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*Research Article*

**The educational differential in fertility in  
transitional China: Temporal and regional  
variation**

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## **The educational differential in fertility in transitional China: Temporal and regional variation**

**Jianlin Niu<sup>1</sup>**

**Yaqiang Qi<sup>2</sup>**

### **Abstract**

#### **BACKGROUND**

Education expansion has contributed significantly to fertility decline during the worldwide fertility transition. Yet, it is less clear whether the educational gradient in fertility remains stable and persists in the post-transition era. In light of the rapid education expansion in many low-fertility countries, the education–fertility nexus becomes increasingly relevant to demographic and socioeconomic prospects.

#### **OBJECTIVE**

In this study we investigate the education–fertility relationship in China by focusing on its robustness in different socio-institutional contexts both during and after the demographic transition.

#### **METHODS**

We use the cohort parity progression ratios (PPRs) to unveil women’s reproduction progress over the life course. The PPRs are estimated for each educational group, jointly classified by cohort, period, place of residence, and province, using China’s census and mini-census data between 1982 and 2015. We fit multilevel models to investigate the education–fertility relationship and to explore its temporal and contextual variation.

#### **RESULTS**

We find strong empirical support for a negative association between women’s education and each of the successive PPRs in China, both during and after the course of fertility transition. Nevertheless, the strength of the relationship changes over time, particularly for second and higher order births. The education–fertility link also varies profoundly by contextual features.

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## **CONTRIBUTION**

This study extends the literature by exploring the potential dynamics and structural variation of the education–fertility link from demographically transitional to post-transition China. The results provide a panoramic picture of fertility change in China, and insights that lead to a better understanding of world population prospects in the post-transition era.

## **1. Introduction**

Education development has contributed significantly to the worldwide fertility decline (Caldwell 1982; Caldwell and Ruzicka 1978; Goujon, Lutz, and KC 2015; Lutz and KC 2011). As a result, an increasing number of countries observe very low fertility and rapid population aging, giving rise to severe socioeconomic challenges such as economic slowdown or stagnation and overspending on medical and social welfare. Meanwhile, in virtually every post-transition society, education expansion continues, either as a result of socioeconomic development or as a strategy to boost human capital and counteract labor shortages. Thus, whether the negative relationship between education and fertility persists in the post-transition era is highly relevant to the demographic prospect and future socioeconomic outlook.

In contrast to the unanimous agreement on the existence of a negative education–fertility link over the course of the worldwide demographic transition, to date empirical findings on the relationship in post-transition societies are rather equivocal. While some report a persistent negative education–fertility association (e.g., Raymo et al. 2015), others suggest a positive relationship, or even no association whatsoever in low-fertility contexts (e.g., Caltabiano, Castiglioni, and Rosina 2009). These contradictory findings are drawn from different populations and societies, leading to conjecture regarding the relevance to the relationship between education and fertility of cultural and institutional settings. Is the education–fertility association context-dependent in the post-transition stage? And does it change over time in response to the evolving demographic, social, and institutional milieu? These questions are at the heart of a better understanding – and possibly a unified theory – of the post-transition demographic outlook.

This study examines the relationship between women’s education and fertility by focusing on its structural and temporal variation during and after China’s first demographic transition. China is particularly relevant to a systematic understanding of the education–fertility link, for the following reasons. First, China underwent its first demographic transition in the past half century. The immediacy of the transition means that it is easier to trace it back and closely examine the dynamics of the focal

relationship. Second, China is a very large country with extensive geographic, sociocultural, and institutional variation. Thus, it provides an invaluable case for examining potential structural variation in the education–fertility link. Third, China accounts for about one-fifth of the global population and China’s demographic outlook weighs heavily on world population prospects. Lastly, China’s demographic transition has been very much propelled by the forced birth control policy, especially in its early stages (Lavelly and Freedman 1990), and it is unclear whether the education–fertility association differs in such a unique context and how it evolves over time in response to the rapid demographic and socio-institutional changes.

This study aims to address the following questions: First, is there a negative association between women’s education and fertility in China during its demographic transition? Second, how does the nature and strength of the education–fertility nexus vary across the socio-institutionally different provinces in China? Third, does the education–fertility relationship in China change over time, especially at the different stages of the demographic transition?

Our study makes several contributions to the literature. First, we test the validity of the theoretical proposition regarding a negative education–fertility association in the context of China. This helps to incorporate the Chinese case into the global demographic regime and to form a unified understanding of the worldwide fertility decline. Second, by exploring the dynamics of and structural variation in the education–fertility relationship both during and after China’s demographic transition, the findings can cast light on the population prospects of low-fertility China. Third, instead of synthesized fertility indicators we scrutinize cohort parity progression ratios to decipher the progress of women’s reproduction and the role of education. This makes it possible to compare the detailed fertility trajectories of a wide range of cohorts that witnessed various stages of China’s fertility transition, thus providing a systematic and panoramic view of fertility decline in China.

The remainder of this paper is organized as follows: In the next section we briefly review existing research on the education–fertility relationship in low-fertility societies, and summarize the findings on China’s peculiar fertility transition process. Section 3 provides a detailed description of our data, key measures, and analytical models. Section 4 reports the main research findings, and section 5 concludes.

## **2. Literature review on the education–fertility nexus in low-fertility settings**

Throughout the world, the first demographic transition ends up with below-replacement fertility (Caldwell, Caldwell, and McDonald 2002; Caldwell and Schindlmayr 2003;

Coale and Watkins 1987). Yet low fertility still varies significantly across countries, ranging from very close to the replacement level to half the replacement level or even lower (e.g., Caldwell and Schindlmayr 2003). Women's education has been found to be a key factor in explaining the persistent fertility variation and in predicting post-transition fertility trends. Previous studies have examined the education–fertility relationship in different societies and have discussed potential changes in the relationship across cohorts or over time. However, the findings are mixed at best.

## **2.1 Cross-national variations of the relationship**

The long-established negative association between women's education and fertility does not hold true in many reported instances in low-fertility contexts. Newman and Hugo (2006) examine the relationship between women's education, religion, and fertility in South Australia. They find that the education–fertility relationship differs substantially by women's religiosity, and highly educated women do not have uniformly low fertility. New Protestant/New Christian women especially have substantially higher fertility than their counterparts in other religious denominations. Their study highlights the role of religion and culture in reshaping the educational gradient in fertility. Similarly, Caltabiano and colleagues (2009) revisit the education–fertility link using empirical data from Italy. Based on women's completed reproductive histories, they find evidence supporting a fertility recovery among highly educated young women in North Italy, and the association between women's education and fertility recovery is positive in the youngest generations. They conclude that institutional arrangements in North Italy, such as parental leave, childcare provision, and part-time employment support, may reshape the relationship between women's education and fertility.

Using cross-national data from 20 industrialized low-fertility countries, Raymo and colleagues (2015) examine the educational differential in women's early childbearing behaviors measured by the first 20% of births of a cohort. They find a strong negative association between women's education and early childbearing in all studied countries. By contrast, using data from 14 low-fertility nations including Australia and some European countries, Wood and colleagues (2014) find that the educational gradient in fertility varies substantially across countries. As far as the cohort parity progression ratio (PPR) is concerned, the association between women's education and fertility is negative in some countries and neutral or even positive in others. This is especially the case concerning the educational gradient in second or higher order births (see also Osiewalska 2017).

In short, according to the existing literature, the negative association between women's education and fertility in the post-transition era is not robust. The association seems to be context-sensitive and subject to moderating effects of social and institutional factors. These inconclusive findings warrant further investigation of the education–fertility relationship in the ever-expanding post-transition world.

## **2.2 Intertemporal changes of the relationship**

While some studies address cross-sectional variation in the relationship between education and fertility, other research explores intertemporal changes. Wood and colleagues (2014) find that the education–fertility relationship remains largely constant over time within a country. However, many other studies suggest the opposite. For instance, Brand and Davis (2011) examine the fertility difference among highly educated women in the United States in the wake of higher education expansion. They find that women from disadvantaged social strata who otherwise might have failed to attain higher education are more likely to trade their fertility pursuits for personal socioeconomic achievement, and therefore have lower fertility on average. According to their study, the negative association between women's education and fertility strengthens over time along with higher education expansion.

Some studies report a converging trend in the education–fertility gradient. For instance, Van Bavel (2014) re-examines the association between women's education and fertility during the baby boom in Belgium in the mid-20<sup>th</sup> century. Although during the baby boom fertility recovered in virtually all educational groups, recovery was more substantial among highly educated women, and consequently the educational gradient in fertility declined. Similar findings are also reported in Columbia (Batyra 2016) and South Korea (Yoo 2014). Raymo and colleagues (2015) report different scenarios regarding inter-cohort changes in the education–fertility relationship. Of the 20 examined countries, in some the educational gap in women's early-life fertility widens across cohorts, in many it remains constant, and in one (Poland) it declines.

As discussed above, so far there has been limited consensus regarding the education–fertility relationship in post-transition societies. Nevertheless, the existing literature highlights the significance of sociocultural and institutional factors in shaping the education–fertility relationship in low fertility settings (Caltabiano, Castiglioni, and Rosina 2009; Newman and Hugo 2006; Wood et al. 2014). Furthermore, continuing education expansion adds another layer to the complex dynamics of the education–fertility nexus (Brand and Davis 2011; Zeman 2018).

## **2.3 China's transition to low fertility**

China has observed below-replacement fertility for more than two decades. The fertility transition in China has occurred at such an unprecedented pace that it has led to heated debates on the authenticity of fertility statistics and the impact of China's peculiar birth control policy. Demographers generally agree that China had completed its demographic transition by the mid-1990s, with both the birth control policy and the rapid socioeconomic development making significant contributions (Guo 2017; Wang 2008; Zhai, Chen, and Li 2015). While the birth control policy played a larger role in decreasing fertility during the 1970s and 1980s, socioeconomic factors have taken the driver's seat since the 1990s (Chen et al. 2009; Zhao 2015; Zhao and Zhang 2018).

### **2.3.1 China's birth control policy**

China's family planning program is frequently conceived as a strict one-child policy. However, this is an insufficient and even misleading portrayal of the birth control policy implemented in China over the past half century. The initial family planning program introduced in China in the 1970s was lenient and it encouraged each couple to have no more than two children, summarized in the slogan "one is best, at most two, and never a third" (Short and Zhai 1998). In 1980 the central government announced a stringent birth control policy in response to the growing tension between rapid population growth and economic development targets. Known as the 'one-child' policy, the new policy forbade a second birth for all couples (with very limited exemptions). The stringent 'one-child' policy was found to be too radical and was short-lived. It encountered strong resistance and widespread backlash in rural China, and the central government replaced it with a more relaxed policy four years after its enactment (Greenhalgh 1986; Short and Zhai 1998). The 1984 policy adjustment took into consideration the complicated demographic and socioeconomic heterogeneity across regions and took the important step of decentralizing policy by partially authorizing provinces to make necessary modifications and to formulate their own birth control policies. Consequently, fertility policy in China began to exhibit substantial regional differences; for example, differences in exemptions allowing for a second birth, incentives to have only one child, and penalties for unauthorized second or higher-parity births.

Roughly speaking, provincial birth control policies can be classified as follows: (1) Four municipalities directly under the central government (Beijing, Tianjin, Shanghai, Chongqing) and two provinces (Sichuan and Jiangsu) had a strict one-child policy in both rural and urban areas; (2) Nineteen provinces implemented a hybrid regime with a



one-child policy in urban areas and a one-and-a-half-child policy in rural areas which allowed rural couples whose first child was a girl to have a second birth; (3) Five provinces (Hainan, Ningxia, Qinghai, Yunnan, Xinjiang) enforced a hybrid regime with a one-child policy in urban areas and a universal two-child policy in rural areas; and (4) in Tibet there was no forced birth control. To articulate the policy differences quantitatively, scholars (Guo et al. 2003; Gu et al. 2007) have calculated the policy total fertility rate (TFR), defined as the hypothetical TFR assuming that the local fertility policy is strictly observed. According to Guo et al. (2003), the provincial policy TFR ranged between 1.06 and 2.37 in 1990, with the first group of provinces falling below 1.3, the second in the range of 1.3–2.0, and the last two groups no less than 2.0.

In addition to decentralized policymaking, policy implementation also varied significantly across provinces in China. As illustrated in Short and Zhai (1998), provincial birth control policies were executed fairly flexibly over time. Some exemptions allowing for a second birth, such as the dual-only-child-couple exemption, were removed in periods when population growth pressure necessitated tighter birth controls. When there was no severe population pressure the exemptions designed solely for rural couples (such as the daughter-only exemption) were applied in urban areas as well. These facts highlight the complex interplay between institutional arrangements and demographic and socioeconomic realities in China's rapid fertility decline. How these complex institutional variations affect the education–fertility relationship in China merits serious investigation.

### **2.3.2 The education–fertility link in China**

The literature has highlighted the contribution of socioeconomic development to China's overall fertility decline (Cai 2010; Chen 2008; Chen et al. 2009; Poston and Gu 1987; Zhao 2015). However, few studies have systematically examined the particular role of education in China's fertility transition. This is somewhat surprising in that the significance of education has been widely studied and is well established in the international fertility literature. It is likely that the overemphasis on China's family planning policy has distracted from or overshadowed academic endeavors to examine the education–fertility relationship.

Sporadic empirical findings show that women's education has a negative effect on fertility in China (Feeney et al. 1989; Lavelly and Freedman 1990; Piotrowski and Tong 2016; Tian 2018). Some studies report that the impact of education on fertility declined substantially with the enactment of China's birth control policy (Lavelly and Freedman 1990; Whyte and Parish 1984). Nevertheless, the empirical evidence mainly dates back to the early transition period or from older cohorts born before 1970, casting little light

on the relationship in late or post-transition China. In addition, different fertility measures have been used, which poses challenges for drawing a synthesized conclusion. Essentially, we know little about how the relationship has evolved over the past half century in China, not to mention how it responds to various socio-institutional contexts.

Therefore, conducting a systematic investigation of the education–fertility relationship in China is imperative. This will cast light on the robustness of the focal relationship in a rapidly transforming Chinese society and contribute to the literature on the education–fertility link in the post-transition world. In view of the recent reforms of China’s birth control policy and the massive education expansion, a systematic study of the education–fertility relationship in China is both theoretically valuable and practically important for understanding population prospects in post-transition China.

### 3. Data and methods

#### 3.1 Data source and key measures

In this study we use data collected through China’s national population censuses and mini-censuses from 1982 to 2015. In each census/mini-census we restrict our analysis to women aged 20 to 49. The rationale for this is as follows: First, fertility information is consistently available for these women in all the datasets, which makes it feasible to compare the fertility indicators over time. Second, these ages represent the prime reproductive lifespan of Chinese women, and childbearing beyond this range is very rare. Third, fertility records at these ages are less likely to be contaminated by selectivity or recalling errors. As a result, the women under investigation are from cohorts born between 1933 and 1995, spanning all stages of China’s fertility transition. Therefore, scrutinizing the reproductive records of these women promises comprehensive insight into the relationship between women’s education and fertility and an overview of its variation across cohorts and over time.

In this study we use cohort parity progression ratios (PPRs) as the fertility indicator. These PPRs are calculated using the information on women’s number of children ever born reported in each census/mini-census. Specifically, the  $PPR_i$  is calculated as the ratio of the number of women in a cohort having at least  $i+1$  live births to the number of women in the same cohort having at least  $i$  live births.<sup>3</sup> We calculate the cohort PPRs at a set of successive reproductive stages, by ages 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49. The last stage is normally regarded as the end of

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<sup>3</sup> For the conceptual or technical details, see Henry (1953) or Preston, Heuveline, and Guillot (2002).

women's reproductive life, and thus the PPRs at that stage indicate a cohort's complete fertility. Nevertheless, the PPRs achieved at other reproductive stages provide information about the detailed reproduction process, and jointly they cast light on the tempo and quantum of fertility for each cohort. Therefore, in addition to the overall cohort differences, these fertility indicators facilitate a systematic study of the education–fertility relationship over women's life course, while making it possible to retain younger cohorts and most recent fertility changes in our analysis. Unlike period fertility measures, these cohort PPRs pertain to the fertility experiences of real women cohorts, and they are strongly preferred in examining the education–fertility relationship in a rapidly changing population where the assumption of stable fertility profiles does not hold.

To investigate the educational gradient in the cohort PPRs and explore its temporal and contextual variation we calculate the cohort PPRs for different educational groups, jointly classified by cohort, period, place of residence, and province. The groups of women thus defined are relatively homogeneous regarding socioeconomic traits and are likely to be structurally equivalent in the process of fertility transition.

To preserve a reasonable group size and minimize random fluctuations, we use a tripartite classification (i.e., low, medium, and high) for women's education. Specifically, the category of low education corresponds to lower secondary schooling or less, the medium refers to upper secondary schooling, and the high group indicates at least some tertiary education.<sup>4</sup> Women cohorts are measured by 5-year groups, consistent with the 5-year groups of women's reproductive age at the time of census/mini-census. The place of residence is treated as a dichotomy (rural versus urban). The 31 mainland provinces are the focus of our study.<sup>5</sup> In total, we have 1,116 groups of women at each time point (i.e., census/mini-census year). We analyze the cohort parity progression ratios to the first birth (PPR0), second birth (PPR1), and third or higher order birth (PPR2) of these women groups. These PPRs provide a comprehensive overview of fertility during China's rapid demographic transition.

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<sup>4</sup> The group size of high education is smaller for earlier cohorts, especially those born before 1950s. For a robust check, we collapsed "medium" and "high" categories and redid the analyses, and the results are essentially unchanged.

<sup>5</sup> To make a more balanced data structure, we made the following imputations for province and place of residence: (1) We treat Chongqing and Hainan as provincial units consistently from the baseline and on, and impute their prior-establishment records (i.e., in 1982 and 1990) with data from their affiliated provinces (i.e., Sichuan and Guangdong respectively). (2) We impute the rural and urban records in 1982, when no information is collected on place of residence, with provincial aggregate data in that year. In doing so, it evens out the initial rural-urban difference, yet has negligible effects on our results as telling from our sensitive checks. Eventually, the procedure produces 1116 groups of women at each census/mini-census occasion, given by the multiplication of the numbers of education categories (3), cohorts (6), place of residence (2), and provinces (31).

### 3.2 Analysis strategy

We fit two-way error-component models for each of the PPRs to decompose provincial and intertemporal variations, and use three-level mixed-effect models to test the education–fertility link therein. Specifically, we treat the women groups defined above as level-1 units, which are nested in provinces (level 2) and time occasions (level 3). The model is specified in this way for two reasons: First, women’s reproductive behavior is contextualized by provincial structures and policies, and different time occasions signify important milestones in the overall fertility transition. While the fertility transition in each province may itself be path-dependent, these provincial transitions could also assume similarities at each phase of the national transition due to interprovincial socioeconomic exchange, population migration, and cultural diffusion. Second, we have fewer time occasions and a relatively larger number of provinces in the data: thus, treating time occasions as level-3 units helps to produce more efficient estimates.

In addition to women’s education, in our model we also consider other traits of the women groups and important structural factors. Specifically, at level 1 we include women’s reproductive stage and preceding PPRs (for PPR1 and PPR2) to capture the demographic traits and relative size at risk (of targeted parity progression) for each women group. At level 2 we include provincial GDP per capita, urbanization rate, proportion of women with tertiary education, women’s singulate mean age at marriage (SMAM), interprovincial migration (out-migration and in-migration) rates, and the provincial policy TFR. These variables reflect key socioeconomic, demographic, and institutional features that are theoretically relevant to our study, and they have been examined frequently in the literature. All these provincial variables, with the exception of the policy TFR, are time-varying, capturing the evolving contextual traits of provinces. The policy TFR is operationalized as a time-invariant four-category variable, as in Guo et al. (2003), to reveal the main differences in provincial policy regimes. Finally, at level 3 we include the variable ‘time’, defined as the number of years elapsed since the baseline (i.e., 1982), and its squared term to model the temporal trajectory parsimoniously. All the models are fitted for women in rural and urban China separately.

To the special interest of this study, we include the cross-level interactions between women’s education and the contextual factors measured at level 2 (such as GDP per capita and policy TFR) and the time variable at level 3 to test the variation and changes in the education–fertility link in China. Table 1 summarizes the descriptive statistics for these variables.

**Table 1: Summary of the key variables used in this study**

Variable	Definition	Range	Mean	SD
<b>Level 1</b>				
Education	Women's highest educational attainment (1=low, or junior middle and lower, 2=medium, or senior middle, 3=high, or tertiary)	[1, 3]		
Reproductive stage	Women's age grouped in 5 years (1=20–24, 2=25–29, 3=30–34, 4=35–39, 5=40–44, 6=45–49)	[1, 6]		
<b>Level 2</b>				
Urbanization	Provincial rate of urbanization	[1.2, 87.6]	32.93	19.78
GDP per capita	GDP per capita, in 10 thousand <i>yuan</i>	[0.03, 10.8]	1.89	2.26
Women's education	% of women aged 25-64 with tertiary education	[0.03, 13.03]	0.98	1.40
SMAM	Females' singulate mean age at first marriage	[19.3, 26.3]	22.69	1.18
In-migration rate	Provincial in-migration rate of women	[0, 40.4]	4.21	7.20
Out-migration rate	Provincial out-migration rate of women	[0.03, 14.3]	3.43	3.31
Policy	Provincial fertility policy, classified into four groups according to the policy TFR, estimated by Guo et al. (2003). The categories are as follows: Tier 1: policy TFR below 1.3, with 6 provinces/municipalities falling into this category; Tier 2: policy TFR is between 1.3 and 1.5 (not inclusive), with 12 provinces falling into this category; Tier 3: policy TFR is between 1.5 and 2 (not inclusive), with 7 provinces in this category; and Tier 4: policy TFR is no less than 2, with the remaining 6 mainland provinces falling into this category.			
<b>Level 3</b>				
Time	Years elapsed since 1982	[0, 33]	15.00	9.72

Note: All the provincial variables are measured as time varying, except for policy TFR.

## 4. Major findings

### 4.1 Bivariate correlations between women's education and the cohort PPRs

Table 2 presents the median statistics of women's PPR0, PPR1, and PPR2 achieved at each reproductive stage, separately by educational group and in each of the three selected years (1982, 2000, 2015). These statistics demonstrate great variation in PPRs over women's reproductive stage, education, and time.

**Table 2: Medians of the PPRs achieved by each educational group at various reproductive stages in 1982, 2000, and 2015**

		1982			2000			2015		
		PPR0	PPR1	PPR2	PPR0	PPR1	PPR2	PPR0	PPR1	PPR2
20–24	Low	0.406	0.303	0.140	0.373	0.069	0.071	0.419	0.221	0.062
	Medium	0.124	0.088	0.059	0.126	0.000	0.000	0.148	0.100	0.000
	High	0.015	0.000	0.000	0.046	0.000	0.000	0.022	0.066	0.000
25–29	Low	0.904	0.670	0.396	0.879	0.232	0.093	0.740	0.374	0.093
	Medium	0.602	0.230	0.111	0.691	0.038	0.000	0.590	0.206	0.040
	High	0.441	0.055	0.000	0.502	0.000	0.000	0.330	0.077	0.000
30–34	Low	0.981	0.917	0.693	0.972	0.595	0.171	0.895	0.582	0.126
	Medium	0.940	0.638	0.269	0.921	0.129	0.077	0.843	0.272	0.071
	High	0.824	0.265	0.080	0.885	0.023	0.000	0.748	0.125	0.031
35–39	Low	0.988	0.979	0.899	0.985	0.808	0.334	0.934	0.630	0.147
	Medium	0.974	0.906	0.465	0.977	0.304	0.136	0.914	0.311	0.047
	High	0.970	0.818	0.200	0.969	0.050	0.000	0.897	0.126	0.020
40–44	Low	0.987	0.983	0.950	0.986	0.856	0.448	0.947	0.663	0.153
	Medium	0.983	0.954	0.675	0.985	0.399	0.212	0.931	0.275	0.089
	High	0.988	0.910	0.422	0.966	0.095	0.000	0.917	0.103	0.033
45–49	Low	0.983	0.979	0.961	0.986	0.904	0.553	0.953	0.691	0.186
	Medium	0.982	0.948	0.728	0.986	0.470	0.200	0.944	0.208	0.086
	High	0.990	0.931	0.510	1.000	0.176	0.000	0.938	0.077	0.000

In any given time and at a specified reproductive stage, the statistics show negative educational gradients in each of the PPRs under examination. Viewed by reproductive stage, the educational gap for PPR0 narrows after women’s mid-reproductive ages when most of the highly educated women eventually enter motherhood after an initial delay. In other words, starting from a cohort’s mid-reproductive ages, the educational gap in PPR0 gradually converges. However, for PPR1 and PPR2, similar convergence only took place in the early transition period (i.e., in 1982). In the late and post-transition periods (i.e., in 2000 and 2015) these educational gaps show no convergence whatsoever over women’s reproductive lifespan.

Table 3 reports the bivariate correlations between women’s education and the PPRs, separately at each reproductive stage in 1982, 2000, and 2015. These coefficients are negative and statistically significant (all but one). Although the magnitude of correlation changes along women’s reproductive life course, it does not dwindle over time. In particular, the negative correlation of women’s education with PPR1 and PPR2 remains substantial even in the post-transition era (as in 2015). In the following we use multilevel models to test these relationships more systematically.

**Table 3: Correlation coefficients between women's education and the PPRs, by reproductive stage and time**

	1982			2000			2015		
	PPR0	PPR1	PPR2	PPR0	PPR1	PPR2	PPR0	PPR1	PPR2
20–24	–0.883	–0.156	–0.459	–0.805	–0.403	–0.210	–0.921	–0.433	<i>insig.</i>
25–29	–0.854	–0.827	–0.679	–0.719	–0.656	–0.258	–0.866	–0.708	–0.497
30–34	–0.765	–0.887	–0.765	–0.357	–0.742	–0.432	–0.502	–0.703	–0.457
35–39	–0.343	–0.654	–0.849	–0.170	–0.743	–0.479	–0.223	–0.680	–0.308
40–44	–0.142	–0.568	–0.827	–0.270	–0.667	–0.603	–0.181	–0.751	–0.403
45–49	–0.121	–0.479	–0.837	–0.351	–0.725	–0.724	–0.171	–0.701	–0.612

Note: The correlation coefficients shown above are Pearson's  $r$ , and all the correlation coefficients but one, which is denoted *insig.*, are statistically significant at  $p=0.05$ .

## 4.2 Multilevel model results

### 4.2.1 Variance composition of the PPRs

We fit two-way error-component models for each of the successive PPRs. The results, presented in Table 4, indicate significant clustering effects by province and time occasion for each PPR. The temporal intra-class correlation outweighs the regional one for all the PPRs, with the exception of the PPR0 in rural areas. This is expected, as the past several decades have witnessed an unprecedentedly rapid fertility decline in China. Compared with PPR1 and PPR2, the PPR0 has much smaller variation over time. It seems that entry into motherhood is still the norm for most Chinese women. The intra-class correlations at provincial level highlight the significant regional differences in China's fertility transition, which foretells the relevance of local context in shaping the pace and trajectory of fertility changes, beyond the general trend of speedy fertility decline.

**Table 4: Unconditional two-way error-component models for the PPRs**

	PPR0		PPR1		PPR2	
	Rural	Urban	Rural	Urban	Rural	Urban
<b>Fixed part</b>						
Intercept	0.748** (0.018)	0.764** (0.011)	0.448** (0.050)	0.325** (0.074)	0.215** (0.054)	0.175** (0.057)
<b>Random part</b>						
Level-3 SD	0.022** (0.441)	0.023** (0.416)	0.116** (0.321)	0.179** (0.318)	0.128** (0.318)	0.138** (0.317)
Level-2 SD	0.079** (0.154)	0.015** (0.659)	0.093** (0.145)	0.069** (0.147)	0.070** (0.143)	0.043** (0.155)
Level-1 SD	0.329** (0.012)	0.307** (0.012)	0.336** (0.012)	0.265** (0.012)	0.239** (0.012)	0.197** (0.012)
<b>Intra-class correlation</b>						
Level 3	0.004	0.006	0.099	0.299	0.209	0.320
Level 2	0.054	0.002	0.065	0.045	0.063	0.031
<i>N</i>	3,330	3,330	3,329	3,329	3,328	3,328

Note: the values in bracket are estimated standard errors, \*\*p<0.01

## 4.2.2 The education–fertility link and its temporal and regional variation

To test the education–fertility relationship and its potential variation in China, we fit three-level mixed-effect models for each of the PPRs, and the results are presented in Tables 5 through 7.

### 4.2.2.1 PPR0: Transiting to motherhood

After controlling for other covariates in the model, the PPR0 in rural China remains largely constant over time (Table 5), yet the PPR0 for urban women exhibits a significant temporal change: It first increases and then declines, with the turning point taking place around 1992. The temporal increase of PPR0 in urban China may be attributable to China’s economic recovery in the 1980s, thanks to economic reform and the ‘opening up’ policy. The economic prosperity boosted young adults’ family formation through improvement of employment, housing, and other necessities. In addition, the lumped return of educated youths to cities starting from the late 1970s and their subsequent family formation may also play a role in the temporal uptrend of PPR0



in the 1980s. In the early 1990s the PPR0 in urban China began to decline as China's fertility transition came close to completion.

**Table 5: Mixed-effect models for the PPR0 in rural and urban China**

	Rural		Urban	
	Estimates	SE	Estimates	SE
<b>Time</b>	0.001	(0.002)	0.004**	(0.001)
<b>Time<sup>2</sup></b>	-0.00001	(0.0001)	-0.0002**	(0.00003)
<b>Education (ref.=low)</b>				
Medium	-0.057**	(0.021)	-0.082**	(0.012)
High	-0.228**	(0.021)	-0.171**	(0.012)
<b>Education*time</b>				
Medium*time	-0.001	(0.001)	0.0001	(0.001)
High* time	-0.001	(0.001)	0.001	(0.001)
<b>Reproductive stage (ref=45-49)</b>				
20-24	-0.667**	(0.011)	-0.781**	(0.006)
25-29	-0.222**	(0.011)	-0.339**	(0.006)
30-34	-0.005	(0.011)	-0.090**	(0.006)
35-39	0.047**	(0.011)	-0.024**	(0.006)
40-44	0.042**	(0.011)	-0.010	(0.006)
<i>Provincial covariate</i>				
<b>GDP per capita</b>	-0.008	(0.006)	0.008*	(0.003)
<b>Women's education</b>	0.015**	(0.004)	-0.0001	(0.001)
<b>SMAM</b>	-0.036**	(0.005)	-0.026**	(0.003)
<b>Urbanization rate</b>	0.001	(0.0004)	0.0002	(0.0001)
<b>In-migration rate, female</b>	-0.0004	(0.001)	-0.0001	(0.001)
<b>Out-migration rate, female</b>	0.001	(0.002)	0.003*	(0.001)
<b>Policy (ref=Tier 1: policy TFR&lt;1.3)</b>				
Tier 2 (policy TFR: 1.3-1.5)	0.002	(0.027)	0.002	(0.013)
Tier 3 (policy TFR: 1.5-2.0)	-0.0004	(0.032)	0.007	(0.016)
Tier 4 (policy TFR: 2+ )	-0.041	(0.033)	-0.013	(0.016)
<i>Cross-level Interaction</i>				
<b>Education*GDP per capita</b>				
Medium*GDP per capita	-0.0002	(0.005)	-0.003	(0.003)
High*GDP per capita	-0.001	(0.005)	-0.008**	(0.003)
<b>Education*policy</b>				
Medium*Tier-2 policy	-0.018	(0.022)	0.003	(0.012)
Medium*Tier-3 policy	-0.016	(0.025)	0.006	(0.014)
Medium*Tier-4 policy	-0.069*	(0.027)	-0.007	(0.015)
High*Tier-2 policy	0.075**	(0.022)	0.020	(0.012)
High*Tier-3 policy	0.067**	(0.025)	0.026	(0.014)
High*Tier-4 policy	-0.134**	(0.027)	-0.003	(0.015)
<b>Intercept</b>	1.795**	(0.105)	1.648**	(0.066)

**Table 5: (Continued)**

	Rural		Urban	
	Estimates	SE	Estimates	SE
<b>Random intercept</b>				
In-SD Level 3	-4.723**	(0.575)	-25.459**	(<0.001)
In-SD Level 2	-3.158**	(0.160)	-3.950**	(0.173)
In-SD Level 1	-1.728**	(0.012)	-2.322**	(0.012)
N	3,312		3,330	

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$

In both rural and urban China, women’s education has significant negative effects on their progression to motherhood. All else being equal, highly educated women have significantly lower PPR0s, and this remains largely constant over time. Nevertheless, the educational gradient in PPR0 differs substantially by socioeconomic and institutional context. For urban women the educational gradient in PPR0 increases in more economically developed provinces, i.e., those with a higher GDP per capita. For rural women the educational gradient increases in the provinces implementing the loosest birth control policy (i.e., policy  $TFR \geq 2$ ), yet it decreases in the provinces implementing a hybrid policy allowing rural couples to have 1.5 children (i.e., Tier 2 and Tier 3). The latter provinces, by implementing a hybrid policy that distinguishes rural couples according to the gender of their first child, are more likely to have a tradition of strong son preference. As a result, the effect of education is dwarfed by traditional norms and practices of son preference. These results suggest that education plays a greater role in fertility when a uniform birth control policy, stringent or loose, is applied for all couples. In fact, the educational effect is the greatest in the provinces that have a very loose fertility policy.

The PPR0 is higher at women’s late reproductive ages in general. The variation across reproductive stages also casts some light on the cohort difference in women’s progression to motherhood. For instance, at the baseline (i.e., in 1982), rural women in late reproductive stages (or at ages 35–39 and 40–44) have significantly higher PPR0s than those at ages 45–49. One possible explanation is that women in the oldest cohort were born and grew up in wartime and experienced the great famine (1959–1961) at their peak reproductive ages, which may have negatively affected their family formation.

After controlling for other covariates, the provincial policy TFR does not have significant main effects on women’s PPR0 in either rural or urban areas. Women’s mean age at marriage shows significant negative effects on PPR0, and delayed marriage is associated with lower PPR0 on average. Both provincial GDP per capita and the proportion of inter-provincial out-migration have significant positive effects on the PPR0 in urban China, and the proportion of women with tertiary education in a

province shows significant positive effects on the PPR0 in rural China. These results verify the significance of social and economic development in boosting local residents' family formation.

#### 4.2.2.2 PPR1: Progression to second birth

Table 6 presents the model results for PPR1. In contrast to PPR0, the PPR1 shows significant changes over time in both rural and urban China. It declines at a decelerating pace over the study period, and the trajectory starts to reverse somewhat around the early 2000s. The sharp reduction in PPR1 in the late 1990s contributed decisively to the rapid fertility transition in both rural and urban China (Chen 2008). From the early 2000s on, the PPR1 appears to recover somewhat as a result of the substantial increase in dual-only-child couples (*shuangdu fufu*) in the population. Although China's birth control policy has allowed dual-only-child couples to have a second birth since the mid-1980s, it did not make much difference to the fertility profile before the early 2000s when the only-child generation started to enter the peak family-formation ages, and the number of dual-only-child couples consequently skyrocketed. The latest policy reforms, especially the partial two-child policy announced in 2013, may have also contributed to the recent upward trend of PPR1 (Guo 2017).

**Table 6: Three-level mixed effect models for the PPR1 in China**

	Rural		Urban	
	Estimates	SE	Estimates	SE
<b>Time</b>	-0.019**	(0.003)	-0.035**	(0.002)
<b>Time<sup>2</sup></b>	0.001**	(0.0001)	0.001**	(0.0001)
<b>Education (ref.=low)</b>				
Medium	-0.149**	(0.022)	-0.152**	(0.019)
High	-0.242**	(0.023)	-0.204**	(0.020)
<b>Education*time</b>				
Medium*time	-0.001	(0.001)	-0.003**	(0.001)
High*time	-0.005**	(0.001)	-0.003**	(0.001)
<b>Reproductive stage (ref=45-49)</b>				
20-24	-0.366**	(0.017)	-0.545**	(0.024)
25-29	-0.389**	(0.012)	-0.418**	(0.014)
30-34	-0.279**	(0.011)	-0.276**	(0.010)
35-39	-0.139**	(0.011)	-0.160**	(0.010)
40-44	-0.049**	(0.011)	-0.066**	(0.010)
<b>PPR0</b>	0.321**	(0.018)	-0.129**	(0.028)

**Table 6: (Continued)**

	Rural		Urban	
	Estimates	SE	Estimates	SE
<i>Provincial covariate</i>				
<b>GDP per capita</b>	-0.035**	(0.007)	-0.011	(0.006)
<b>Women's education</b>	0.003	(0.004)	-0.004**	(0.001)
<b>SMAM</b>	-0.005	(0.005)	-0.014**	(0.005)
<b>Urbanization rate</b>	-0.0002	(0.001)	-0.0004	(0.0003)
<b>In-migration rate, female</b>	0.002	(0.001)	0.005**	(0.001)
<b>Out-migration rate, female</b>	-0.003	(0.002)	-0.002	(0.002)
<b>Policy (ref=Tier 1: policy TFR&lt;1.3)</b>				
Tier 2 (policy TFR: 1.3~1.5)	0.090**	(0.034)	0.120**	(0.026)
Tier 3 (policy TFR: 1.5~2.0)	0.156**	(0.040)	0.189**	(0.030)
Tier 4 (policy TFR: 2+)	0.245**	(0.040)	0.247**	(0.030)
<i>Cross-level Interaction</i>				
<b>Education*GDP per capita</b>				
Medium*GDP per capita	0.010	(0.006)	0.008	(0.005)
High*GDP per capita	0.029**	(0.006)	0.005	(0.005)
<b>Education*policy</b>				
Medium*Tier-2 policy	0.042	(0.023)	-0.031	(0.020)
Medium*Tier-3 policy	0.041	(0.026)	-0.063**	(0.022)
Medium*Tier-4 policy	-0.046	(0.028)	-0.074**	(0.024)
High*Tier-2 policy	-0.001	(0.023)	-0.085**	(0.020)
High*Tier-3 policy	-0.039	(0.026)	-0.128**	(0.023)
High*Tier-4 policy	-0.129**	(0.028)	-0.153**	(0.024)
<b>Intercept</b>	0.754**	(0.122)	1.363**	(0.124)
<b>Random intercept</b>				
In-SD Level 3	-4.048**	(0.371)	-4.556**	(0.450)
In-SD Level 2	-2.841**	(0.149)	-3.209**	(0.158)
In-SD Level 1	-1.675**	(0.012)	-1.834**	(0.012)
N	3,311		3,329	

Notes: \*\*p<0.01

After controlling for other covariates in the model, women's education shows significant negative effects on PPR1. In both rural and urban China, highly educated women have a significantly lower propensity to have a second birth. In addition, the educational gradient in PPR1 varies substantially across provincial contexts and over time. For rural women, while the gap between medium and low educational groups remains constant, the gap between high and low educational groups is context-sensitive and increases over time. All else being equal, the educational gap in PPR1 is

significantly larger in the provinces implementing the loosest birth control policy (i.e., policy  $TFR \geq 2$ ). This is in line with what is found for PPR0, and it confirms the salient role of women's education in bringing down fertility where no severe birth control policy was enforced. Over the study period there is a general increasing trend of the educational gap in PPR1 for rural women, as seen from the significant interaction effects between education and time. Nevertheless, the educational gap narrows significantly in more economically developed provinces. These results suggest that highly educated women lead the process of birth control, giving rise to an increasing educational gap over time, yet economic development helps to decrease the educational gap through increasing childbearing and rearing costs (and opportunity costs), diffusing modern values and ideologies, and other like mechanisms (Lesthaeghe and van de Kaa 1986; Lesthaeghe 1998; van de Kaa 2004). In line with these forces, in urban China the educational gap in PPR1 also increases significantly over time and in the provinces where a relatively loose birth control policy was enforced. The interaction effects are significant for both medium and high educational groups.

The PPR1 is significantly higher at women's late reproductive stages, and this is expected in that reproduction (of each parity) is fulfilled progressively over women's lifespan. Net of other covariates in the model, the PPR1 in rural areas is positively associated with the preceding PPR0, while a negative association is observed in urban areas. This highlights the differences in fertility regime between rural and urban China. In rural areas, higher PPR0s coincide with higher PPR1s, and vice versa. In urban areas, however, PPR1 is significantly higher in the areas where the preceding PPR0 is relatively lower. This indicates greater heterogeneity in women's reproductive behavior in urban areas, where childless women and those having more than one birth coexist. It is also possible that the level of PPR0 indicates the extent of population growth pressure, and may refer to local policy implementation. The areas observing lower PPR0s, and thus lower pressure to control fertility, are more likely to apply loose birth control practically and allow urban couples to have a second birth, as discovered by Short and Zhai (1998).

Holding other things constant, fertility policy plays a significant role in the PPR1 for both rural and urban women. A more relaxed birth control policy predicts significantly higher PPR1s. Provincial socioeconomic characteristics are also important predictors of women's PPR1. Specifically, the PPR1 is lower in provinces with higher GDP per capita (significant only for rural women), and higher proportions of women with tertiary education (significant in urban areas). These results confirm the role of socioeconomic development in reducing fertility in China, particularly beyond the first birth. In addition, in urban areas the PPR1 is significantly higher in the provinces with higher rates of interprovincial in-migration of women. It is likely that in-migrants, disproportionately comprised of rural women, may contribute to the higher PPR1 in the

hosting urban areas. Yet, given the fact that interprovincial migration of women became perceptible mainly after the mid-1990s when many developed urban areas had already accomplished their first demographic transition, it is also possible that the hosting urban areas have greater shares of dual-only-child couples that were entitled to have a second birth. Lastly, women's delayed entry into marriage predicts significantly lower PPR1s, and this effect is statistically significant for urban women.

#### 4.2.2.3 PPR2: Higher order births

Table 7 reports the model results for the PPR2. Similar to what is found for PPR1, the PPR2 also exhibits a significant reduction over the study period. The decline of PPR2 in rural areas is faster than that in urban areas, yet it decelerates over time. A possible explanation for this rural–urban difference is that rural women had much higher initial PPR2s, which necessitated greater reduction in the course of China's rapid demographic transition.

**Table 7: Three-level mixed effect models for the PPR2 in China**

	Rural		Urban	
	Estimates	SE	Estimates	SE
<b>Time</b>	-0.020**	(0.001)	-0.015**	(0.002)
<b>Time<sup>2</sup></b>	0.0002**	(0.00005)	0.0001	(0.0001)
<b>Education (ref.=low)</b>				
Medium	-0.154**	(0.018)	-0.152**	(0.015)
High	-0.251**	(0.018)	-0.222**	(0.015)
<b>Education*time</b>				
Medium*time	0.007**	(0.001)	0.009**	(0.001)
High* time	0.012**	(0.001)	0.014**	(0.001)
<b>Reproductive stage (ref=45–49)</b>				
20–24	-0.085**	(0.013)	-0.030**	(0.010)
25–29	-0.093**	(0.011)	-0.035**	(0.009)
30–34	-0.106**	(0.010)	-0.051**	(0.008)
35–39	-0.097**	(0.009)	-0.053**	(0.008)
40–44	-0.049**	(0.009)	-0.028**	(0.007)
<b>PPR1*PPR0</b>	0.383**	(0.014)	0.461**	(0.013)
<i>Provincial covariate</i>				
<b>GDP per capita</b>	0.015**	(0.005)	0.021**	(0.004)
<b>Women's education</b>	-0.003	(0.003)	0.00003	(0.001)
<b>SMAM</b>	-0.011**	(0.004)	-0.009**	(0.003)
<b>Urbanization rate</b>	-0.0001	(0.0003)	-0.001**	(0.0003)

**Table 7: (Continued)**

	Rural		Urban	
	Estimates	SE	Estimates	SE
<b>In-migration rate, female</b>	0.002**	(0.001)	0.001	(0.001)
<b>Out-migration rate, female</b>	0.0004	(0.002)	0.003*	(0.001)
<b>Policy (ref=Tier 1: policy TFR&lt;1.3)</b>				
Tier 2 (policy TFR: 1.3~1.5)	0.084**	(0.023)	0.042**	(0.014)
Tier 3 (policy TFR: 1.5~2.0)	0.100**	(0.027)	0.044**	(0.016)
Tier 4 (policy TFR: 2+ )	0.253**	(0.028)	0.133**	(0.017)
<i><u>Cross-level Interaction</u></i>				
<b>Education*GDP per capita</b>				
Medium*GDP per capita	-0.010*	(0.005)	-0.012**	(0.004)
High*GDP per capita	-0.007	(0.005)	-0.019**	(0.004)
<b>Education*policy</b>				
Medium*Tier-2 policy	-0.018	(0.019)	-0.022	(0.015)
Medium*Tier-3 policy	-0.040	(0.021)	-0.031	(0.017)
Medium*Tier-4 policy	-0.136**	(0.023)	-0.099**	(0.018)
High*Tier-2 policy	-0.044*	(0.019)	-0.039**	(0.015)
High*Tier-3 policy	-0.084**	(0.021)	-0.057**	(0.017)
High*Tier-4 policy	-0.185**	(0.023)	-0.147**	(0.018)
<b>Intercept</b>	0.585**	(0.089)	0.499**	(0.079)
<b>Random intercept</b>				
In-SD Level 3	-5.601**	(1.418)	-4.536**	(0.391)
In-SD Level 2	-3.331**	(0.164)	-4.187**	(0.215)
In-SD Level 1	-1.896**	(0.012)	-2.097**	(0.012)
N	3,310		3,328	

Note: \*\*p<0.01, \*p<0.05

Similar to the educational impacts on PPR1 and PPR0, women's education has significant negative effects on PPR2. Over time the educational gap in PPR2 converges gradually as the demographic transition progresses. This is expected, due to the diffusion of birth control from highly educated women to the lower educational groups. Women's education also shows significant interactions with provincial GDP per capita and policy TFR. Holding other things constant, the educational gap in PPR2 strengthens in more economically developed areas (mainly between medium and low educational groups) and in provinces with loose birth control policy. This reinforces the significant contextual effects in shaping the education–fertility link in China. Highly educated women in economically more developed areas, rural or urban, are even more likely to forgo higher order births. Similarly, highly educated women are also less likely than

their low-educated counterparts to take advantage of the loose policy restriction to have higher order births.

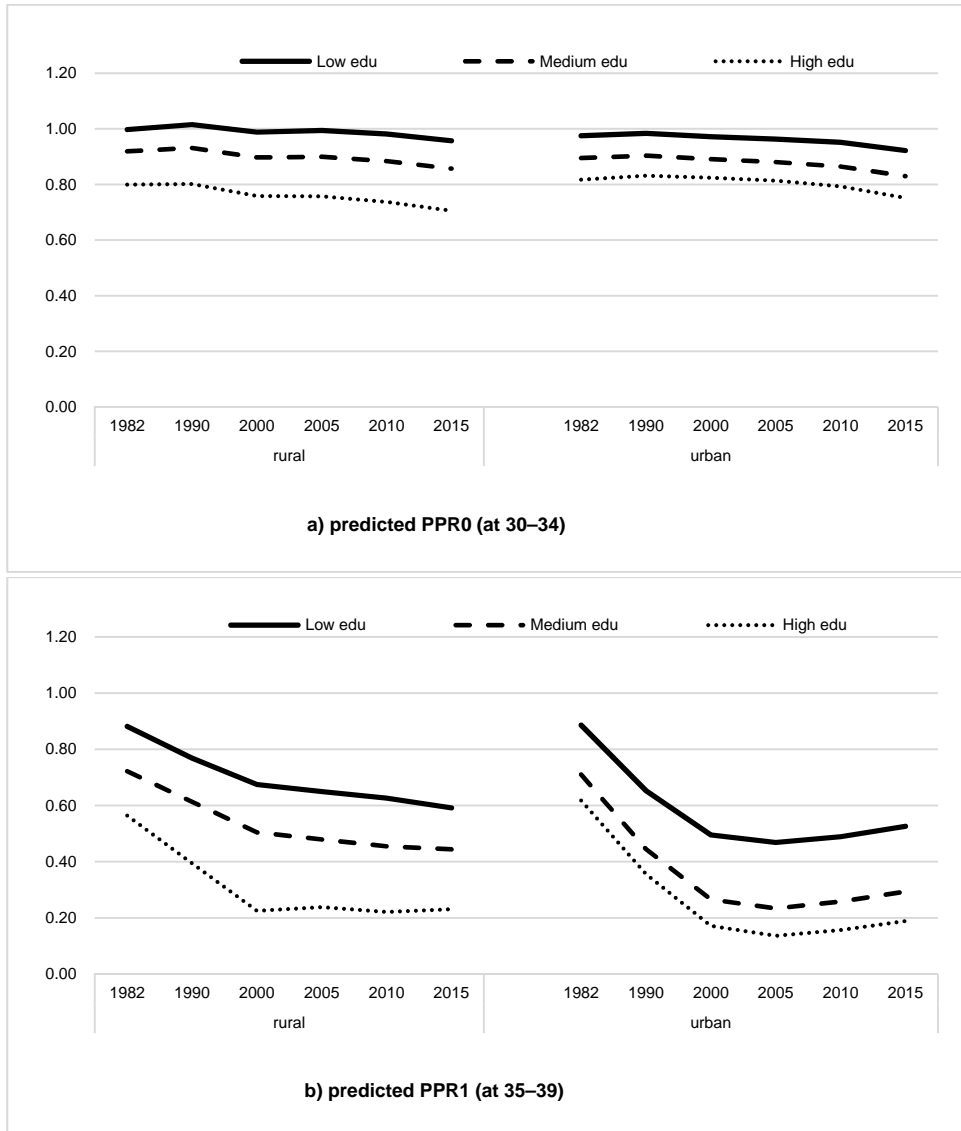
In line with what is found for PPR0 and PPR1, the PPR2 is significantly lower in the provinces where a prolonged delay in women's marriage is observed. The PPR2 of urban women is also significantly lower in more urbanized provinces. These women are likely to be the forerunners in adopting modern family norms and adjusting their fertility behaviors accordingly. All else being equal, the PPR2 is significantly higher in provinces with higher GDP per capita. Yet, this effect is very small in magnitude and it predicts a difference no bigger than 0.07, even when the poorest and wealthiest provinces are compared. The PPR2 is higher for rural women in the provinces with higher inter-provincial in-migration rates, and for urban women in the provinces with higher out-migration rates. As women's inter-provincial migration did not take place on a large scale before the 1990s, the effect may be better comprehended in the context of post-transition China. It is possible that the provinces observing high inter-provincial in-migration rates are economically more developed, which helps to improve the affordability of high order births in rural areas. By contrast, high out-migration rates usually signify slower provincial socioeconomic development, and thus the urban labor market may be less competitive in those provinces, making high order births less costly in terms of economic and opportunity costs. Moreover, traditional fertility norms are more likely to dominate in these less developed areas. Above all, the PPR2 is quite low in the post-transition era, and its contribution to fertility should not be overstated.

#### **4.3 A summary of PPR educational gradients**

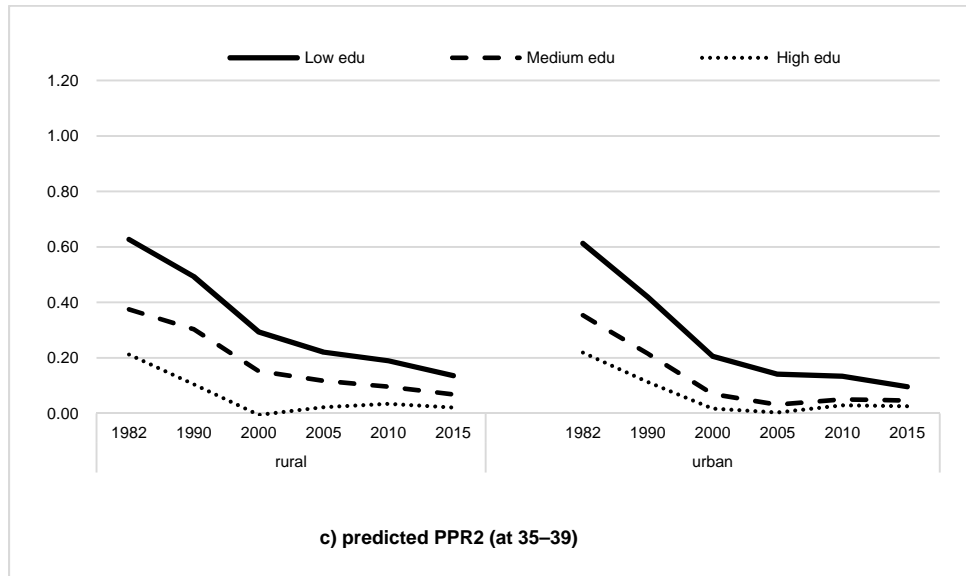
So far, our analyses consistently support a significant negative relationship between women's education and each of the PPRs, both over the course of China's demographic transition and in the post-transition era. Nonetheless, the magnitude of the relationship changes significantly over time, especially for the PPRs to second and higher order births. The relationship is also context-sensitive in light of the glaring socioeconomic and institutional disparities across provinces in China. To make a synthesized and visual picture, we use post-estimation predictions to summarize the educational gradients in the PPRs along the chronicle line. These predictions are made at women's mid-reproductive stage, fixed specifically at ages 30–34 for PPR0 and at ages 35–39 for PPR1 and PPR2, with all other covariates held at the sample means. The results are illustrated in Figure 1.



**Figure 1 : Predicted cohort PPRs by education and year, for rural and urban women**



**Figure 1 : (Continued)**



Although it is true that the majority of Chinese women in each birth cohort eventually enter motherhood, the timing has been postponed substantially over time. As shown in Figure 1, the cohort PPR0 by women's mid-reproductive life (30-34) has declined for every educational group, in both rural and urban China. The decline has been more substantial for urban women, and also for higher educational groups. Over the study period the predicted educational gap in PPR0 between the high and low educational groups of rural women remains above 0.2, and is around 0.16 in urban China.

For PPR1 the educational gradient is much larger and remains so throughout the study period. By 2015 the predicted educational gap (between high and low education) in cohort PPR1 is 0.36 for rural women and 0.34 for urban women. Finally, the educational gradient also persists in PPR2, despite the fact that it has declined to very low levels in both rural and urban China. Highly educated women have substantially lower propensities to make the transition to third or higher order births.

## **5. Conclusion and discussion**

Using data collected by China's national censuses and mini-censuses between 1982 and 2015, this study reexamines the relationship between women's education and fertility over the course of the fertility transition and in the post-transition era. We investigate women's cohort parity progression ratios for a wide range of birth cohorts, from the mid-1930s to the 1990s. The education–fertility relationship examined provides a panoramic perspective of the impact of education throughout China's demographic transition and in the contemporary low-fertility era.

Our study provides strong empirical support for a persistent negative education–fertility association in China, which is manifested by women's progression to each of the successive parities. In general, highly educated women have a lower propensity to enter motherhood or progress to a next birth. This is in line with the well-established relationship between women's education and fertility during the fertility transition worldwide. Our findings also suggest that the association between women's education and each of the successive PPRs persists in China's post-transition low-fertility era.

However, it is noteworthy that the strength of the education–fertility association varies by birth order, phase of fertility transition, and socio-institutional context. In particular, the association is stronger for the progression ratios at second and higher parities. While the fertility decline in China is predominantly characterized by rapid declines in higher parity births, more-educated women go much further in restricting their progression to higher parities. By comparison, the educational gap is smaller, yet still significant, for the first birth. Despite the fact that the majority of Chinese women eventually make the transition to motherhood, subtle declines in PPR0 are observed in late and post-transition China.

Over the course of China's fertility transition, the educational gradient for first birth remains largely stable over time. By contrast, the magnitude of the educational gradient for second birth changes significantly over time, as does that for higher order births. Our results show that the educational gap increases for the second birth, but decreases for third or higher order births. There is an overall inverse J-shaped trend in the PPR1, resulting partly from the increasing share of dual-only-child couples in younger generations and partly from the recent policy relaxation (e.g., the partial two-child policy since 2013). Despite the general upward trend, in the post-transition era the educational gap in PPR1 is increasing, indicating that low-educated women are more likely to take advantage of the policy changes to have a second birth. The educational gradient in third or higher order births converges at very low levels over time. This suggests that the decline in higher order births has diffused successively from highly educated women to other educational groups along China's fertility transition.

Our study also shows significant contextual effects shaping the relationship between women's education and fertility. Based on socioeconomic and institutional factors at the provincial level, the educational gradient is larger in provinces with a less stringent birth control policy, for both rural and urban areas. Regional socioeconomic development also significantly moderates the education–fertility association. Compared with the less developed provinces, the more economically developed provinces have a smaller educational gradient in PPR1 but a larger educational gap in PPR2. The highly educated women in more developed areas are much less likely to progress to a second or higher order birth. A possible explanation could be that in the economically more developed areas, highly educated women tend to value independence and personal fulfillment to a greater extent, and usually face higher opportunity costs of childbearing and rearing and stronger role incompatibility. Marriage postponement in contemporary China also plays a significant role in the decline of each of the successive PPRs.

Above all, our study shows that there is a salient negative relationship between women's education and fertility, both during and after China's fertility transition. Yet, the education–fertility link is neither stable over time nor constant across provinces. That the education–fertility link might be flexible and reactive may be a useful insight when designing feasible socio-institutional arrangements and policy interventions in order to minimize the suppressing impact of massive education expansion on fertility, especially in view of the lower progression ratios of highly educated women to first and second births.

There are several caveats concerning this study. First, due to a lack of detailed information on the timing of each birth, our data prevent us from identifying twin or multiple births from successive parities in the sample. This may introduce some upward biases when calculating the PPR1 and PPR2. Nevertheless, given that twin or multiple births are rare in the population and are less likely to interact with women's education, the resulting error is expected to be negligible. Second, in the past several decades China has observed both a rapid demographic transition and socioeconomic development. Women's education profile has changed unprecedentedly during this period. As a result, it is difficult to construct an intertemporally comparable and efficient measure of education for the entire study period. We use the three-category education measure, with the high education group denoting at least some tertiary education, and this operationalization results in small sample sizes for some of the high-education groups of the oldest cohorts of women. Thus the PPRs calculated from these small samples may be sensitive to random variations. We conducted sensitivity analyses by excluding the small groups in the multivariate model, and the main results appear to be robust. Third, due to data availability we use aggregated data instead of individual records, and thus the findings may not be inferred to individual relationships directly.

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## References

- Batyra, E. (2016). Fertility and the changing pattern of the timing of childbearing in Colombia. *Demographic Research* 35(46): 1343–1372. doi:10.4054/DemRes.2016.35.46.
- Brand, J.E. and Davis, D. (2011). The impact of college education on fertility: Evidence for heterogeneous effects. *Demography* 48(3): 863–887. doi:10.1007/s13524-011-0034-3.
- Cai, Y. (2010). China's below-replacement fertility: Government policy or socioeconomic development. *Population and Development Review* 36(3): 419–440. doi:10.1111/j.1728-4457.2010.00341.x.
- Caldwell, J.C. (1982). *Theory of fertility decline*. New York: Academic Press.
- Caldwell, J.C., Caldwell, P., and McDonald, P. (2002). Policy responses to low fertility and its consequences: A global survey. *Journal of Population Research* 19: 1–24. doi:10.1007/BF03031966.
- Caldwell, J.C. and Ruzicka, L.T. (1978). The Australian fertility transition: An analysis. *Population and Development Review* 4(1): 81–103. doi:10.2307/1972148.
- Caldwell, J.C. and Schindlmayr, T. (2003). Explanations of the fertility crisis in modern societies: A search for commonalities. *Population Studies* 57(3): 241–263. doi:10.1080/0032472032000137790.
- Caltabiano, M., Castiglioni, M., and Rosina, A. (2009). Lowest-low fertility: Signs of a recovery in Italy? *Demographic Research* 21(23): 681–718. doi:10.4054/DemRes.2009.21.23.
- Chen, J., Retherford, R.D., Choe, M.K., Li, X., and Hu, Y. (2009). Province-level variation in the achievement of below-replacement fertility in China. *Asian Population Studies* 5(3): 309–328. doi:10.1080/17441730903351651.
- Chen, W. (2008). Population transition in China during the first three decades under the reform and opening-up policy. *Population Research* 32(6): 18–29.
- Coale, A.J. and Watkins, S.C. (eds.) (1987). *The decline of fertility in Europe*. Princeton, NJ: Princeton University Press.
- Feeney, G., Wang, F., Zhou, M., and Xiao, B. (1989). Recent fertility dynamics in China: Results from the 1987 one percent population survey. *Population and Development Review* 15(2): 297–332. doi:10.2307/1973706.

- Greenhalgh, S. (1986). Shifts in China's population policy, 1984–86: Views from the central, provincial, and local levels. *Population and Development Review* 12(3): 491–515. doi:10.2307/1973220.
- Goujon, A., Lutz, W., and KC, S. (2015). Education stalls and subsequent stalls in African fertility: A descriptive overview. *Demographic Research* 33: 1281–1295. doi:10.4054/DemRes.2015.33.47.
- Gu, B., Wang, F., Guo, Z., and Zhang, E. (2007). China's local and national fertility policies at the end of the twentieth century. *Population and Development Review* 33(1): 129–147. doi:10.1111/j.1728-4457.2007.00161.x.
- Guo, Z. (2017). The main features of the low fertility process in China: Enlightenment from the results of the national 1% population sampling survey in 2015. *Chinese Journal of Population Science* 4: 2–14.
- Guo, Z., Zhang, E., Gu, B., and Wang, F. (2003). Diversity of China's fertility policy by policy fertility. *Population Research* 27(5): 1–10.
- Henry, L. (1953). Theoretical basis of measures of natural fertility. In: Henry, L.: *On the measurement of human fertility*. New York: Elsevier. (Fécondité des Mariages: Nouvelle Méthode de Mesure. Institut National d'Etudes Démographiques, Travaux et Documents. Cahier 16. Paris: Presses Universitaires de France).
- Lavelly, W. and Freedman, R. (1990). The origins of the Chinese fertility decline. *Demography* 27(3): 357–367. doi:10.2307/2061373.
- Lesthaeghe, R. (1998). On theory development and applications to the study of family formation. *Population and Development Review* 24(1): 1–14. doi:10.2307/2808120.
- Lesthaeghe, R. and van de Kaa, D.J. (1986). Twee demografische transitities? In: Lesthegehe, R. and van de Kaa, D.J. (eds.). *Bevolking: Groei en krimp, Mens en Maatschappij book supplement*. Deventer: Van Loghum-Slaterus: 9–24.
- Lutz, W. and KC, S. (2011). Global human capital: Integrating education and population. *Science* 333: 587–592. doi:10.1126/science.1206964.
- Newman, L.A. and Hugo, G.J. (2006). Women's fertility, religion and education in a low-fertility population: Evidence from South Australia. *Journal of Population Research* 23(1): 41–66. doi:10.1007/BF03031867.

- Osiewalska, B. (2017). Childlessness and fertility by couples' educational (in)equality in Austria, Bulgaria, and France. *Demographic Research* 37: 325–362. doi:10.4054/DemRes.2017.37.12.
- Piotrowski, M. and Tong, Y. (2016). Education and fertility decline in China during transitional times: A cohort approach. *Social Science Research* 55: 94–110. doi:10.1016/j.ssresearch.2015.10.001.
- Poston, D.L. Jr. and Gu, B. (1987). Socioeconomic development, family planning, and fertility in China. *Demography* 24(4): 531–551. doi:10.2307/2061390.
- Preston, S.H., Heuveline, P., and Guillot, M. (2002). *Demography: Measuring and modeling population processes*. Hoboken, N.J.: Blackwell Publishing.
- Raymo, J.M., Carlson, M.J., Van Orman, A., Lim, S.J., Perelli-Harris, B., and Iwasawa, M. (2015). Educational differences in early childbearing: A cross-national comparative study. *Demographic Research* 33(3): 65–92. doi:10.4054/DemRes.2015.33.3.
- Short, S. and Zhai, F. (1998). Looking locally at China's one-child policy. *Studies in Family Planning* 29: 373–387. doi:10.2307/172250.
- Tian, S. (2018). Women's educational structure and the completed fertility. *Population and Society* 34(2): 60–70.
- Van Bavel, J. (2014). The mid-twentieth century baby boom and the changing educational gradient in Belgian cohort fertility. *Demographic Research* 30(33): 925–962. doi:10.4054/DemRes.2014.30.33.
- van de Kaa, D.J. (2004). The true commonality: In reflexive modern societies fertility is a derivative. *Population Studies* 58: 77–92. doi:10.1080/0032472032000183762.
- Wang, Q. (2008). Analyzing China's fertility trends using cohort cumulative fertility. *Population Research* 32 (6): 1–6.
- Whyte, M.K. and Parish, W.L. (1984). *Urban life in contemporary China*. Chicago: University of Chicago Press.
- Wood, J., Neels, K., and Kil, T. (2014). The educational gradient of childlessness and cohort parity progression in 14 low fertility countries. *Demographic Research* 31(46): 1365–1416. doi:10.4054/DemRes.2014.31.46.
- Yoo, S.H. (2014). Educational differentials in cohort fertility during the fertility transition in South Korea. *Demographic Research* 30(53): 1463–1494. doi:10.4054/DemRes.2014.30.53.



- Zeman, K. (2018). Cohort fertility and educational expansion in the Czech Republic during the 20th century. *Demographic Research* 38(56): 1699–1732. doi:10.4054/DemRes.2018.38.56.
- Zhai, Z., Chen, J., and Li, L. (2015). China's recent total fertility rate: New evidence from the household registration statistics. *Population Research* 39(6): 22–34.
- Zhao, Z. (2015). Closing a socioeconomic chapter of Chinese history. *Population and Development Review* 41: 681–686. doi:10.1111/j.1728-4457.2015.00090.x.
- Zhao, Z. and Zhang, G. (2018). Socioeconomic factors have been the major driving force of China's fertility changes since the mid-1990s. *Demography* 5(2): 733–742. doi:10.1007/s13524-018-0662-y.

