are sparse and reach divergent conclusions. With simulations, Karra et al. (2017) estimate that for Nigeria, compared to the moderate declining scenario where the TFR declines from 5.61 to 2.70 in the next century, the more rapid decline in TFR from 5.61 to 1.35 would lead to 2.47 more years of growth in average schooling. On the contrary, other studies argue that the contribution of fertility decline to educational improvement is limited. Joshi and Schultz (2007) found that in Bangladesh, a 15 per cent reduction in TFR, resulting from a randomized intervention, brought only 0.52 more years of schooling for males aged 9–14. Similarly, with simulations, Li et al. (2017) claimed that among the 17 Latin American and Asian countries examined, except Turkey and Vietnam, fertility decline can explain "*only a small portion of the increase in the average educational attainment of the societies*" (The precise portions of the increase for each country are not provided). Their study excluded China from the analysis. However, like other developing countries, China experienced a rapid fertility decline since the 1970s due to socioeconomic changes and policy interventions. If the negative association between sibship size and educational attainment bears any implication at the societal level, we should expect the decrease in the average fertility rates to translate into an improvement in the average education level of the society. Thus, the first hypothesis is proposed as follows:

H1 The Fertility decline in China has improved average educational attainment.

Apart from the overall decline in fertility rates, the heterogeneous trends of fertility decline between groups might lead to between-group inequality. Scholars have argued that compared with the higher-status group, fertility decline happens later and slower for the lower-status group, which can increase inequality (Eastwood & Lipton, 1999). The divergence in fertility rates between the higher-status and lower-status groups tends to worsen inequality and poverty rates, while the convergence in fertility rates reduces inequality. In the literature, differential fertility by various characteristics, such as socioeconomic status (Dribe et al., 2014), income (De La Croix & Doepke, 2003; Lam, 1986), education (Vogl, 2016; Westoff, 1954), and race (Kuo & Hauser, 1995; Mare, 1997; Preston, 1974), is well documented. However, empirical evidence on the link between differential fertility and inequality is not in consensus. Mare (1997) revealed that the racial differences in fertility between white and African-American women have a limited impact on between-group educational inequality. Sen et al. (2023) reported that family size differences between high-caste Hindus and Muslims in India account for 10% of the between-group inequality in education. As the TFR of these two groups converges over time, the educational gap is expected to decline.

As in China, fertility rates differ across various characteristics, like regions, education levels, and socioeconomic status. Fertility decline began earlier and more rapidly for groups with higher education (Lavely and Freeman, 1990), higher socioeconomic status and urban residency (Merli & Smith, 2002). Moreover, a series of birth control regulations represented by the famous "one-child limits" set different birth limits across groups. For instance, while the urban population is under the strict one-child limit, the rural population is subjected to more relaxed regulations, which might enlarge the fertility differences between rural and urban populations and lead to more inequality in education. In the previous studies on rural–urban inequalities in China, the household registration system (*hukou*),[1] which institutionalizes the

[1] *Hukou* refers to the household registration system in China under which everyone is assigned a *hukou* (household registration certificate) at birth. The *hukou* contains two-fold information. First, the category of one's *hukou* status. The *hukou* status is divided into rural vs. urban or agricultural vs. non-agricultural. Second, the local administrative unit the *hukou* registered. The *hukou* must register to only one administrative unit at the lowest available level as one's official/permanent residential place and under the supervision of all the higher levels of administrative authorities.

divide between rural and urban populations, is regarded as the most critical determinant of urban/rural inequality (Wu & Treiman, 2004). Fertility differential is a less-mentioned factor; however, it should have played a role in the process. The second hypothesis is proposed as follows:

H2 In China, the sibship size differences between urban and rural populations contribute to the changes in between-group educational inequalities.

Moreover, fertility decline can influence gender inequality, as scholars asserted that fertility decline is associated with changes in gender attitudes and societal norms (Yount et al., 2014). However, empirical studies reveal that the relationship between fertility decline and gender inequality depends on the social context. Girls can benefit from fertility declines in societies with lower son preference, while in societies with strong son preference, studies indicate that a decline in fertility intensifies the gender gaps in mortality and nutrition. For instance, girls' excess mortality in India grew as fertility rates fell (Das Gupta & Bhat, 1997). In China, the fertility decline is accompanied by an increasing male-to-female sex ratio at birth (Junhong, 2001; Li et al., 2011). Regarding educational attainment, previous studies have speculated that the fertility decline in China should promote gender equality as more women enjoyed the only-child premium and obtained similar attainment as men (Ye & Wu, 2010; Wu et al., 2012). Some empirical studies revealed that in urban one-child families, daughters and sons were treated equally (Tsui & Rich, 2002), and no difference was found in their educational achievement (Lee, 2012). However, these findings cannot be generalized to the rural areas where only-child families are less common. More importantly, whether the increase in the proportion of only-child daugthers is large enough to affect the overall trends in gender inequality is questionable. Thus, the third hypothesis is proposed as follows:

H3 In China, the sibship size differences between female and male populations contribute to the changes in gender educational inequalities.

The Chinese Context

Trends in Fertility in China from 1950 to 1990

The fertility level in China has experienced drastic changes since 1950. The total fertility rates (TFR) in China throughout the 1950s and 1960s were around 5 to 6 births per mother (Banister, 1987). In the early 1970s, the Chinese government promoted a "Two is Enough" advocacy. It advocated that couples should delay marriage and childbearing and have no more than two children with wider birth spacing. It is also known as the "*wanxishao*" (later, longer, and fewer) campaign. During the 1970s, China witnessed its most rapid fertility decline. The TFR plummeted from

5.8 in 1970 to 2.7 in 1979, more than half in 10 years (Cai, 2008). The "two-child advocacy" and subsequent fertility control regulations culminated in the "One-Child limits" in 1979. The initial statement of the policy was to encourage one child per couple. However, the implementation of the policy gradually became stricter. In 1983, it developed into a forced sterilization and abortion campaign. The campaign backfired as the rebellion of the society led to severe unsettlement, threatening security. In response, the central government relaxed the fertility control in 1984 and transferred the power to provincial governments to set fertility limits. Therefore, under the guidance of the provincial governments, lower-level governments execute fertility control according to the local conditions. (See Gu et al. (2007) for a detailed summary of the variations of the local fertility limits at the provincial level.)

The fertility policies of the 31 provinces of mainland China are divided into the following categories. For the urban population, the one-child limit was enforced. For the rural population, there were three scenarios: (1) in six provinces, including Beijing and Shanghai, all residents followed the one-child rule; (2) in 19 provinces, rural residents were allowed to have a second child if the first birth was a girl. It is also called a "1.5-child limit"; (3) All rural couples could have two children in the remaining five provinces. Apart from these, 26 provinces permitted couples to have two children when they both were the only child in their families. Moreover, ethnic minorities were exempted from fertility control. (See Gu et al., 2007: pp. 134–135, Table 1, for a summary of provincial fertility policies in China revised or changed through the 1980s to late 1990s.)

During the 1980s, the observed TFR fluctuated around 2.5 (Feeney and Wang, 1993). At the beginning of the 1990s, the TFR dropped further. The 1990 census reported a TFR of 2.3 (Cai, 2008). Analysis based on surveys and census suggests that the TFR in China declined to the under-replacement level in the 1990s, from 1.8 in 1991 to 1.2 in 2000 (Retherford et al., 2005). Though issues like underreporting have led to a debate on the exact level of TFR in China (Goodkind, 2004; Hermalin & Liu, 1990), the consensus is that during the 1990s, fertility rates continued to decline and fell below the replacement level.

It is well documented that the fertility trends in China are heavily influenced by its population regulations (Goodkind, 2017; Lavely & Freedman, 1990). On top of policy interventions, studies emphasized that socioeconomic factors also contributed to the process. Earlier work indicated that well before the implementation of government programs in the 1960s and 1970s, evidence of voluntary family birth control and fertility declines were observed among the better-educated population and residents in urban areas (Greenhalgh, 1989; Lavel & Freedman, 1990). After several decades of high-speed development, people's fertility intentions and behavior experienced profound changes. For example, studies recorded increases in average age at first marriage and first birth (Feng & Quanhe, 1996), contributing to the fertility decline. Moreover, the rising costs of child-rearing and education and other factors have led to people's voluntary choices of having fewer children (Zhang, 1990). It is challenging to distinguish policy intervention's impact from socioeconomic factors' impact on fertility decline, as these forces are interwoven and often work collectively.

It is less discussed in the literature whether social groups experienced the decline differently. However, there are valid reasons to expect heterogeneity in fertility decline. Policy interventions and individual characteristics, such as education, social status, and preference, can create divergent fertility trends within the population. First, regarding individual characteristics, similar to other countries, the fertility decline in China began with educated groups. Lavely and Freeman (1990) mentioned that better-educated elites intentionally practiced birth control before the government's intervention. Norm or preference is another crucial factor because of the tradition of son preference in China (Murphy et al., 2011). Parents with son preference might have multiple births to reach their desired result without policy or resource constraints or practice sex-selective abortion (Goodkind, 2011; Den Boer & Hudson, 2017) if having multiple births is not an option. Moreover, rural parents tend to have more children than urban parents owing to the practical consideration of having more workforce in the household for agricultural production and norms that large family size represents prosperity in traditional Chinese culture. Second, as for policy regulations, the strict 1979 "One-Child limits" and its ancillaries set varied birth limits for social groups. While most urban residents were subjected to a strict one-child limit, rural residents and ethnic minorities could have multiple births with or without conditions. Moreover, studies indicated the heterogeneity in people's degree of acceptance and compliance with the policies, as urban and industrialized areas demonstrate higher acceptance than others (Merli & Smith, 2002). Thus, we should expect the fertility decline to begin earlier and more rapidly for groups with higher education, socioeconomic status, weaker son preference, and urban residency.

Trends in Educational Attainment and Inequality in China Since 1950

It is well documented that educational attainment in China has increased gradually since 1950. Cohort studies reveal that the average years of schooling increased for both men and women in rural and urban China (Wu & Zhang, 2010; Fig. 2; Treiman, 2013; Fig. 1).

The gender gap in education closed over cohorts (Wu & Zhang, 2010), while the rural–urban gap persisted. The average years of schooling for males increased from around seven years for the 1950 cohort to around ten years for the 1980 cohort, while that for females increased from less than six years for the 1950 cohort to around ten years for the 1980 cohort. The level of educational attainment for men and women converged over time (Treiman, 2013). Meanwhile, the urban–rural gap persisted. The average years of schooling for urban males born in 1950 was around 10, while it was slightly above six for rural males. The gap was maintained over cohorts. Regarding the 1980 cohort, the average years of schooling for urban males was 12 years, while it was around eight years for rural males. A similar pattern can be observed for females: the urban–rural education gap was maintained at around four years over cohorts (Wu & Zhang, 2010).

Vietnam as a Counterfactual Scenario for China

This study uses counterfactual simulations to assess the educational consequences of fertility decline. The key is to find a suitable counterfactual to show what would have happened if the fertility rates in China had declined less radically. The case of Vietnam is chosen for the following reasons. Previous studies have argued that Vietnam and China share various similarities (Womack, 2009) as both countries experienced market reform and rapid socioeconomic development after the 1970s, cherished strong son preference and are under a single-party system (Goodkind, 2017, Table 1). Moreover, Vietnam also implemented a birth control policy but set the quota at two. As shown in Fig. 1, the fertility rate in Vietnam was at a similar high level as China in the 1960s and started to decline as China did around the 1970s but less rapidly. Previous studies have used Vietnam as a counterfactual scenario for China when conducting population projections. Though it is not a perfect case, the Vietnam pattern can help us understand what would have happened if China's fertility rates had been higher and had not declined so rapidly.

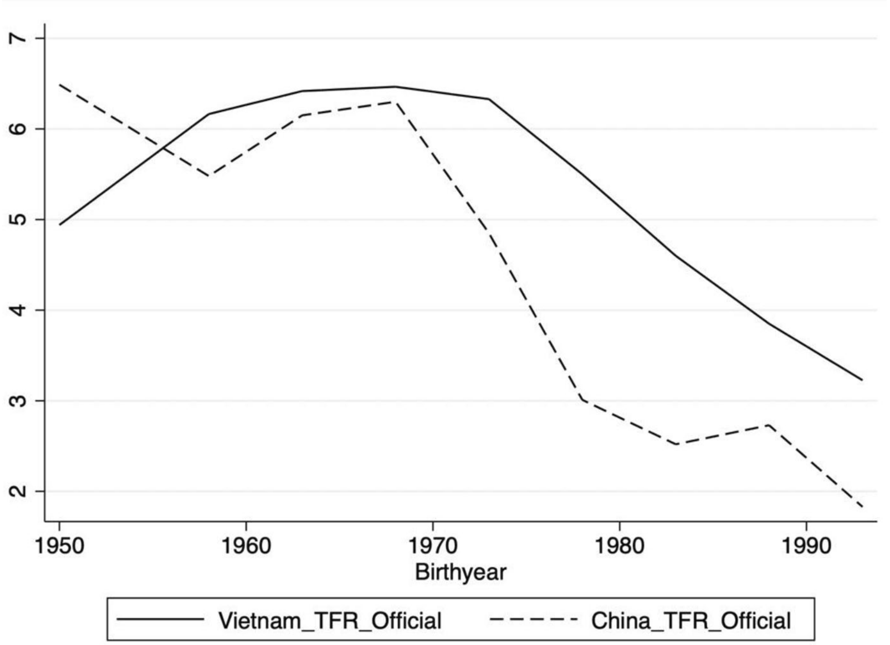

Fig. 1 Total Fertility Rates (TFR) of Vietnam (solid line) and China (dash line) from 1950 to 1990. Source: Data Bank, The World Bank

Data and Methods

Data and Measurements

This study uses data from the China General Social Survey (CGSS) 2006, 2008, and 2017 and the China Family Panel Survey (CFPS) 2010–2018 to construct a cross-sectional dataset. CGSS is a nationally representative cross-sectional survey on mainland China (Bian & Li, 2012). The respondents' number of siblings is known only in the 2006, 2008, and 2017 waves. The CFPS is a nationally representative longitudinal dataset. The survey sample is drawn from 25 provinces or administrative equivalents, representing 94.5% of the total population in mainland China (Xie & Lu, 2015). CGSS and CFPS draw their sample according to the PPS principle to achieve regional representation using multistage probability sampling. These are the most recent data sources to observe the completed education for cohorts born after implementing the "one-child limits." Notably, they provide the information of completed education of the 1990 cohorts who turned 25 years old after 2015 and have not been covered in the previous studies.

From the CGSS data, the analytic sample selects respondents born after the People's Republic of China (PRC) was founded (1949) and older than 25 in each survey year. The CFPS data are in the longitudinal format. To pool them with the cross-sectional CGSS data, the analytic sample selects CFPS respondents who were born after 1949 and were older than 25 in the 2010 baseline wave and includes those who would turn 25 in the following waves and have records of the completed education. The final sample contains 44,918 respondents born between 1950 and 1993 with complete information on their sibship size and educational attainment. CGSS and CFPS construct individual weights to reflect the Chinese population, and individual weights are applied in the analysis. Education attainment is measured as the years of education the respondent completed. Sibship size is measured as the total number of siblings, including those who had passed away at the time of the survey. Urban and rural populations are distinguished according to the *hukou* registration status of the mother when the respondent is 14 years old.

For the counterfactual simulations, the corresponding average sibships sizes for the Vietnamese cohorts are obtained from the 1989, 1999, and 2009 Vietnam censuses produced by the Vietnam General Statistical Office accessed through IMPUS International. The analytic sample selects respondents born between 1950 and 1993 with complete information on their gender, residential regions (urban/rural), and mother's fertility records ($N=5,311,728$). The sibship size is not directly collected in the census. To compute the values of sibship size, this study draws on the experience of Li et al. (2017) to obtain this measurement by subtracting one from the linked mother's number of children ever born.

Methods

Descriptive Analysis

This study calculated the 5-year moving average of sibship size and educational attainment to portray the trends over cohorts. For example, the average sibship size for the focal cohort t is computed as follows:

$$\widehat{X}_t = \frac{x_{t-2} + x_{t-1} + x_t + x_{t+1} + x_{t+2}}{5}. \tag{1}$$

The average sibship sizes for the Vietnam sample are also obtained with the 5-year moving average method. Table A1 in the Online Appendix presents the sample size and the 5-year moving average sibship size and year of schooling for each cohort in the Chinese and Vietnamese samples, respectively.

Counterfactual Simulations

To assess the consequences of fertility decline on education, this study uses counterfactual simulations to compare what happened with what would have happened. First, for each cohort t, this study predicted individual (i)'s education attainment as follows:

$$y_{it} = a + \beta_1 X_{it1} + \ldots + \beta_7 X_{it7} + \in, \tag{2}$$

where X_{its} are predictors including his/her sibship size, age and age square, gender, *hukou* status, ethnicity, parental birth years, provinces of birth, and parents' education. The parameters β_s are obtained with OLS regression. The potential endogeneity concern is discussed in the Robustness Check section.

With the estimates of β_s, this study obtained the counterfactual predictions of educational attainment $\widehat{y}_t$ for each cohort t by substituting the sibship size with its counterfactual values and holding other variables at their cohort means. Two counterfactual scenarios are considered. First, the simulation takes on the fertility trend in Vietnam to see what would have happened to the average educational attainment if the fertility in China had not declined so rapidly. Second, to gauge to what extent sibship size differences contributed to the educational differences between groups, the simulation analysis let females have the same level of sibship size as the males and let rural residents have the same level of sibship size as the urban residents. Table A2 in the online Appendix presents the average sibship size for each cohort by gender and urban/rural regions.

Results

Sibship Size and Educational Attainment: Trends, Group Variations, and Inequality

Figure 2 depicts the changes in average sibship size and year of education over cohorts in China. Overall, the average sibship size decreased while the education attainment increased. As illustrated in Panel a of Fig. 2, the average sibship size decreased from around 4.2 for the oldest cohort (1950) to around 1.0 for the youngest cohorts (1993). The average sibship size declined most rapidly for the 1970–1980 cohorts by 1.23, from 2.73 to 1.50, while for cohorts born after the implementation of the "one-child limits" (1980–1993 cohorts), their average sibship size decreased by 0.50, from 1.50 to 1.0, which echoes with the previous findings that family size began to decline in China before the implementation of "one-child limits," and it has declined most rapidly during the 1970s (Hesketh et al., 2005). Regarding education, as illustrated in Panel b of Fig. 2, the average years of schooling increased over cohorts, from around 7.3 years for the 1950s to 13.1 years for the 1990s, except for fluctuations experienced by the 1960s cohorts whose education was disrupted by the Cultural Revolution (1966–1976).

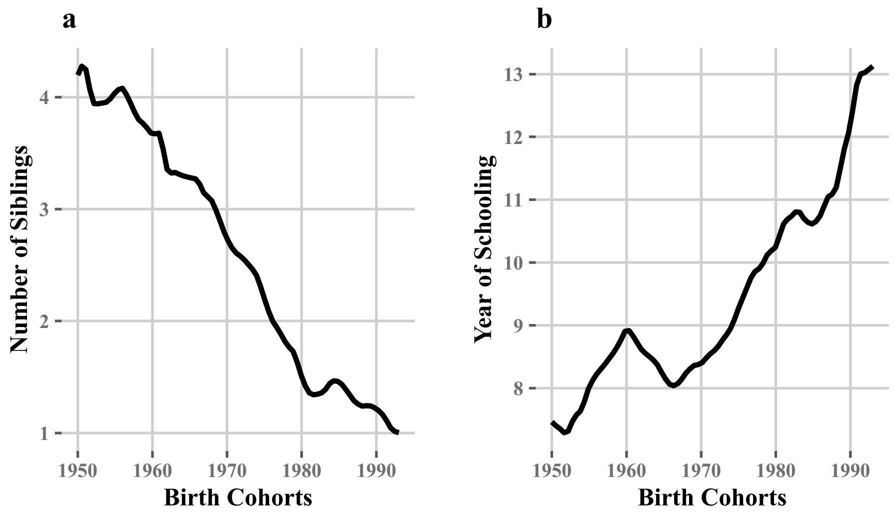

Fig. 2 Cohort Trends of the Average Number of Siblings (**a**) and Average Years of Schooling (**b**) in China

As for gender differences, according to Panel a in Fig. 3, females had more siblings than males over cohorts. Gender difference in sibship size was maintained at around 0.3 during the observed periods. Meanwhile, the gender difference in average education decreased over cohorts (Panel b in Fig. 3). The largest gender gap in education is observed for the 1960 cohort, where males had 1.27 years more education than females. The gender gap diminished afterward and closed for the 1988 cohort and onward.

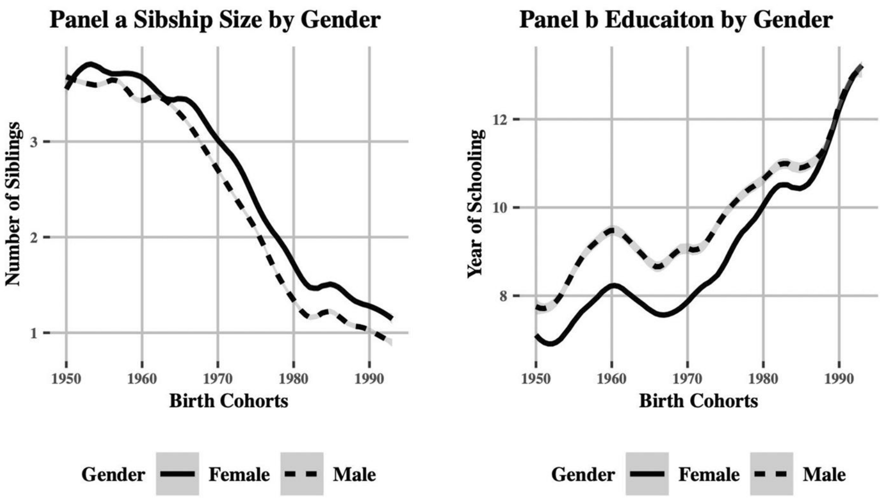

Fig. 3 Cohort Trends of Sibling Size (**a**) and Average Year of Schooling (**b**) by Gender in China

Regarding rural/urban discrepancy, rural residents had more siblings than urban residents, and the difference first decreased from around one for the 1960 cohort to 0.82 for the 1970 cohort (Panel a in Fig. 4). Thereafter, it fluctuated at around 0.8 for the 1970s cohorts and increased after the implementation of the “one-child limits.” It oscillated at around one since the 1978 cohort. It is worth noticing that the average sibship size for urban residents fell below one after 1979, which suggests a high proportion of the only-child among urban residents. Figure 5 depicts the share of only-child among urban and rural residents. For cohorts born before 1970, the percentage of the only-child is less than 5% in both urban and rural populations. Since 1970, the share of the only-child among urban residents has increased dramatically. The number increased from less than 5% for the 1970 cohort to 40% for the 1979 cohort. After the implementation of the “one-child limits,” the share of the only-child in urban increased by around 38%, from 40 to 78% for the 1993 cohort. By comparison, the increase in the share of only-child among rural residents was relatively modest. It slowly increased from less than 5% for the 1970 cohort to less than 10% for the 1980 cohort and around 20% for the 1993 cohort. As for educational attainment (Panel b in Fig. 4), over cohorts, though urban and rural residents both experienced an improvement in average educational attainment, urban residents constantly had around four more years of education than rural residents and this gap only started to diminish for recent cohorts (the 1990s).

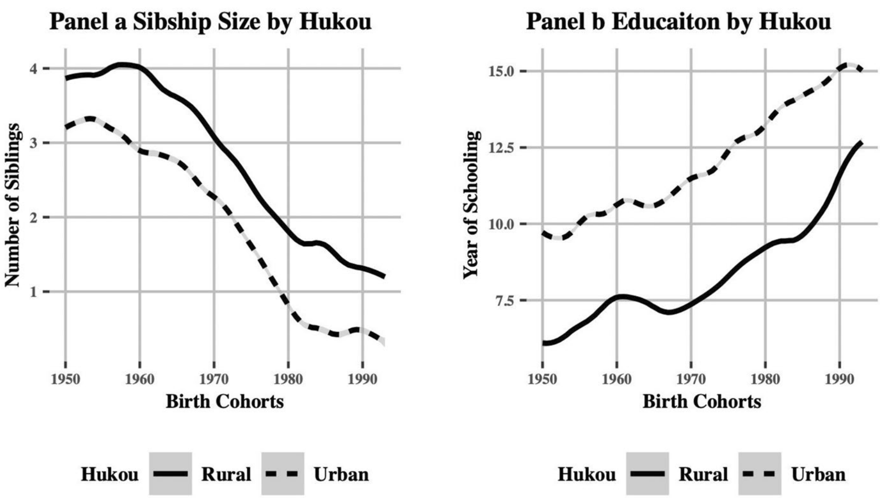

Fig. 4 Cohort Trends of Sibling Size (**a**) and Average Year of Schooling (**b**) by *Hukou* in China

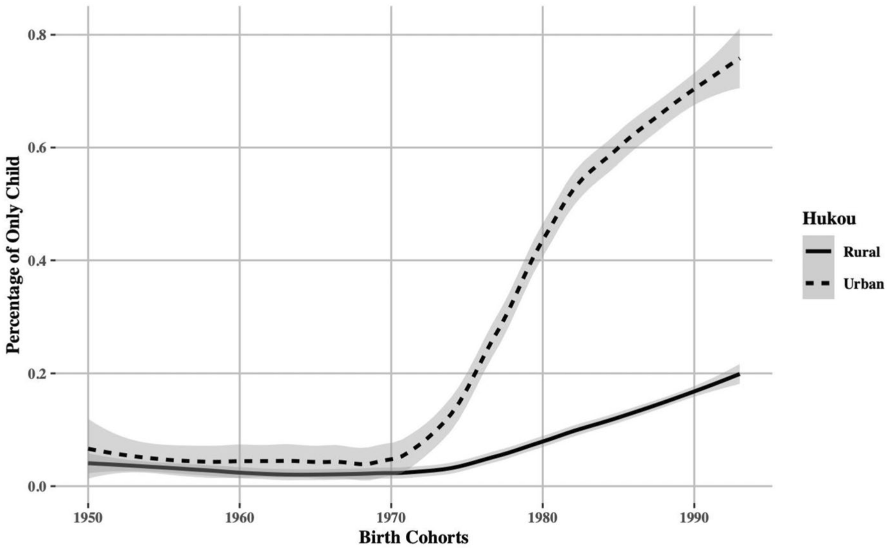

Fig. 5 Cohort Trends of the Percentages of Only Child in the Chinese Sample by *Hukou*

Sibship Size and Educational Attainment

To link sibship size changes with changes in educational attainment, we first need to answer how one's sibship size is associated with his/her educational attainment. Figure 6 illustrates how the association between sibship size and educational attainment evolves over cohorts. The estimates for each cohort are obtained with OLS regressions (Eq. 2). In accordance with the previous work, sibship size is negatively associated with one's educational attainment in China (Li et al., 2007; Rosenzweig & Zhang, 2009; Liu, 2014; Chen, 2020), and the negative association became stronger gradually (Choi et al., 2020; Lu & Treiman, 2008). Having one more sibling is associated with around 0.1 years less education (statistically insignificant, $p > 0.01$) for the oldest cohorts (the 1950s). The association increased to around 0.6-unit less of education ($p < 0.000$) for the youngest cohorts (the 1990s). The enlarged sibship size disadvantages in education are also reported in the previous studies (Choi et al., 2020; Lu & Treiman, 2008). The rapid transition to the market economy and changing education and labor market institutions are argued to contribute to the increasing sibship size disadvantages in China. Moreover, after the implementation of the "one-child limits," families that comply with the regulation receive allowance and subsidies. Only child of rural families receive bonus points in high school and college entrance exams in some provinces, which may also contribute to the increasing sibship size penalty in education for the post-1980 cohorts. For the early cohorts (the 1950s and 1960s) and some of the recent cohorts (the 1980s), the sibship size disadvantage is larger for females than for males (Panel b in Fig. 6). No statistically significant difference exists between urban and rural residents in the sibship size penalty (Panel c in Fig. 6).

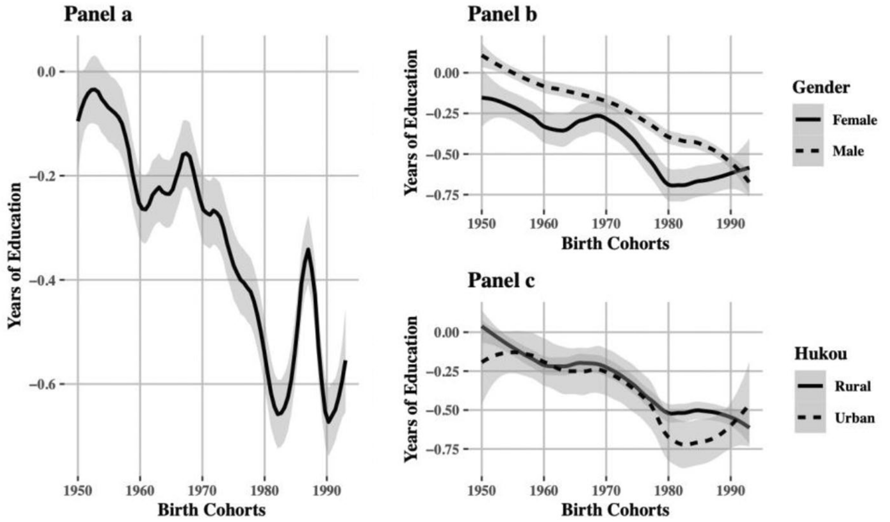

Fig. 6 Cohort Trends of Sibship Size Disadvantage in the Years of Education (**a**) and Trends by Gender (**b**) and by *Hukou* Status (**c**) in China. *Note* Shadows show 95% confidence intervals of the coefficient. Parental education and birth years, ethnicity, gender, hukou, age and age square, and provinces of birth are controlled

Fertility Decline and its Educational Consequences

Two counterfactual simulation analyses are conducted to assess the consequences of fertility decline on education. First, the average sibship sizes of the Chinese cohorts take on the values of their Vietnamese counterparts. Results are shown in Fig. 7. First, if the sibship sizes in China had followed the Vietnamese pattern, its average educational attainment would have been lower across cohorts. Under the counterfactual scenario, the average years of schooling for the 1970 cohort have been 7.52 years, which is 0.87 years or 10.4% lower than the observed level. The average years of schooling for the 1980 cohort would have been 8.77 years, which is 1.48 years or 14.4% lower than the observed level. The average attainment of the youngest cohort (1993) would have been 12.36 years under the counterfactual scenario, which is 0.76 years or 6% less than the observed.

Second, the educational progress would have happened slower under the Vietnamese counterfactual. Over cohorts, the sibship size of the Chinese sample decreased by 3.20 from 4.20 to 1.00, and the average years of schooling increased by 5.66 years. If the sibship size had followed the Vietnamese pattern, from 1950 to the 1993 cohort, the average sibship size would have decreased by 2.68 from 4.72 to 2.04. The average years of schooling would have increased by 5.13 years, 9% less than observed.

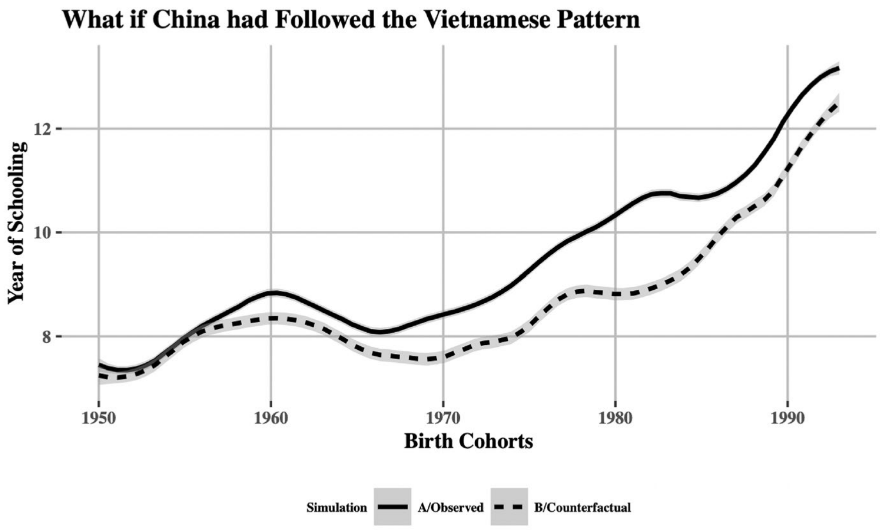

Fig. 7 The Observed and Counterfactual Trends of Average Year of Schooling in China. *Note* The dash line represents the counterfactual scenario. Shadows show 95% confidence intervals

The second counterfactual simulation focuses on between-group inequalities. First, regarding the gender gap in education, Fig. 8 illustrates what would have happened if females had had the same level of sibship size as males. The hypothetical trends are almost the same as the observed. The gender gap in education would have closed as early as the 1983 cohort, five cohorts ahead of the observed. The sibship size differences between males and females have contributed modestly to the gender gap in education. It should not be surprising considering that the gender differences in sibship size are only around 0.3 over cohorts. Although the rapid decline in fertility rates leads to an increasing proportion of only-daughters, it mainly happened in the urban population (Fig. 5), and the scale is not large enough to change the overall pattern in sibship size differences between females and males. Furthermore, Figure A1 in the Online Appendix depicts the cohort trends of educational attainment by gender for those with and without siblings. As revealed, there is no statistically significant difference in educational attainment between only-child females and only-child males over cohorts. For those with siblings, the gender gap closed over cohorts as well. It echoes with the simulation results that the gender gap in education would have disappeared over cohorts even if there had been no difference between genders in their sibship sizes.

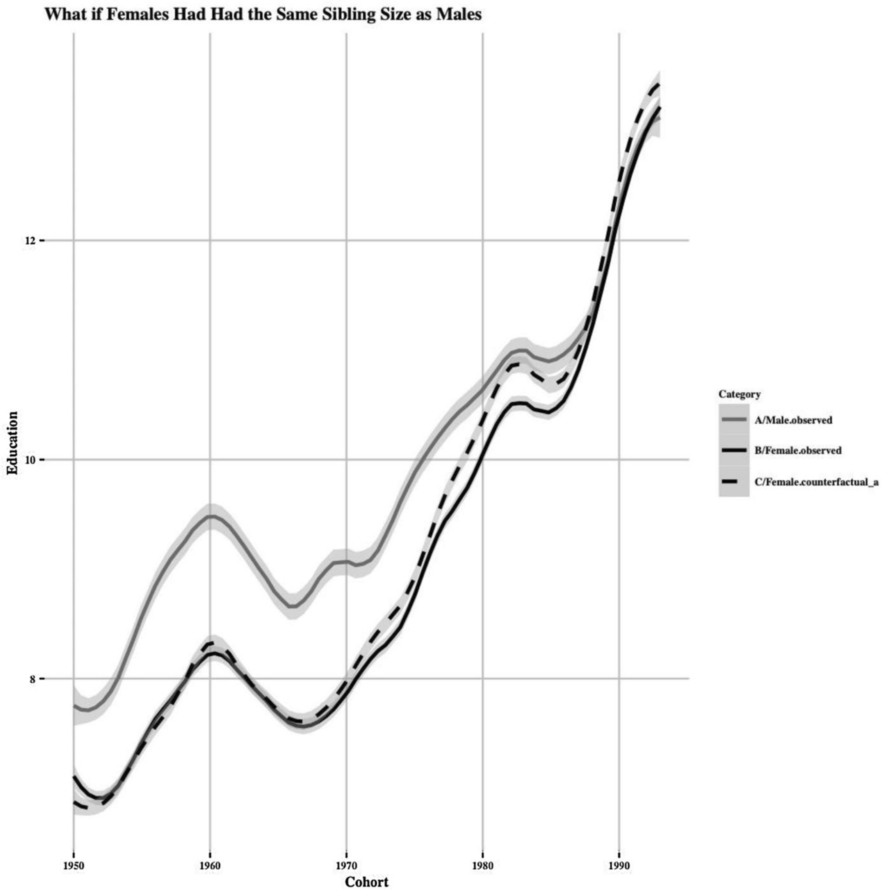

Fig. 8 The Observed and Counterfactual Trends of Gender Inequality in Schooling in China. *Note* Dash lines represent the counterfactual scenarios. Shadows show 95% confidence intervals

Next, regarding rural/urban differences, Fig. 9 illustrates that if rural residents had had the same sibship size over cohorts as their urban counterparts, it would have significantly reduced the regional educational inequalities. Under the counterfactual scenario, for the 1970 cohort, the average attainment of the rural residents would have been 8.03 years, which is 0.67 years higher than the observed and reduces the regional educational gap by 16.1%. Moreover, the impact of the sibship size differences on educational gaps continued to increase over cohorts. As for the 1980 cohort, the average attainment of the rural residents under the counterfactual scenario would have been 10.21 years, which is 1.08 years higher than the observed, reducing the rural/urban gap by 26.3%. When it comes to the 1990 cohort, if the rural residents had had the same sibship size as their urban counterparts, their average years of schooling would have been 12.60 years, which is 1.08 years higher than the observed and reduced the rural/urban educational gap by 30.2%. Overall, the counterfactual analysis shows that the sibship size differences between rural and urban China have a marked impact on the rural–urban disparity. Since the negative association between sibship size and educational attainment became stronger over cohorts (Fig. 6), its contribution to educational inequality grows over time.

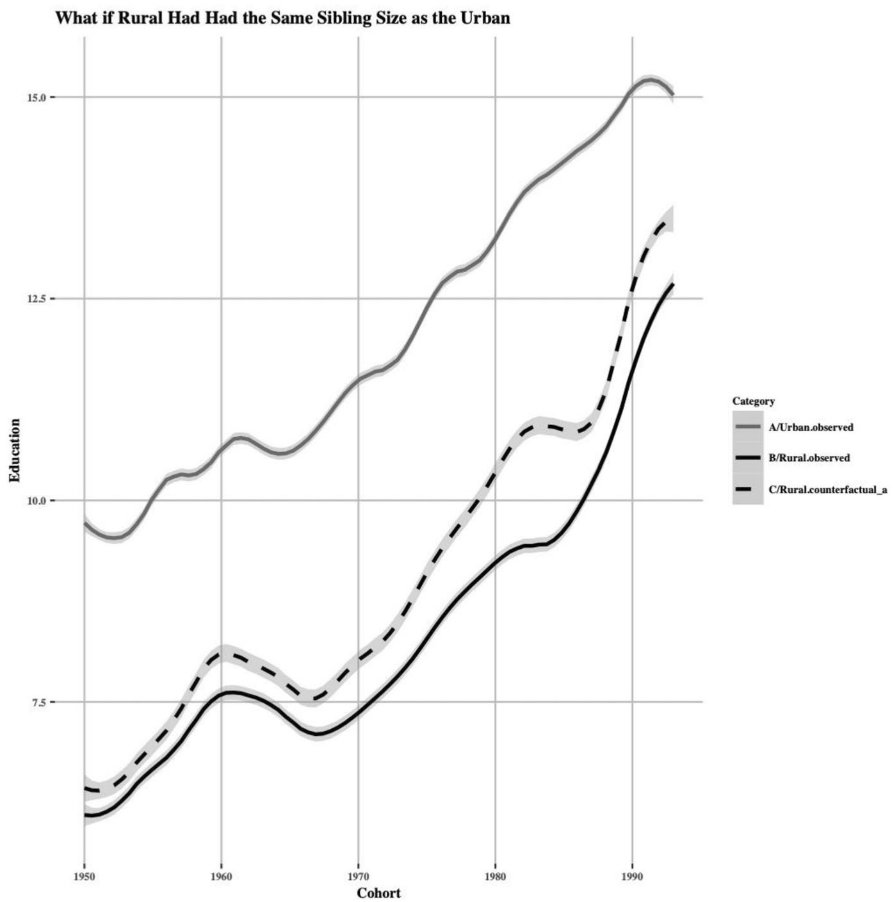

Fig. 9 The Observed and Counterfactual Trends of Urban/Rural Inequality in Schooling in China. *Note* Dash lines represent the counterfactual scenarios. Shadows show 95% confidence intervals

Robustness Check

Internal Migration

When examining the cohort trends, the rural and urban populations are defined according to the mother's *hukou* status when the respondent is young. However, China has experienced massive rural-to-urban migration since the early 1980s. In 2007, about 10% of China's population were rural-to-urban migrants (Kwong, 2011), while in 2011, 29.7% of the population with a rural origin lived in urban areas. If only the policy intervention is considered, not isolating the internal migrants from the rural sample should not be a concern because one's fertility behavior is subjected to local regulation where the person's *hukou* is registered. For a migrant who lives in the urban areas, if his/her mother has the rural *hukou* when the respondent is young, his/her sibship size is affected by the rural rather than the urban regulations. However, the assimilation theory of migration (Warner & Srole, 1945) expects migrants and their children to adapt to the hosting environment and to have similar attitudes and behaviors as residents at their destinations. Thus, rural-to-urban migrants may voluntarily adopt the fertility strategies of urban residents to have fewer children. Moreover, migration experience influences one's educational attainment. Empirical studies report mixed findings on the impact of migration on one's educational attainment (Liang & Chen, 2007; Wu & Zhang, 2015; Xu & Xie, 2015). The concern is that if migrants are positively or negatively selected and intrinsically different in childbearing and rearing from their rural counterparts, including them in the rural sample might bias the results. According to the literature, the most advantaged migrants are those who successfully switch to urban *hukou* (Wu & Treiman, 2004), as the government set a quota on *hukou* conversion to 1.5 to 2.0 per thousand persons each year (Yilong, 2003). The conversion can be achieved by obtaining higher education, party membership, and military service. Among the 32,815 rural cases in the sample, 3,033(9.24%) cases switched to urban *hukou* at the time of the survey. I replicated the analysis by excluding the migrants from the sample. Results do not reveal a substantial difference as reported.

The Endogeneity Problem of Sibship Size

The simulation model is constructed based on the assumption that changes in sibship size are exogenous. However, as reviewed, previous studies raised concerns about the endogeneity problem of sibship size, and estimates from OLS regression might be biased. In response, I used the instrumental variable approach and compared the 2SLS and OLS estimates to see whether and how the endogeneity problem can affect the conclusions. Results suggest that the OLS estimate is preferred for its efficiency.

In the literature, studies often employ twin births or the sex composition of the first two births as instruments for sibship size (Angrist et al., 2010; Black et al., 2005; Conley & Glauber, 2006). However, these instruments have drawbacks when applied to the Chinese context. Neither can capture the increase in sibship size from zero to one, which is the most common scenario in China during the observational periods. In practice, the variation in family size owing to these instruments is confined to families with at least two children.[2] Moreover, the sex composition is endogenous in a society with a strong son preference. Instead, I used the variations in rural China's "one-child limits" as instruments. Several studies employed this policy instrument at the aggregated level, for instance, the urban and rural differences (Wu & Li, 2012) or provincial or county-level differences (Liu, 2014; Qian, 2009). For the robustness check, I used the detailed community/village-level regulations as instruments available only in the China Family Panel Studies (CFPS) 2010 wave. The local policy is measured by (a) whether more than one birth is allowed and (b) the amount of fine on the excess births. The sample for the robustness check is selected among those born after 1949 and older than 25 in 2010 in rural China. Since, in the literature, birth order (Bagger et al., 2013; Booth & Kee, 2009; De Haan, 2005) and birth spacing (Blake et al., 2005) are argued to confound the sibship size effect, the analysis focuses on the firstborn to avoid potential bias. The final analytic sample contains 1461 mothers residing in 338 communities in 23 different provinces with complete information on the variables used in the analysis. Details on the sample and variables used for the IV analysis can be found in the Online Appendix (Section III).

The instrument exogeneity assumption requires that the local fertility regulations should not be correlated with unmeasured confounders. Several potential confounders are considered. First, it is tested in previous studies whether the family size preferences varied at the community level. Previous studies reported no evidence suggesting that communities with more relaxed fertility policies have a higher proportion of parents preferring a larger family (Liu, 2014). The analysis further controls local educational resources measured by government's educational expenditure and number of schools in the communities in case local governments with stricter fertility policies invest more in education. Another potential violation of the exogeneity assumption is the migration for fertility purposes. Communities with fewer restrictions on fertility may attract migrants who wish to have more children, and if the migrants are intrinsically different in educating their children, the exogeneity

[2] When using twin births as an instrument, the effects of sibship size are uncovered by estimating the effect of a twin birth at birth N on the outcomes of children born prior to this birth, conditional on families having at least N births. Since twins and singleton children are different in their birth endowment, like birth weight, and various other aspects that are related to future development, it is not appropriate to use births of twins as an instrument at N = 1, i.e., to compare twins with the single child at first birth, to estimate the effect of an increase in sibship size from 0 to 1. Similarly, the sex composition can only be used for families with at least two children to estimate the effect of the sibship size increase from 2 to more.

assumption is violated. In response, I excluded the migrants from the analysis. Moreover, I checked the exogeneity assumption with a placebo test and the robustness of the results against potential measurement errors in the instrumental variables. Details are provided in the Online Appendix (Section III).

The OLS and IV results are presented in Table 1. All the models controlled the following variables: (1) the gender and age of the child; (2) the characteristics of the mother: her age at first birth and year of schooling; (3) the father's year of schooling and the logarithm of annual net family income; (4) local educational resources measured by the educational expenditure of the government and number of schools in the communities in 2010.

According to the OLS estimates, a one-unit increase in sibship size is associated with a 0.583-year ($p<0.000$), or 7-month, decrease in the educational attainment of the first child. As for the IV estimates, the first-stage regression results indicate that the one-child fertility limit is negatively associated with sibship size. Living in communities where only one birth is allowed, *ceteris paribus*, is associated with a 0.185-unit ($p<0.01$) decrease in sibship size. As for the level of fine, it is negatively associated with sibship size. A 1% increase in the fine charged on excess birth is associated with a 0.3% decrease ($p<0.000$) in sibship size. The two instruments together explained 3.5% of the variance in sibship size, and the F-statistics passed the threshold of 10 (Bound et al., 1995).

The IV estimate reveals the same patterns as the OLS estimate that the sibship size harms the educational attainment of the firstborn children. Compared with the OLS estimate, the IV estimate has a sizeable standard error, and its 95% confidence interval contains the point estimate from the OLS regression. To decide which estimator is preferred, I tested the endogeneity of sibship size with the Hausman (1978) test. It compares the OLS and 2SLS estimates to see whether the difference is statistically significant. The test results give large p-values ($p=0.091$), suggesting that there lacks sufficient evidence to reject the null hypothesis that the OLS and 2SLS estimates are statistically indifferent. Thus, the OLS estimate is preferred for its efficiency.

Table 1 Robustness check: The comparison between the OLS and 2SLS estimates of the sibship size effects on the educational attainment of the first-born child in rural China

	OLS	IV	
		1st Stage	2SLS
Outcome variables	Education of the 1st born	Sibling size	Education of the 1st born
Number of siblings	**– .583*****		**– 1.847***
	(.107)		(.851)
Instruments			
One-child limit (No = 0; Yes = 1)		– .182**	
		(.076)	
Log of fine		– .291***	
		(.074)	
N	1461		
adj. R^2	.157	.182	.072
1st Stage statistics			
Partial R^2		.035	
Robust F-statistics		14.680	

Sample selected from CFPS 2010. (Details on the selection criteria can be found in Online Appendix Section III.) Four sets of variables included as controls: (1) the child's gender and age; (2) the characteristics of the mother: her age at first birth and year of schooling; (3) the father's year of schooling and the logarithm of annual net family income; (4) annual educational expenditure and number of schools of the communities. Parameters for control variables are omitted here. Standard errors are adjusted to account for the clustering of residents within communities shown in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Conclusion and Discussion

This study answered two questions regarding the educational consequences of the fertility decline in China.

First, has fertility decline improved human capital via shrinking sibship size? The answer depends on (a) the magnitude of fertility decline and (b) the magnitude of the association between sibship size and educational attainment. Regarding the former, from 1950 to the 1993 cohort, the sibship size of the Chinese sample decreased by 3.20 from 4.20 to 1.00. If the sibship size had followed the Vietnamese pattern, from the 1950 to the 1993 cohort, the average sibship would have decreased by 2.68 from 4.72 to 2.04. The counterfactual analysis demonstrates that if the fertility decline in China had followed the Vietnamese pattern, the improvement in education under the counterfactual scenario is 9% less than the observed. As the methods and underlying assumptions of models vary, it is challenging to compare this estimate with previous studies on other Asian countries to see whether the contribution of fertility decline to educational improvement in China falls in the average range. Future research should seek a general research framework to assess the variations across countries.

Regarding the second component, the magnitude of the effect of fertility on educational attainment, a methodological concern is whether the OLS estimates suffer from the endogeneity problem. To address this concern, I employed instruments from the local variations of the "one-child limits" in rural areas. IV results confirm a negative link between sibship size and educational attainment. The OLS estimate is preferred for its efficiency since the difference between the OLS and IV estimates is not statistically significant. Furthermore, the OLS estimate is preferred since the IV analysis requires a set of strong assumptions, and its estimate is a local effect for the compliers.

The second question answered is whether differential fertilities contributes to between-group educational inequality. First, the observed gender gap in education closed for the 1988 cohort and onward. Counterfactual analysis suggests that if females had had the same number of siblings as males, the gender gap in education would have disappeared slightly earlier for the 1983 cohort and onward. The impact of sibship size on gender inequality in education is limited. Previous studies argue that fertility decline should have promoted gender equality as more girls enjoyed the only-child premium and obtained similar attainment as boys (Lee, 2012; Tsui & Rich, 2002). Descriptive results first show that the sibship size gap between females and males had maintained at 0.3 over cohorts during the past decades, and no significant change was observed. Although the rapid decline in fertility rates leads to an increasing proportion of only-daughters, it mainly happened in the urban population (Fig. 5), and the scale is not large enough to change the overall pattern in sibship size differences between females and males. Factors other than fertility should have driven the convergence of females' and males' educational attainment in China.

Second, regarding rural–urban discrepancy, results reveal that differential fertilities have marked impacts on rural–urban inequality in education, and the impacts became stronger over cohorts. The counterfactual analysis reveals that if rural residents had had the same sibship size over cohorts as their urban counterparts, it would have significantly reduced the regional educational inequalities by 16.1% for the 1970 cohort, by 26.3% for the 1980 cohort, and by 30.2% for the 1990 cohort. By fixing the sibship size for urban and rural populations at the same level, this analysis reveal that differential fertility can explain up to 30% of the education gap. These findings highlight the less-mentioned consequences of fertility declines in China and bring up a new perspective to understand the educational inequality in contemporary China. It should inspire future research on the inequality of other dimensions where differences in fertility rates between groups are observed. For instance, a promising candidate is the inequality between ethnic groups (Han Chinese vs. ethnic minorities). Ethnic groups might cherish different childbearing and rearing values, which leads to discrepancies in fertility outcomes between groups. Moreover, ethnic minorities are exempted from the one-child limit, which can further enlarge the fertility gap between groups. As ethnic inequality in educational attainment (Hannum, 2002) and occupation status (Hannum & Xie, 1998) is documented, it is a fruitful avenue of research to explore the long-term impact of fertility differences on these ethnic inequalities.

It is worth emphasizing that multiple factors have led to fertility decline in China. The results should not be interpreted as the impact of the “one-child limits” on education. The effects of policy intervention and socioeconomic factors on fertility decline are interwoven. Evaluating the consequence of the “one-child limits” bears its own significance. Findings from previous studies varied greatly depending on the methods and the chosen counterfactuals when the simulation method is employed (Gu, 2022; Li & Zhang, 2017; Rosenzweig & Zhang, 2009; Zhu et al., 2014). Findings from this analysis show that under the counterfactual of the Vietnamese pattern, and taking the influence of policy and other factors together, what is the upper bound of the contribution of fertility decline to education?

To conclude, this study finds that the fertility decline during the 1950–1993 cohorts in China brought a 9% improvement in the average years of schooling compared to the Vietnamese counterfactual. Its impact on the educational disparity between genders is limited. However, during this period, the divergent trends of fertility decline for urban and rural populations significantly impacted the rural–urban disparity in education.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11113-023-09834-7.

Acknowledgements The author is grateful to Richard Breen, John Ermisch, Jan O.Jonsson, and Vida Maralani for their valuable comments and suggestions on the earlier draft of this paper. The author also thanks the journal editor and reviewers for constructive comments. The research is supported by the PhD scholarship from the Chinese Scholarship Council.

Funding This work is supported by Chinese Scholarship Council, 201808060314,Hanzhi Hu.

Data availability The data used are publicly available and can be accessed through the following approaches. The CGSS data can be accessed at http://cgss.ruc.edu.cn/English/Home.htm. The CFPS data can accessed at http://www.isss.pku.edu.cn/cfps/en/index.htm. The Vietnam Population Census data are provided by the General Statistical Office of Vietnam and accessed through IMPUS International.

References

Angrist, J., Lavy, V., & Schlosser, A. (2010). Multiple experiments for the causal link between the quantity and quality of children. *Journal of Labor Economics, 28*(4), 773–824.

Ashraf, Q. H., Weil, D. N., & Wilde, J. (2013). The effect of fertility reduction on economic growth. *Population and Development Review, 39*(1), 97–130.

Åslund, O., & Grönqvist, H. (2010). Family size and child outcomes: Is there really no trade-off? *Labour Economics, 17*(1), 130–139.

Bagger, J., Birchenall, J. A., Mansour, H., & Urzúa, S. (2013). Education, birth order, and family size (No. w19111). *National Bureau of Economic Research.*

Banister, J. (1987). *China's changing population*. Stanford University Press.

Becker, G. S., & Lewis, H. G. (1973). On the interaction between the quantity and quality of children. *Journal of Political Economy, 81*(2), S279–S288.

Bian, Y., & Li, L. (2012). The Chinese general social survey (2003–8) sample designs and data evaluation. *Chinese Sociological Review, 45*(1), 70–97.

Black, S. E., Devereux, P. J., & Salvanes, K. G. (2005). The more the merrier? The effect of family size and birth order on children's education. *The Quarterly Journal of Economics, 120*(2), 669–700.

Bloom, D. E., & Williamson, J. G. (1998). Demographic transitions and economic miracles in emerging Asia. *The World Bank Economic Review, 12*(3), 419–455.
Bloom, D., Canning, D., & Sevilla, J. (2003). *The demographic dividend: A new perspective on the economic consequences of population change*. Rand Corporation.
Bloom, D. E., Canning, D., Hu, L., Liu, Y., Majhal, A., & Yip, W. (2010). The contribution of population health and demographic change on economic growth in China and India. *Journal of Comparative Economics, 38*, 17–33.
Bongaarts, J. (2003). Completing the fertility transition in the developing world: The role of educational differences and fertility preferences. *Population Studies, 57*(3), 321–335.
Bongaarts, J. (2008). Fertility transitions in developing countries: Progress or stagnation? *Studies in Family Planning, 39*(2), 105–110.
Bongaarts, J., & Hodgson, D. (2022). *Fertility transition in the developing world* (p. 144). Springer.
Booth, A. L., & Kee, H. J. (2009). Birth order matters: The effect of family size and birth order on educational attainment. *Journal of Population Economics, 22*(2), 367–397.
Bound, J., Jaeger, D. A., & Baker, R. M. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association, 90*(430), 443–450.
Cáceres-Delpiano, J. (2006). The impacts of family size on investment in child quality. *Journal of Human Resources, 41*(4), 738–754.
Cai, Y. (2008). An assessment of China's fertility level using the variable-r method. *Demography, 45*(2), 271–281.
Chen, S. (2020). Parental investment after the birth of a sibling: The effect of family size in low-fertility China. *Demography, 57*(6), 2085–2111.
Choi, S., Taiji, R., Chen, M., & Monden, C. (2020). Cohort trends in the association between sibship size and educational attainment in 26 low-fertility countries. *Demography, 57*(3), 1035–1062.
Conley, D., & Glauber, R. (2006). Parental educational investment and children's academic risk estimates of the impact of sibship size and birth order from exogenous variation in fertility. *Journal of Human Resources, 41*(4), 722–737.
Cuaresma, J. C., Lutz, W., & Sanderson, W. (2014). Is the demographic dividend an education dividend? *Demography, 51*(1), 299–315.
Das Gupta, M., & Mari Bhat, P. N. (1997). Fertility decline and increased manifestation of sex bias in India. *Population Studies, 51*(3), 307–315.
De La Croix, D., & Doepke, M. (2003). Inequality and growth: Why differential fertility matters. *American Economic Review, 93*(4), 1091–1113.
Den Boer, A., & Hudson, V. (2017). Patrilineality, son preference, and sex selection in South Korea and Vietnam. *Population and Development Review, 43*(1), 119–147.
Dribe, M., Oris, M., & Pozzi, L. (2014). Socioeconomic status and fertility before, during, and after the demographic transition: An introduction. *Demographic Research, 31*, 161–182.
Eastwood, R., & Lipton, M. (1999). The impact of changes in human fertility on poverty. *The Journal of Development Studies, 36*(1), 1–30.
Fang, C. (2018). Population dividend and economic growth in China, 1978–2018. *China Economic Journal, 11*(3), 243–258.
Fang, C., & Wang, D. (2005). China's Demographic Transition: Implications for Growth. In R. Garnaut & L. Song (Eds.), *The China Boom and Its Discontents.* Asia Pacific Press.
Feeney, G., & Feng, W. (1993). Parity progression and birth intervals in China: The influence of policy in hastening fertility decline. *Population and Development Review, 19*(1), 61–101.
Feng, W., & Quanhe, Y. (1996). Age at marriage and the first birth interval: The emerging change in sexual behavior among young couples in China. *Population and Development Review, 22*(2), 299–320.
Goodkind, D. M. (2004). China's missing children: The 2000 census underreporting surprise. *Population Studies, 58*(3), 281–295.
Goodkind, D. (2011). Child underreporting, fertility, and sex ratio imbalance in China. *Demography, 48*(1), 291–316.
Goodkind, D. (2017). The astonishing population averted by China's birth restrictions: Estimates, nightmares, and reprogrammed ambitions. *Demography, 54*(4), 1375–1400.
Greenhalgh, S. (1989). *Fertility trends in China: approaching the 1990s* (Vol. 8). Population Council, Research Division.
Gu, J. (2022). Fertility, human capital, and income: The effects of China's one-child policy. *Macroeconomic Dynamics, 26*(4), 979–1020.

Gu, B., Feng, W., Zhigang, G., & Erli, Z. (2007). China's local and national fertility policies at the end of the twentieth century. *Population and Development Review, 33*(1), 129–147.
Guo, G., & VanWey, L. K. (1999). Sibship size and intellectual development: Is the relationship causal? *American Sociological Review, 64*(2), 169–187.
de Haan, Monique (2005) Birth Order, Family Size and Educational Attainment, Tinbergen Institute Discussion Paper, No. 05–116/3, Tinbergen Institute, Amsterdam and Rotterdam
Hannum, E. (2002). Educational stratification by ethnicity in China: Enrollment and attainment in the early reform years. *Demography, 39*(1), 95–117.
Hannum, E., & Xie, Y. (1994). Inequality in China: 1949–1985. *Research in Social Stratification and Mobility, 13*, 73–98.
Hannum, E., & Xie, Y. (1998). Ethnic stratification in Northwest China: Occupational differences between Han Chinese and national minorities in Xinjiang, 1982–1990. *Demography, 35*(3), 323–333.
Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica: Journal of the Econometric Society, 46*(6), 1251–1271.
Hermalin, A. I., & Liu, X. (1990). Gauging the validity of responses to questions on family size preferences in China. *Population and Development Review, 16*(2), 337–354.
Hesketh, T., Lu, L., & Xing, Z. W. (2005). The effect of China's one-child family policy after 25 years. *New England Journal of Medicine, 353*(11), 1171–1176.
Joshi, S., & Schultz, T. P. (2007). *Family planning as an investment in development: Evaluation of a program's consequences in Matlab* (p. 951). Yale University Economic Growth Center Discussion Paper.
Junhong, C. (2001). Prenatal sex determination and sex-selective abortion in rural central China. *Population and Development Review, 27*(2), 259–281.
Karra, M., Canning, D., & Wilde, J. (2017). The effect of fertility decline on economic growth in Africa: A macrosimulation model. *Population and Development Review, 43*, 237–263.
Kuo, H. H. D., & Hauser, R. M. (1995). Trends in family effects on the education of black and white brothers. *Sociology of Education, 68*(2), 136–160.
Kwong, J. (2011). Education and identity: The marginalisation of migrant youths in Beijing. *Journal of Youth Studies, 14*(8), 871–883.
Lam, D. (1986). The dynamics of population growth, differential fertility, and inequality. *The American Economic Review, 76*(5), 1103–1116.
Lavely, W., & Freedman, R. (1990). The origins of the Chinese fertility decline. *Demography, 27*(3), 357–367.
Lee, M. H. (2012). The one-child policy and gender equality in education in China: Evidence from household data. *Journal of Family and Economic Issues, 33*(1), 41–52.
Lee, R., Mason, A., & Miller, T. (2000). Life cycle saving and the demographic transition: The case of Taiwan. *Population and Development Review, 26*, 194–219.
Li, H., & Zhang, J. (2007). Do high birth rates hamper economic growth? *The Review of Economics and Statistics, 89*(1), 110–117.
Li, B., & Zhang, H. (2017). Does population control lead to better child quality? Evidence from China's one-child policy enforcement. *Journal of Comparative Economics, 45*(2), 246–260.
Li, H., Yi, J., & Zhang, J. (2011). Estimating the effect of the one-child policy on the sex ratio imbalance in China: Identification based on the difference-in-differences. *Demography, 48*(4), 1535–1557.
Li, J., Dow, W. H., & Rosero-Bixby, L. (2017). Education gains attributable to fertility decline: Patterns by gender, period, and country in Latin America and Asia. *Demography, 54*(4), 1353–1373.
Liang, Z., & Chen, Y. P. (2007). The educational consequences of migration for children in China. *Social Science Research, 36*(1), 28–47.
Liu, H. (2014). The quality–quantity trade-off: Evidence from the relaxation of China's one-child policy. *Journal of Population Economics, 27*(2), 565–602.
Lu, Y., & Treiman, D. J. (2008). The effect of sibship size on educational attainment in China: Period variations. *American Sociological Review, 73*(5), 813–834.
Maralani, V. (2008). The changing relationship between family size and educational attainment over the course of socioeconomic development: Evidence from Indonesia. *Demography, 45*(3), 693–717.
Mare, R. D. (1997). Differential fertility, intergenerational educational mobility, and racial inequality. *Social Science Research, 26*(3), 263–291.
Mason, A., Lee, R., Abrigo, M., & Lee, S. H. (2017). Support ratios and demographic dividends: Estimates for the World. Technical Paper, 1.

McElroy, M., & Yang, D. T. (2000). Carrots and sticks: Fertility effects of China's population policies. *American Economic Review, 90*(2), 389–392.
Merli, M. G., & Smith, H. I. (2002). Has the Chinese family planning policy been successful in changing fertility preferences? *Demography, 39*(3), 557–572.
Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 7.3. Minneapolis, MN: IPUMS, 2020. https://doi.org/10.18128/D020.V7.3
Murphy, R., Tao, R., & Lu, X. (2011). Son preference in rural China: Patrilineal families and socioeconomic change. *Population and Development Review, 37*(4), 665–690.
Parish, W. L., & Willis, R. J. (1993). Daughters, education, and family budgets Taiwan experiences. *Journal of Human Resources, 28*(4), 863–898.
Ponczek, V., & Souza, A. P. (2012). New evidence of the causal effect of family size on child quality in a developing country. *Journal of Human Resources, 47*(1), 64–106.
Pong, S. L. (1997). Sibship size and educational attainment in Peninsular Malaysia: Do policies matter? *Sociological Perspectives, 40*(2), 227–242.
Preston, S. H. (1974). Differential fertility, unwanted fertility, and racial trends in occupational achievement. *American Sociological Review, 39*(4), 492–506.
Preston, S. H., & Campbell, C. (1993). Differential fertility and the distribution of traits: The case of IQ. *American Journal of Sociology, 98*(5), 997–1019.
Qian, N. (2009). Quantity-quality and the one child policy: The only-child disadvantage in school enrollment in rural China (No. w14973). *National Bureau of Economic Research*.
Retherford, R. D., Choe, M. K., Chen, J., Xiru, L., & Hongyan, C. (2005). How far has fertility in China really declined? *Population and Development Review, 31*(1), 57–84.
Rosenzweig, M. R., & Zhang, J. (2009). Do population control policies induce more human capital investment? Twins, birth weight and China's "one-child" policy. *The Review of Economic Studies, 76*(3), 1149–1174.
Sen, G., Surana, M., & Basant, R. (2023). To what extent does the fertility rate explain the education gap? *Population Research and Policy Review, 42*(3), 35.
Torche, F. (2010). Educational assortative mating and economic inequality: A comparative analysis of three Latin American countries. *Demography, 47*(2), 481–502.
Treiman, D. J. (2013). Trends in educational attainment in China. *Chinese Sociological Review, 45*(3), 3–25.
Tsui, M., & Rich, L. (2002). The only child and educational opportunity for girls in urban China. *Gender & Society, 16*(1), 74–92.
Vogl, T. S. (2016). Differential fertility, human capital, and development. *The Review of Economic Studies, 83*(1), 365–401.
Wang, F., & Mason, A. (2008). The Demographic Factor in China's Transition". In L. Brandt & T. G. Rawski (Eds.), *China's Great Economic Transformation.* Cambridge University Press.
Warner, W. L., & Srole, L. (1945). *The social systems of American ethnic groups*. Yale University Press.
Wei, Z., & Hao, R. (2010). Demographic structure and economic growth: Evidence from China. *Journal of Comparative Economics, 38*(4), 472–491.
Westoff, C. F. (1954). Differential fertility in the United States: 1900 to 1952. *American Sociological Review, 19*(5), 549–561.
Whyte, M. K., & Gu, S. Z. (1987). Popular response to China's fertility transition. *Population and Development Review, 13*(3), 471–493.
Wietzke, F. B. (2020). Poverty, inequality, and fertility: The contribution of demographic change to global poverty reduction. *Population and Development Review, 46*(1), 65–99.
Womack, B. (2009). Vietnam and China in an era of economic uncertainty. *The Asia-Pacific Journal, 36*(2), 1–15.
Wu, X., Ye, H., & He, G. G. (2012). Fertility decline and women's empowerment in China. *International Center for Research on Women Fertility & Empowerment Working Paper Series*, 006–2012.
Wu, X., & Li, L. (2012). Family size and maternal health: Evidence from the One-Child policy in China. *Journal of Population Economics, 25*(4), 1341–1364.
Wu, X., & Treiman, D. J. (2004). The household registration system and social stratification in China: 1955–1996. *Demography, 41*(2), 363–384.
Wu, X., & Zhang, Z. (2010). Changes in educational inequality in China, 1990–2005: Evidence from the population census data. In E. Hannum, H. Park, & Y. G. Butler (Eds.), *Globalization, changing demographics, and educational challenges in East Asia.* Emerald Group Publishing Limited.

Wu, X., & Zhang, Z. (2015). Population migration and children's school enrollments in China, 1990–2005. *Social Science Research, 53*, 177–190.
Xie, Y., & Lu, P. (2015). The sampling design of the China family panel studies (CFPS). *Chinese Journal of Sociology, 1*(4), 471–484.
Xu, H., & Xie, Y. (2015). The causal effects of rural-to-urban migration on children's well-being in China. *European Sociological Review, 31*(4), 502–519.
Ye, H., & Wu, X. (2010). Fertility decline and educational gender inequality in China. *International Sociological Association-Research Committee on Social Stratification and Mobilit*y (ISA-RC28).
Yilong, Lu. "The Household Registration System-Control and Social Distinction (hu ji zhi du—kongzhiyu she hui cha bie)." (2003): 124–126.
Yount, K. M., Zureick-Brown, S., Halim, N., & LaVilla, K. (2014). Fertility decline, girls' well-being, and gender gaps in children's well-being in poor countries. *Demography, 51*(2), 535–561.
Zhang, J. (1990). Socioeconomic determinants of fertility in China. *Journal of Population Economics, 3*(2), 105–123.
Zhao, Z. (2015). Closing a sociodemographic chapter of Chinese history. *Population and Development Review, 41*(4), 681–686.
Zhu, X., Whalley, J., & Zhao, X. (2014). Intergenerational transfer, human capital and long-term growth in China under the one child policy. *Economic Modelling, 40*, 275–283.