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ABSTRACT

Free Education and the Intergenerational Transmission of Cognitive Skills in Rural China*

This paper estimates the impact of the Free Education Policy, a major education reform implemented in rural China in 2006, as a natural experiment on the intergenerational transmission of cognitive skills. The identification strategy relies on a difference-in-differences approach and exploits the fact that the reform was implemented gradually at different times across different provinces. By utilizing nationally representative data from the China Family Panel Studies, we find that an additional semester of exposure to the Free Education Policy reduces the intergenerational transmission of parent and child cognitive scores by an approximately 1% standard deviation in rural China, indicating a reduction of 3.5% in intergenerational cognitive persistence. The improvement in cognitive mobility across generations might be attributed to enhanced school attainment, the relaxation of budget constraints, and increased social contact for children whose parents are less advantaged in terms of cognitive skills.

JEL Classification: H52, I24, J24

Keywords: free education policy, intergenerational transmission, cognitive skills

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1. Introduction

The importance of cognitive skills has been widely recognized for various economic and social outcomes, such as children's school performance (Reynolds et al., 2010; Almlund et al. 2011), educational attainment, wages, crime (Currie and Thomas, 2001; Heckman et al., 2006; Pearce et al., 2016), and health outcomes in adulthood (Hatch et al., 2007).[1] Owing to a mixture of nature and nurture effects (Anger and Heineck, 2010), parents play a significant role in the development of their children's cognitive skills (Heckman, 2006; Zhang et al., 2020), resulting in intergenerational transmission (IGT) of such skills. The persistence of intergenerational transmission of cognitive skills has been found to be a major source of intergenerational income mobility and inequality (Becker and Tomes, 1979; Grönqvist et al., 2017). Understanding the IGT of cognition is therefore crucial to policy design (Conti and Heckman, 2014).

To date, a growing number of economic studies have focused on the IGT of cognitive skills. Some studies have investigated the correlation of cognitive skills between parents and children (Black et al., 2009; Bjorklund et al., 2010; Anger and Heineck, 2010; Anger, 2012). Other studies have explored the causal effects of parental cognitive ability on children by employing an instrumental variables approach with adoptee or sibling samples (Black and Devereux, 2011; Hanushek et al., 2021; Grönqvist et al., 2017).[2] All of these studies arrive at a rather consistent conclusion that a strong and persistent correlation between parents' and children's cognitive skills exists. However, our understanding of whether and how the persistency of such a correlation can be shaped is still limited. In particular, to the best of our knowledge, no study has specifically explored the impact of a specific public policy on the transmission of cognitive skills between parents and children.[3]

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[1] The correlation between cognitive skills and various outcomes such as school performance, income, and political capital is also found in the Chinese context (Huang et al., 2015).

[2] For noneconomic literature, please see Bouchard and McGue (1981) for a review.

[3] There are a few studies exploring the impact of public polies on the intergenerational transmission of income

In this study, we attempt to understand this by providing evidence from China. In our setting, we focus on examining a major education reform, the Free Education Policy enacted in 2006 in rural China. This reform aims to exempt all rural students from compulsory school fees. Theoretically, the impact can be either positive or negative. The positive effect is the provision of educational opportunities for children from disadvantaged families, which is the main motivation of such public policies (Pekkarinen et al., 2009; Shi, 2016; Currie and Aizer, 2016). In particular, this policy aims to alleviate financial constraints on education, which has been shown to be important in improving children's cognitive development (Dahl and Lochner, 2012; Gennetian and Miller, 2002; Akee et al., 2010; Del Boca et al., 2012; Zhou et al., 2020).[4] The negative effect is attributed to the fact that children from privileged backgrounds are better equipped to take advantage of the new opportunities afforded by the policy (Torche, 2019) because their parents might have better parental investment (List et al., 2021); therefore, the outcomes of advantaged children may be more positive even when the policy provides equal opportunities for advantaged and disadvantaged children. In reality, which effect is more dominant, and what are the underlying mechanisms that can explain the effect? In this study, we aim to provide a rigorous evaluation to answer these questions.

China enacted the Compulsory Education Law of China in 1986, which requires all children to attend primary and junior high schools for nine years. However, the law was not fully enforced due to the high cost of education, especially for disadvantaged families. To significantly increase school enrollment and improve the degree of economic opportunity, China has initiated a series of reforms to reduce educational costs. The Free Education Policy is one of the most essential reforms in this regard.[5] Provinces enacted this policy at different

(Pekkarinen et al., 2009) and education (Bauer and Riphahn, 2006; Guo et al., 2019).

[4] We refer to Heckman and Mosso (2014) for a more detailed review.

[5] The policy is found to have an effect on enhancing school enrollment (Shi, 2016), reducing the incidence to be child labor (Tang et al., 2020), etc.

times, either in 2006 or 2007.[6]

In this paper, by exploiting the difference in effective dates of the Free Education Policy across different provinces and utilizing nationally representative data from the China Family Panel Studies (CFPS hereafter), we adopt a difference-in-differences empirical strategy that exploits within-cohort and within-province variation in exposure to the policy to estimate the impact of the policy on the intergenerational transmission of cognitive skills. We discovered that the benefit of free education in boosting a child's cognitive skills, as measured by word and math cognition test scores, is greater for children whose parents have lower cognitive skills, hence increasing cognitive mobility through generations. Our study therefore indicates that the positive effects of the policy on intergenerational cognitive mobility outweigh the negative effects.

Further exploration of the underlying mechanisms reveals multiple possible channels, which we summarize as follows. First, the policy increases children's years of attending school, reduces the incidence of dropping out of compulsory school, and increases the completion of senior high school education, with the effect being amplified for children whose parents' cognitive skills are lower, resulting in increased cognitive mobility between generations. Second, by making compulsory education free, the policy alleviates the financial constraints of disadvantaged families and makes education more accessible to their children, therefore leading to more investment in children's education for those families. Finally, the policy enhances the social interaction of children, as going to school provides children with more opportunities to interact with their peers, which is particularly beneficial for children from disadvantaged families who would otherwise remain at home rather than attending school without the policy. Notably, due to data constraints, our analysis of the mechanisms underlying the policy effect is indirect. We can only suggest potential channels rather than establishing

[6] The implementation dates of the policy for each province are in Appendix Table 1.

explicit causal relationships. This section should be understood as a comprehensive exploration of the possible channels through which the policy influences the intergenerational transmission of cognitive skills between children and their parents.

Our paper contributes primarily to the literature in the following ways. First, the economic literature has found a strong correlation and persistence of intergenerational transmission of cognitive skills; however, it remains to be explored whether and to what extent an exogenous public shock impacts the intergenerational transmission of cognitive skills. We are among the first economic studies to investigate the direct effects of this type of public policy aimed at relaxing family budget constraints on such transmission.

Second, studies indicate that public educational policies improve children's cognition; however, whether and how the impacts of such policies on children's cognitive development differ with different parental cognitive abilities remain to be determined. Our study suggests that the impact of such policies is heterogeneous in terms of parents' cognitive status. In particular, we find that the effect of the policy on children's cognition is more pronounced among parents with lower cognitive skills.

Third, our research explores a number of potential mechanisms. We demonstrate that the positive effects of free education on promoting school enrollment, relaxing budget constraints, and expanding the social contacts of children are the possible mechanisms driving cognitive mobility across generations.

The rest of the paper is arranged as follows: Section 2 introduces the policy context, the data, and the sample. Section 3 describes the empirical design, key findings, and suggestive evidence for identification assumptions. Section 4 presents the underlying mechanisms, and Section 5 presents robustness checks. The paper's conclusions are provided in Section 6.

2. Policy Background and Data

2.1 Free Education Policy in China

In 1986, the Chinese central government released the Compulsory Education Law of China (CELC), also known as the 9-year compulsory educational law, to guarantee the right of children of primary- and junior-high-school age to receive an education and to improve people's quality of life. Although the CELC intends to guarantee tuition-free education for compulsory education levels, it was not strictly enforced due to the local government's lack of financial resources. Consequently, households had to shoulder the heavy burden of educational expenditures, which account for 8-16% of total household expenses in rural areas (Shi, 2012).

To alleviate the financial burden of rural households and further increase school enrollment, a series of educational financing reforms were implemented in rural areas in the early 2000s. These reforms included tuition control starting in 2001, the Two Exemptions and One Subsidy Policy (TEOS) starting in 2003 (Chyi and Zhou, 2014), and the Free Education Policy. All of these reforms targeted compulsory education levels. The Free Education Policy program implemented in 2006 is a global program that exempts all rural students from paying tuition. The Free Education Policy is identical to a conditional cash transfer program (Shi, 2016) and is in some ways an extension of the TEOS, as it primarily benefits students who are ineligible for the TEOS (Tang et al., 2020).

The Free Education Policy was implemented in 16 provinces in the spring of 2006, 4 provinces in the fall of 2006, and the remaining provinces in the spring of 2007 (Tang et al., 2020). In Appendix Table 1, the specific implementation dates of the policy for each province used in our sample are summarized.

2.2 Data Sources and Samples

Our main dataset is drawn from three waves of the China Family Panel Studies (CFPS), namely, 2010, 2014, and 2018, which is a nationally representative, longitudinal survey of

Chinese communities, families, and individuals initiated in 2010 by the Institute of Social Science Survey (ISSS) of Peking University.

The nationwide CFPS baseline survey in 2010 successfully interviewed 14,798 households from 635 communities, including 33,600 adults and 8,990 children, in 25 designated provinces, with an approximate response rate of 81%, where the majority of nonresponses were due to noncontact (Xu and Xie, 2015). The stratified multistage sampling strategy ensures that the CFPS sample represents 95% of the total population in 2010 (Xie, 2012). We integrated the three waves of the CFPS (2010, 2014, and 2018) into pooled cross-sectional data to increase the sample size, as the same questionnaire on the cognitive skills of individuals aged 10 years and above was used for all three years.

Our sample consists of pairs of children and parents. As our objective is to investigate the intergenerational transmission of cognitive skills, we employ an adult sample of both children and their parents to obtain stable measures of cognitive skills, as is typical in the literature on intergenerational cognition transmission (Black et al., 2009; Bjorklund et al., 2010; Anger and Heineck, 2010; Grönqvist et al., 2017). To utilize the variation in children's exposure to the Free Education Policy, we restrict our sample to young adult children between the ages of 16 and 25 in the survey years.[7] Then, we match the parent and child data and omit observations with missing values for relevant variables. As the CFPS investigates all household members, it is possible to match parents and children completely. Eventually, a sample of 4,866 children with complete parental information was compiled.

2.3 Main Variables

2.3.1 Policy exposure

Following Tang et al. (2020), we measure an individual's exposure to the Free Education

[7] As the survey year is either 2010, 2014, or 2018, the sample children were born from 1985 to 2002. We also experimented to include children of younger cohorts aged 10 to 15, and older cohorts of 26- to 30-year-olds in the survey years into our sample. The results are robust.

Policy on the basis of the number of semesters they are expected to be influenced by the policy at the time of the survey.[8] According to the CELC, children must enroll in primary school after their sixth birthday. Each academic year in China consists of a fall semester and a spring semester, and a child normally begins primary school in the fall semester. Thus, the number of semesters a child is exposed to the policy is jointly determined by the date the policy went into effect in the province of residence and his or her date of birth. A child born between September 1993 and August 1994, for instance, would have entered primary school in September 2000 and junior high school in September 2006. Suppose that the policy implementation date in his or her province was September 2006; then, the child was exposed to the Free Education Policy for six semesters. As the sample children are older than 16 years, they had already completed junior high school in the survey year, so the exposure of the same individual in different survey years, i.e., 2010, 2014, or 2018, is the same. However, if a child was born in 1990, he or she would enter primary school in September 1996 and graduate from junior high school in June 2005. He or she was exposed to the policy for zero semesters regardless of whether the implementation year was 2006 or 2007 because he or she had completed compulsory education before the reform.

2.3.2 Measures of cognitive skills

The 2010, 2014, and 2018 CFPS contain two tests to measure cognitive skills, namely, the word test and the math test, both of which are designed to be taken by both adults and children aged 10 to 15 years, with the child and adult tests having the same rules and containing the same questions. These three survey years have equivalent test questions and score systems.

The word test measures the ability to recognize and pronounce words in Mandarin. It consists of eight sheets, and each sheet has 34 words or phrases. The math test measures

[8] The calculation of expected exposure at the time of the survey assumes that the child attends school at the age of six following the law (CELC). An alternative measure is the actual number of semesters a person was affected by the Free Education Policy, which is dependent on the child's actual school enrollment age and could be endogenous (Tang et al., 2020).

cognitive ability in mathematics and logic analysis and consists of four problem sets of 24 questions each. Each interviewee chose at random a sheet of the word test and of the math test and answered all the questions; therefore, the maximum score for the word test was 34, and that for the math test was 24. In our final sample, approximately 5 percent of the children received full marks on the tests.[9] In the estimation, we use age-standardized scores for both the word tests and math tests rather than the raw scores.[10]

3. Empirical Strategy and Results

3.1 Empirical Approach

Our primary research question concerns the effect of children's exposure to the Free Education Policy on the intergenerational transmission of cognition from parents to children. We begin with the classic model for estimating intergenerational elasticity (IGE) (Solon, 1999; Black and Devereux, 2011):

$$y = \alpha + \beta y^{P} + \varepsilon \quad (1)$$

where y and y^{P} are the logged permanent income of the child and parent, respectively. Similarly, when assessing the intergenerational persistence of cognition, we replace the income of the child and parent with cognitive skills and estimate the OLS model below (Anger and Heineck, 2010):

$$Cognition = \alpha + \beta Cognition^{P} + \varepsilon \quad (2)$$

where $Cognition$ and $Cognition^{P}$ are the cognitive skills of the child and parent, respectively. The key parameter of interest is β, which measures the intergenerational transmission of cognition. We examine whether and how a public policy, the Free Education Policy, influences intergenerational cognitive mobility. Thus, we allow β to vary depending

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9 We discuss the plausible estimation bias caused by the right censored test scores in Section 5.1.

10 We experiment with several measures, such as sample-standardized word and math test scores, and averaged standardized word and math test scores. All estimates are robust to various of cognitive test measures.

on an individual's exposure status to the policy:

$$\beta = \gamma + \delta Exposure \quad (3)$$

Taking Equation (3) into Equation (2) and accounting for the cohort- and province-specific characteristics as well as other demographic and socioeconomic characteristics of children and parents, we construct the following difference-in-differences (DID) model in sample form as our baseline empirical model:

$$\begin{aligned} Cognition_{iptm} &= \alpha_0 + \gamma\delta Cognition_{iptm}^{P} * Exposure_{ptm} + \gamma Cognition_{iptm}^{P} \\ &+ \theta Exposure_{ptm} + \mu X_{iptm} + Cohort_t + Province_p + Month_m + Trend_{pt} \\ &+ Survey\_year_{iptm} + \varepsilon_{iptm} \quad (4) \end{aligned}$$

where $Cognition_{iptm}$ is the age-standardized cognitive skill of child i born in year t and month m in province p and where $Cognition_{iptm}^{P}$ is the age-standardized cognitive skill of child i's parent. $Exposure_{ptm}$ is the number of semesters in which a child was exposed to the Free Education Policy, which is jointly determined by birth year, birth month, and province. X_{iptm} contains a set of child and parent features. We control for the child's gender and ethnicity, father's and mother's age and educational level, and survey year dummy variables. To account for unobserved cohort and province-specific characteristics in determining children's cognitive skills, we also control for birth year fixed effects $Cohort_t$, birth month fixed effects $Month_m$ and birth province fixed effects $Province_p$. We also include province-specific time trends $Trend_{pt}$ to account for different patterns of age trends regarding cognitive skills across provinces. As the sample is drawn from the 2010, 2014, and 2018 survey years, we control for survey year fixed effects $Survey\_year_{iptm}$ to account for the unobservable heterogeneity that is invariant within survey years. The key parameter of interest is $\gamma\delta$, which reflects the impact of the Free Education Policy on the intergenerational transmission of cognition. Notably, Equation (4) is used to qualify the direct effect of the policy on intergenerational cognitive transmission (Ichimura and Taber, 2000). The descriptive statistics of the main variables used in the estimations are presented in Table 1.

[Table 1 near here]

3.2 Baseline Results

3.2.1 Intergenerational transmission of cognitive skills

We begin our empirical estimations by introducing the coefficients of intergenerational cognitive transmission. As observed in Table 2, both word and math cognitive skills have significant intergenerational links. Specifically, a one standard deviation increase in fathers' word or math test scores leads to a 21 and 22 percent standard deviation increase in children's word or math test scores, respectively, whereas a one standard deviation increase in mothers' word or math test scores leads to a 25 and 24 percent standard deviation increase in children's word or math test scores, respectively, which is slightly greater than that of fathers. In addition, an additional semester of exposure to the Free Education Policy leads to a more than 5 percent standard deviation increase in a child's word and math test scores.

[Table 2 near here]

Notably, girls outperform boys in both word and math tests.[11] In a recent study based on CFPS data, Gu & Jean Yeung (2021) reported that adolescent girls have greater verbal and math achievements than boys do, where the gap in verbal scores is greater than that in math scores. They explained that three factors account for these gender gaps: (1) (grand) parents hold higher expectations for girls, monitor girls more closely, and invest as much in girls as they do in boys; (2) girls possess better noncognitive skills; and (3) girls' stronger performance

[11] To assure the validity of the cognition tests in the CFPS, we turn to other nationally representative survey data, the China Education Panel Survey (CEPS). The CEPS has both the academic outcomes and cognition tests for children aged 6-15. We combine the data from two years of the survey (2013-2014 and 2014-2015). The results show that girls also outperform boys in both cognitive tests and school exams both in math and language, which is consistent with what we found in the CFPS data.

in earlier years gives them an edge for later achievement.

3.2.2 Free education and intergenerational transmission of cognition

Table 3 displays the key findings regarding the effect of exposure to the Free Education Policy on the intergenerational transmission of cognition. We investigate the father–child and mother–child transmission of cognition separately.[12] Columns (1) and (2) represent the transmission of word cognitive skills from parent to child, whereas Columns (3) and (4) represent math cognitive skills. The coefficients of the interaction term between either the father's or mother's cognitive scores and the child's exposure to the policy are significantly negative, indicating that the policy has significantly weakened the intergenerational transmission of cognition. As Columns (1) to (4) show, the specifications are rather similar; therefore, we use the coefficient of Column (1) for illustration. The results show that an additional semester of exposure to the Free Education Policy reduces the intergenerational transmission of father- and child-word cognitive scores by 1.2% standard deviations, a reduction of 3.5% in the intergenerational cognitive correlation. Thus, the intergenerational persistence of cognitive skills is reduced by 20 percent when a mean exposure (5.81 semesters in Table 1) is provided with free education (by comparing the estimated $\gamma\delta$ and γ in Equation (4)) if we assume that the policy effect is linear with exposure. The findings further imply that the reason why the Free Education Policy increases cognitive mobility is that its effect on a child's cognition is greater for children whose parents have lower cognitive skills (by comparing the estimated $\gamma\delta$ and θ in Equation (4)). Our findings are consistent with the idea that public education increases intergenerational income mobility, as demonstrated by previous research (Pekkarinen et al., 2009).

[Table 3 near here]

[12] In robustness checks, we also try to include both the father's and mother's cognitive scores in the same equation and use the average or the maximum scores of the father and mother. The results are similar. Please see Section 5.1.

3.3 Indirect Assessment of the Identification Assumptions

As the assumptions of the DID strategy are inherently untestable, we conduct multiple robustness checks to provide supporting evidence to the validity of our identification assumptions. To check whether there are pretreatment differences between the treatment group and the control group, we include a placebo test using older cohorts who were already adults and therefore were not in the compulsory school stage when the policy was implemented. To address the potential threat of possible confounding province-level policies in effect simultaneously with the Free Education Policy, we conduct a placebo test with children of the same cohorts from urban areas who were not exposed to this education policy. Additionally, as the cohorts in our sample vary across 10 years, we conduct several robustness checks to ensure that there are no other confounding policy effects during the periods. We also conduct a permutation test to assess whether the policy effect we examined can be attributed to random probabilities.

3.3.1 Placebo test: older cohort

The parallel trends assumption, as the key assumption of the DID identification, indicates that the outcomes in the treatment and control groups would follow the same time trends in the absence of the treatment, which is difficult to directly verify. To indirectly check that there are no pretreatment cohort trends in the intergenerational transmission of cognitive skills, we conduct a placebo test in the spirit of Duflo (2001), in which a sample of older cohorts is used. Because the Free Education Policy only affected those aged 6 to 15 years in compulsory education stages at the time it was implemented, we suppose in this placebo test that the policy had been implemented earlier and affected those aged 18 to 27 years who were older than the compulsory education age when the policy went into force. It is expected that the "artificial" policy should have no effect on the older cohorts. We therefore restrict the sample in this control experiment to rural youths aged 18 to 27 years who were exposed to the "artificial" policy but not the actual policy at the time the policy went into force.[13] Table 4 lists the outcomes of this test. As expected, the exposure of older cohorts to the "artificial" policy had no significant effect on children's cognitive skills or intergenerational persistence of cognition. Thus, our results indicate that before the reform, the treatment and control groups are likely to follow the same cohort trend.

[Table 4 near here]

3.3.2 Placebo test: urban sample

The identification of the DID strategy relies on the assumption that no other events take place simultaneously with the treatment. In particular, to check that the results are unlikely to be driven by other province-level shocks overlapping with the Free Education Policy, we conduct a placebo test using an urban sample. The Free Education Policy did not become available in urban areas until 2008. As a result, we conduct a placebo test on urban children of the same age as rural children in our main analysis. Then, we calculate the "placebo" exposure of urban individuals to the policy by using the implementation date of the Free Education Policy in rural areas of the same province, and we anticipate that the "placebo" exposure has no significant influence on intergenerational cognitive transmission in urban areas. Table 5 displays the results of the placebo test using the urban sample. As anticipated, the results in Columns (3) to (6) indicate that exposure to "placebo" policies has no significant effect on intergenerational cognitive transmission in urban areas.[14]

[Table 5 near here]

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[13] We exclude those aged 16 to 17 in the year when the Free Education Policy was enacted. Despite the fact that they were not targeted by the policy, they might have been affected as a result of grade repetition, delayed school entry, and the spillover effect from younger siblings within household. However, even if these individuals are included in the test, the results are similar.

[14] The coefficients on "placebo" exposure are significantly negative. One possible explanation is the much smaller sample size of the urban sample, which covers only 1662 observations. Once we relax some variables, for example, if we drop the cohort fixed effects as a control, the coefficients of exposure become insignificant.

3.3.3 Other confounding factors

To further exclude other shocks that might confound the impact of the Free Education Policy on cognition transmission, we also conduct several robustness checks.

Provincial characteristics before the reform. In the main specification, we use province fixed effects to control for time-invariant provincial characteristics. However, as the cohorts of children in our sample cover 10 years, the impact of provincial characteristics on cognitive transmission could vary across different cohorts. As such, following Tang et al. (2020), we add the interaction terms of the cohort dummy with three province characteristics in 2005 to our baseline models as a robustness check, namely, GDP per capita, the share of tertiary industry in GDP, and the local population. The results are presented in Panel A of Appendix Table 2 and indicate that the baseline results are robust after accounting for the impact of provincial characteristics across different cohorts.

Other public policies. Given that the three waves of the survey span a maximum of eight years, it is possible that the parents in our sample have encountered different specific public policies, which may be confounding factors influencing the cognitive outcomes of both the parents and the children.

In the literature, three major factors have been proven to contribute considerably to the cognitive abilities of the parental generation: parents' exposure to the CELC, their enrollment in public health insurance, and their enrollment in the public pension system (Cheng et al., 2018; Cui et al., 2019). For example, parents of the generation who were exposed to the 1986 Compulsory Education Laws in China (CELC) are likely to have benefited from the policy, and these beneficial effects may also influence the cognitive outcomes of their children. Therefore, we further control for parents' years of exposure to the 1986 CELC and the interaction with parents' cognitive scores to account for the confounding effect of the policy. The results in Appendix Table 2 Panel B demonstrate that it has little effect on the main findings, confirming the reliability of our findings. In addition, the results when controlling for parents' enrollment in public health insurance and the pension system are similar.[15]

In addition, we also consider large-scale school closures and mergers in rural China that might affect a generation of the children (Tang et al., 2020; Xiao et al., 2017). The policy began taking effect in 2001, and the number of primary schools was reduced by more than 50% by 2010. This policy may have a potential confounding effect in our setting, as the costs of attending schools have increased for those affected children who had to travel to cities or towns to attend primary schools due to the closure of schools in their villages. School closure and merger policies are measured by whether there was any primary school in the village where the child was living in 2010 (Tang et al., 2020). We add the interaction between child cohort dummies with school closures and merger policy, and the results hold constant (in Appendix Table 2 Panel C).

Migrations. Another concern is that household migration patterns may affect eligibility for the Free Education Policy. The CFPS asked each surveyed individual whether he or she still lived in his or her birthplace at the age of 12. More than 96% of the individuals in our final sample still resided in their birthplace when they were 12 years old, and the results remain similar if we exclude those who were living elsewhere at the age of 12. Hence, migration is not an issue for our main findings.

3.3.4 Permutation test

The last check is a permutation test, which verifies that our findings are attributable to policy exposure as opposed to a false association in the data or random statistical results (Rosenbaum, 2007; Tang et al., 2020). In the permutation test, the same sample used in the main analysis is utilized, but random exposure values ranging from 0 to 18 are assigned to each birth cohort in each province. We then examine the effect of this simulated "random" exposure

[15] The results are not tabulated for brevity and are available upon request.

to the policy on intergenerational cognitive transmission. We next repeat this procedure 1,000 times with the expectation that "random" exposure has no significant influence on intergenerational cognitive transmission. Figure 1 depicts the distribution of 1,000 "random" exposure coefficients for father-child and mother-child word and math cognitive skills. The p value of the permutation test is the proportion of "random" exposure coefficients whose absolute value exceeds that of the actual coefficients from Table 3. All permutation test p values are less than 5%, demonstrating that the effects of policy exposure on intergenerational cognitive transmission in the main analysis cannot be attributed to random incidence.

[Figure 1 near here]

4. Mechanisms

In this section, we explore the potential mechanisms through which the Free Education Policy enhances the intergenerational mobility of cognitive skills. The Free Education Policy may affect intergenerational cognitive skill mobility in multiple ways. As the Free Education Policy aims to increase school attendance, it can enhance intergenerational mobility when this effect on education is greater among disadvantaged families. It is also possible that free education makes education more affordable and enables families, particularly disadvantaged families, to invest more in their children's development. The Free Education Policy can also relate to cognition mobility by increasing children's socialization with peers due to school attendance, especially for children from disadvantaged families, who would have been less likely to attend school if not for public funding.

It is worth noting that our mechanism analysis focuses only on potential channels with indirect evidence from various attempts rather than establishing causal relationships. Different from an explicit causal mediation analysis in which the overall effect of policy exposure can be decomposed into components operating through different mediator variables, we are unable to disentangle the direct effect which includes any causal mechanisms not operating through the mediators of interest from the indirect effect that is operating through one or several intermediate variables (Flores and Flores-Lagunes, 2009; Huber, 2019). Accordingly, we are also unable to quantify the relative importance of the different possible channels. As we focus on the post-treatment variables (e.g., children's school attainment, family budget constraints and children's social contact) for mechanism analysis, these variables might have been affected by the policy itself. There are no straightforward methods to deal with the causal effects controlling for post-treatment variables (Flores-Lagunes et al., 2010), as one cannot observe the potential outcome of an individual if exposed to the treatment but kept the post-treatment mechanism variable at the level the individual had not been treated.

Also, our analyses are indirect due to data constraints. When examining the mechanism of social contact, the information about social interactions is limited to adulthood rather than childhood. This limitation raises the possibility that social interactions in adulthood could be the result of enhanced cognitive skills rather than the cause of them. Furthermore, we had to use proxies instead of true measurements for some key information. For example, in analyzing budget constraints, we ideally need direct information on family budget constraints during childhood for our sample individuals. However, due to data constraints, we use provincial GDP and whether individuals have siblings as indicators to measure budget constraints, assuming that children from areas with low GDP and those with siblings face higher budget constraints. Therefore, caution is needed when interpreting the analysis of these mechanisms.

4.1 Educational Attainment

4.1.1 Free education, educational attainment, and the IGT of cognition

Formal education is essential for the cognitive development of children (Todd and Wolpin, 2003, Cunha and Heckman, 2008; Cunha et al., 2010). A key objective of educational reforms in China is to increase school enrollment, particularly among disadvantaged families. We examine the channel of a child's educational attainment via the same framework as in the main analysis. We estimate Equation (4) via three dependent variables, $Schooling_{iptm}$, which measures children's years of education; $Junior\_School_{iptm}$, which indicates whether the child had completed junior high school; and $High\_School_{iptm}$, which indicates whether the child had completed senior high school. For the purpose of interpretation, we create a dummy variable that equals one if the average of the father's age-standardized word and math cognition test scores is in the top half of the sample and zero if it is in the bottom half. The same indicator is developed on the basis of the cognitive skills of the mother. These two dummy variables represent the child's father or mother' s status of cognitive skills.

Column (1) in Table 6 indicates that exposure to the Free Education Policy for one additional semester results in an increase of approximately 0.1 years of education for children whose parents have low cognitive skills, but the negative interaction term between *father/mother high cognition* exposure* indicates that the policy effect is reduced by more than half for children whose parents have a high level of cognitive skills. In other words, the positive effect of the policy on the completion of junior high school is more pronounced for children whose parents have lower levels of cognitive skills. The results in Column (2) are similar with respect to the completion of compulsory education. To determine whether the policy has far-reaching impacts on education beyond the compulsory level, we further examine the impact of the Free Education Policy on the completion of senior high school. The results in Column (3) show a significantly negative coefficient of the interaction term, which is also consistent with our existing results. As senior high school education is beyond compulsory education in China and is no longer free, this result indicates that the policy not only has a direct effect on the compulsory level of education but also has an indirect positive effect on the senior high school level for children with disadvantaged backgrounds.[16]

[16] One concern is that sample children's educational attainment may not be the highest level of schooling. As

In conclusion, the Free Education Policy increases children's years of education, reduces the incidence of dropping out of compulsory school and increases senior high school education beyond compulsory education, with the effect being amplified for children whose parents' cognitive skills are lower, resulting in increased cognitive mobility between generations. Our findings are consistent with those of Shi (2016), who also reported that the Free Education Policy increases school attendance in rural China, with a greater impact on children from disadvantaged families.

[Table 6 near here]

4.1.2 Heterogeneous policy effects on educational attainment

Gender heterogeneity. We further investigate the impact of the policy on the educational attainment of male and female children separately to identify more precisely who benefits most. On the basis of Table 6, we run heterogeneity tests for boys and girls. The results are listed in Table 7, which shows that the policy in general has rather equivalent effects on the educational attainment of boys and girls, although the effects for boys tend to be slightly stronger if their father has lower cognition, whereas for girls, the effect is more prominent when their mother has lower cognition. In other words, our results suggest that while both boys and girls from disadvantaged families (whose parents have lower cognition) benefit significantly more from educational attainment than their counterparts from advantaged families (whose parents have higher cognition), boys whose fathers have lower cognition and girls whose mothers have lower cognition initially may receive even more benefits once their education becomes free.

[Table 7 near here]

Regional heterogeneity. Additionally, we examine regional heterogeneity by comparing

we have included cohort dummy variables in all the regressions, we are actually comparing the variation of schooling within each cohort which alleviates the bias from schooling incompletion. Additionally, we conduct a robustness check in which we use the subsample of children aged 18 to 25 (raising the lower bound of sample children's age by 2 years) to make sure more children have completed their highest level of schooling. The results are quantitatively similar and available upon request.

effects in provinces with more government education investment and those with less government education investment. We use government fiscal expenditures on education in 2005 (before the reform) as a measure of the level of educational investment and divide the sample into two groups on the basis of whether the sample child was born in provinces with government fiscal expenditures on education in 2005 higher or lower than the sample median. Given that the Free Education Policy aims at exempting schooling fees, we expect that the policy may have even stronger effects for provinces with lower education investment before the reform. We present the results in Table 8. Consistent with our expectation, the significant and more negative coefficients of the interaction term for "*parent high cognition*exposure*" for provinces with lower government fiscal expenditures on education in 2005 show that the impact of the Free Education Policy on increasing the educational attainment of children of parents with lower cognitive skills is more pronounced in those regions. Therefore, the results imply that the policy enhances the intergenerational mobility of education more in provinces with lower education investment.

[Table 8 near here]

4.2 Budget Constraints

Parental investments are essential for the cognitive development of the child (Heckman, 2006; Hernández-Alava1 and Popli, 2017; List et al., 2021). One possible channel through which public free education enhances cognitive mobility is that reduced family credit constraints in terms of educational fees enable families to invest more in child development.[17] The policy benefit of such a global program is believed to be greater for children from disadvantaged backgrounds (e.g., Cornelissen et al., 2018). Because the sample children in our study are young adults who are no longer of compulsory school age during the time of the

[17] Related studies also documented the direct impact of family budget constraints on a child's various outcomes (Keane and Wolpin, 2001; Caucutt and Lochner, 2020).

survey, we are unable to directly observe their family investments and family income when they were of compulsory school age. Nevertheless, assuming that this channel holds, it is anticipated that the effect of exposure to the policy on cognitive persistence will be more prominent among financially challenged households. We conduct three heterogeneity tests for illustration.

First, we use household assets per capita in 2010 as a proxy to capture the household's budget constraints.[18] Ideally, we should use household asset data before the reform. Owing to data constraints, the earliest year we can obtain is the baseline survey year 2010. Although the Free Education Policy was implemented in 2006, we believe that, owing to the rather stable nature of household economic status in the short run, the household assets per capita in the year 2010 may still be able to capture the household budget constraints before the reform to some extent. We divide the sample into two groups on the basis of whether the household assets per capita in 2010 of the sample child is higher or lower than the sample median. The results in Panel A of Table 9 show that the policy effect is stronger among households with lower assets,[19] indicating that the alleviation of budget constraints weakens intergenerational cognitive persistence.

Second, we further investigate regional disparities to test the family investment hypothesis. Recent studies have identified geographic differences in intergenerational mobility (Chetty et al., 2014; Handy and Shester, 2022). As China has large regional disparities, we expect that the effect of the policy might be stronger in regions with stronger economic constraints. We directly use the provincial GDP per capita in 2005 (before the reform) to capture the degree of economic constraints. We divide the sample into two groups on the basis of whether the sample child was born in a province whose GDP per capita in 2005 was higher or lower than the sample median.

[18] We use 2010 information since the first year the CFPS was conducted was in 2010.
[19] The results using household assets net of house assets per capita are similar.

We present the results in Panel B of Table 9. The results show that the policy effect is mainly in provinces with lower GDP per capita, suggesting that families in less economically developed areas are more likely to be affected by the policy.[20]

Finally, inspired by the theory of the quality–quantity tradeoff (Becker and Lewis, 1973; Becker and Tomes, 1976; Li et al., 2008), it is supposed that families with more children face more budget constraints regarding child investment; as such, we might expect to see stronger impacts of the policy among households with more than one child. To test this, we further divide the sample into two groups on the basis of whether the children are only children or those who have siblings. As anticipated, the results in Panel C of Table 9 indicate that the effect of the Free Education Policy on enhancing cognitive mobility is limited to children with siblings.[21] Although this finding is consistent with our expectation that the policy should have stronger impacts on households with more than one child, it is worth noting that parents' fertility decisions might be correlated with the intergenerational persistence of their cognitive ability.[22] That said, what we found here as an outcome is consistent with our expectation; however, we acknowledge that we are unable to attribute the effects of different family structures to the budget constraints due to data availability.

[Table 9 near here]

Overall, the above three tests are consistent with the expectation that the effects of exposure to the policy on cognitive persistence are indeed more prominent among financially challenged households. As such, we may infer that children of households with limited

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[20] Another plausible explanation is that in more developed areas, children might be more likely to reach the maximum scores in the cognition tests so that the effect of the Free Education Policy on the intergenerational cognitive mobility might be underestimated. To exclude this explanation, we estimate a Tobit model and the results are similar.

[21] In another test (not tabulated), we examine whether the significant results are due to the unbalanced sample sizes of the two subsamples. We randomly draw 730 observations from the sample of children with a sibling and calculate the bootstrap standard errors, and the inference remains unchanged.

[22] Even though all the children in our sample were born after the One Child Policy initiated in 1979, but since our sample is from rural China where more than one Child is allowed if the first one is a girl, it is difficult to determine whether the effect of the fertility decisions on the number of children is purely an exogenous policy effect.

financial resources tend to benefit more from the policy through enhanced cognitive skills.

The relaxation of budget constraints may directly increase parents' financial investment in children's development and therefore may increase the cognition of children (Dahl and Lochner, 2012). Another indirect channel is that children are more likely to stay at school,[23] as parents can afford more education costs (decrease the opportunity cost if children go to school), and therefore, their cognitive skills increase accordingly (Scott et al., 2022). The alleviation of budget constraints may also weaken the intergenerational cognitive persistence indirectly through better nutrition and health, and therefore learning ability of the children (e.g., Glewwe et al., 2001; Felnald and Hidrobo, 2011; Macours et al. 2012).[24] Owing to data constraints, we are unable to disentangle these different underlying channels further. Nevertheless, we believe that multiple channels are possible through which the alleviation of budget constraints affects the persistence of IGT.

4.3 Social contact

Social interaction is crucial to the development of a child's cognitive ability (Kuhl et al., 2003). Enhancing students' social contact is another way that public education promotes cognitive mobility, particularly for children from disadvantaged families who would otherwise have fewer opportunities to attend school and interact with classmates.

Although we cannot observe sample children's social interaction during their school years, we can observe their later social behavior in the survey year. We construct a variable to serve as a proxy for a child's social contact using data on the child's time utilization from the CFPS 2010 survey. Specifically, $Social\_Time_{iptm}$ measures the average hours an individual spends

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[23] In the untabulated results, we did find that higher budget constraints lead to less education while policy exposure mediates this negative effect.

[24] For example, Glewwe et al. (2001) suggest that investment in nutrition could improve academic achievement through greater learning productivity per year of schooling. Felnald and Hidrobo (2011) provides evidence for significant benefits of an unconditional cash transfer program for language development in very young children in rural areas where children are more likely to have received vitamin A or iron supplementation because of cash transfer. In the work of Macours et al. (2012), they also find changes in the consumption of food as intermediate inputs into the production of child development.

in social communication and social service. The same framework as in Section 4.1.1 is adopted to estimate the heterogeneous effects of policy exposure on children's social contact on the basis of the cognitive skills of their parents. According to Table 10, exposure to public education enhances a child's social contacts, with the effect being greater for children whose parents have lower-level cognitive skills. As social interaction is important for cognitive development, we may plausibly consider that the effect of the Free Education Policy on reducing cognitive persistence could occur through increased social contact among children. Still, we need to be cautious in interpreting this channel. Since we only have social interactions during adulthood rather than childhood, the variable could be endogenous as it can be the outcome of enhanced cognitive skills rather than the cause of cognitive skill.

[Table 10 near here]

5. Robustness Check

5.1 Cognition test scores

For the robustness check, we first try alternative measurements of cognitive skills. In the main analysis, we examine cognitive mobility as measured by word and math tests, and we study the father and mother independently. In the first test of robustness, we include both fathers' and mothers' cognitive test scores in the same equation. The results show that the effects of the Free Education Policy on the correlation between children's and fathers' cognitive skills are similar, whereas the effect on the correlation between the cognitive skills of children and mothers becomes slightly smaller, indicating that the policy has a greater effect on enhancing intergenerational mobility between children and fathers. This result is presented in Panel A of Appendix Table 3. In the second robustness check, parents' cognitive skills are measured by averaging their word and math test scores, as well as by averaging fathers' and mothers' cognitive scores.[25] Whether cognitive skill is measured by the average of word and math tests or the average of the father's and mother's test scores, the effects of policy exposure on improving cognitive mobility are similar.[26]

In addition, as the cognition tests in the CFPS have upper bounds, one concern is that the effect of the Free Education Policy on the intergenerational transmission of cognitive skills might be biased if many children obtained the highest scores. In our sample, only approximately 5 percent of the children achieved the top scores, and we adopt Tobit models with right censoring at the top score. The results in Appendix Table 3 Panel B indicate that the main results are robust with respect to right censoring.

5.2 Heterogeneity in the staggered DID design

Several recent studies highlighted the issue of heterogeneous treatment effects in the staggered DID framework, where multiple periods are observed before and after treatment (Goodman-Bacon, 2021; de Chaisemartin and D'Haultfœuille, 2020). In our setting, as the Free Education Policy was rolled out in different semesters from 2006 to 2007, we conduct two tests to verify whether our main findings are affected by this issue.

In the first test, we exclude observations from only the staggered periods. In our setting, the treated group contains children who were 15 years old and younger when the policy took place, and the untreated group contains children aged 16 years and older; thus, we exclude those aged 15 to 17 years (who were born in 1990 and 1991, accounting for 17% of the total sample) to ensure that there is no "bad control" group in the regression. The results still hold when we exclude these observations (see Panel A of Appendix Table 4). In the second test, we use the subsamples of children from areas where the policy took place in either 2006 or 2007 so that in the two subsamples, there is no treatment effect heterogeneity, and the DID estimators

[25] Before calculating averages, age-standardization is performed on all cognitive scores.
[26] The results are not tabulated and are available upon request.

are unbiased. The results listed in Appendix Table 4 Panels B and C show that the subsamples of either 2006 or 2007 are qualitatively similar to the baseline results.

6. Conclusions

While it is highly acknowledged that there exists a strong and persistent correlation between parents' and children's cognitive skills, our understanding of whether and how the persistency of such correlation can be shaped is still limited. In particular, there is little direct evidence on the impact of a specific public policy on the transmission of cognitive skills between parents and children. Using nationally representative data from the China Family Panel Studies, this paper investigates the effect of the Free Education Policy on the intergenerational transmission of cognitive skills in rural China. Taking advantage of the fact that the reform was implemented gradually at different times across different provinces, we use difference-in-differences estimation. We find that this education policy reform has significant impacts on intergenerational mobility of cognitive skills. Specifically, an additional semester of exposure to free education reduces the intergenerational transmission of parent and child cognitive scores by an approximately 1% standard deviation in rural China, indicating a reduction of 3.5% in intergenerational cognitive persistence.

A further exploration of the possible channels suggests that the improvement in cognitive mobility across generations might be attributed to enhanced educational attainment, the relaxation of budget constraints, and increased social contact for children of disadvantaged households whose parents have lower cognitive skills. However, our analysis of the underlying mechanisms driving the policy effect is explorative and indirect. Given the data availability, our study is unable to identify the mechanism causally or disentangle the relative contribution of each channel. Future studies may consider formally testing the causal relationship of each channel with proper data.

Our study contributes to a deeper understanding of intergenerational mobility, with important implications for potential policy solutions to improve it. For a society with widening inequality, promoting economic opportunities and enhancing social mobility are crucial for the design of public policy. We demonstrate that the public policy of Free Education enacted in 2006 in rural China has a substantial effect on the cognitive development of children of disadvantaged families, hence reducing the persistence of intergenerational inequality. Future efforts may consider ensuring adequate financial resources and increasing the affordability of education for disadvantaged families by offering education subsidies or loans to poor families, for example.

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Figures and Tables

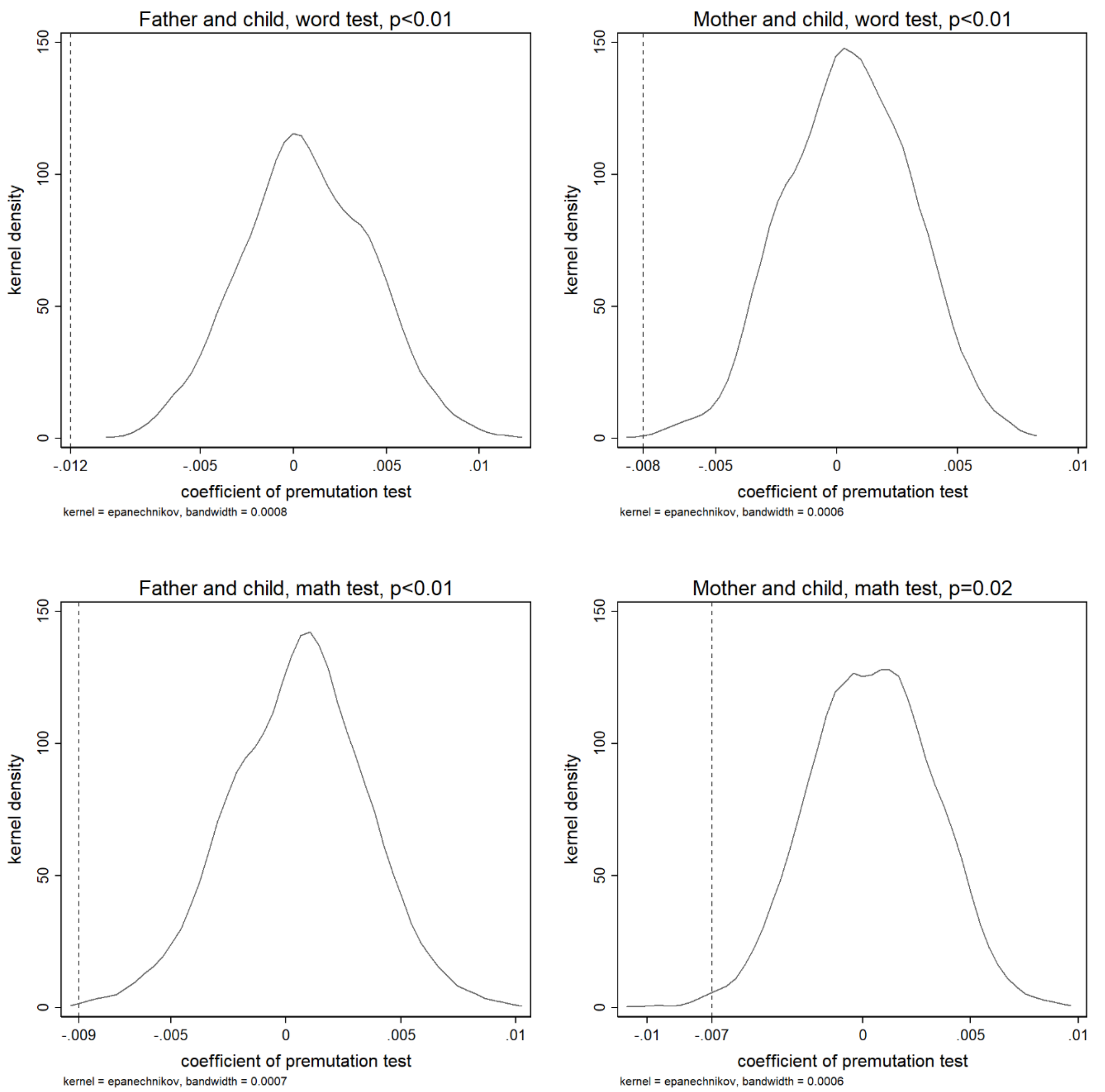

Figure 1 Free Education and Intergenerational Transmission of Cognition: Permutation Test

Source: CFPS 2010, 2014, 2018.

Notes: The figures show the distribution of 1,000 coefficients based on simulated "random" policy exposure. The dashed line indicates the actual effect of policy exposure on intergenerational cognitive transmission from the results in Table 3.

Table 1 Descriptive Statistics

VARIABLES	Obs.	Mean	SD	Min	Median	Max
Dependent variables						
Child's word test (raw scores)	4866	25.60	7.32	0.00	28.00	34.00
Child's math test (raw scores)	4866	15.32	5.52	0.00	16.00	24.00
Independent variables						
Father's word test (raw scores)	4866	17.30	9.15	0.00	20.00	34.00
Father's math test (raw scores)	4866	9.64	5.26	0.00	10.00	24.00
Mother's word test (raw scores)	4866	13.34	10.12	0.00	14.00	34.00
Mother's math test (raw scores)	4866	6.81	5.25	0.00	7.00	24.00
Exposure	4866	5.81	5.98	0.00	5.00	18.00
Year of birth	4866	1993	4.00	1985	1993	2002
Male	4866	0.55	0.50	0.00	1.00	1.00
Ethnicity (1=Hanzu)	4866	0.89	0.32	0.00	1.00	1.00
Father's age	4866	47.33	5.63	33.00	47.00	77.00
Mother's age	4866	45.75	5.28	30.00	45.00	83.00
Father's education						
No schooling	4866	0.22	0.42	0.00	0.00	1.00
Primary school	4866	0.29	0.45	0.00	0.00	1.00
Junior high school	4866	0.37	0.48	0.00	0.00	1.00
Senior high school	4866	0.11	0.31	0.00	0.00	1.00
College and above	4866	0.01	0.11	0.00	0.00	1.00
Mother's education						
No schooling	4866	0.42	0.49	0.00	0.00	1.00
Primary school	4866	0.29	0.45	0.00	0.00	1.00
Junior high school	4866	0.24	0.43	0.00	0.00	1.00
Senior high school	4866	0.04	0.20	0.00	0.00	1.00
College and above	4866	0.01	0.07	0.00	0.00	1.00

Source: CFPS 2010, 2014, 2018.

Table 2 Intergenerational Transmission of Cognition

	(1)	(2)
VARIABLES	Child's word test	Child's math test
Father's word (math) test	0.213***	0.219***
	(0.020)	(0.026)
Mother's word (math) test	0.251***	0.244***
	(0.018)	(0.025)
Exposure	0.057**	0.054**
	(0.023)	(0.022)
Male	-0.192***	-0.128***
	(0.026)	(0.025)
Ethnicity (1=Hanzu)	0.300***	0.275***
	(0.059)	(0.053)
Father's age	-0.008	-0.012***
	(0.005)	(0.005)
Mother's age	-0.006	-0.002
	(0.005)	(0.005)
Father's education (no schooling as baseline)		
Primary school	0.039	0.126***
	(0.042)	(0.040)
Junior high school	0.015	0.022
	(0.044)	(0.048)
Senior high school	-0.061	-0.077
	(0.056)	(0.072)
College and above	0.193**	-0.110
	(0.089)	(0.121)
Mother's education (no schooling as baseline)		
Primary school	-0.043	0.106***
	(0.036)	(0.035)
Junior high school	-0.046	-0.030
	(0.040)	(0.048)
Senior high school	-0.049	-0.007
	(0.064)	(0.083)
College and above	-0.445**	-0.230
	(0.192)	(0.179)
Cohort FE & Birth month FE	YES	YES
Province FE	YES	YES
Province-specific time trends	YES	YES
Survey year FE	YES	YES
Observations	4,866	4,866
R-squared	0.229	0.209

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. In Column (1), the independent variables are the father's and mother's age-standardized word test scores, whereas in Column (2), they are the father's and mother's age-standardized math test scores. * p<0.1; ** p<0.05; *** p<0.01.

Table 3 Free Education and Intergenerational Transmission of Cognition: Main Results

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	**-0.012***		**-0.009***	
	(0.003)		**(0.003)**	
Father's word (math) test	0.340***		0.297***	
	(0.025)		(0.029)	
Mother's word (math) test * Exposure		**-0.008***		**-0.007***
		(0.002)		**(0.002)**
Mother's word (math) test		0.348***		0.315***
		(0.023)		(0.028)
Exposure	0.065***	0.058**	0.054**	0.048**
	(0.023)	(0.023)	(0.022)	(0.022)
Male	-0.203***	-0.194***	-0.132***	-0.132***
	(0.026)	(0.026)	(0.026)	(0.026)
Ethnicity (1=Hanzu)	0.359***	0.355***	0.326***	0.309***
	(0.060)	(0.059)	(0.054)	(0.054)
Father's age	-0.010**	-0.003	-0.014***	-0.008
	(0.005)	(0.005)	(0.005)	(0.005)
Mother's age	-0.002	-0.008	0.002	-0.004
	(0.006)	(0.005)	(0.005)	(0.005)
Father's education (no schooling as baseline)				
Primary school	0.039	0.177***	0.123***	0.224***
	(0.043)	(0.041)	(0.040)	(0.039)
Junior high school	-0.012	0.242***	-0.006	0.302***
	(0.045)	(0.039)	(0.048)	(0.038)
Senior high school	-0.107*	0.269***	-0.120*	0.401***
	(0.057)	(0.048)	(0.073)	(0.048)
College and above	0.115	0.562***	-0.150	0.382***
	(0.087)	(0.086)	(0.115)	(0.105)
Mother's education (no schooling as baseline)				
Primary school	0.166***	-0.053	0.231***	0.107***
	(0.033)	(0.037)	(0.033)	(0.035)
Junior high school	0.285***	-0.077*	0.328***	-0.065
	(0.034)	(0.041)	(0.035)	(0.048)
Senior high school	0.400***	-0.127**	0.554***	-0.067
	(0.056)	(0.065)	(0.062)	(0.083)
College and above	0.071	-0.512**	0.364**	-0.224
	(0.195)	(0.211)	(0.172)	(0.179)
Cohort FE & Birth month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Province-specific time trends	YES	YES	YES	YES
Survey year FE	YES	YES	YES	YES
Observations	4,866	4,866	4,866	4,866
R-squared	0.202	0.211	0.195	0.197

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. In Columns (1) and (2), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (3) and (4), they are fathers' and mothers' age-standardized math test scores.
* $p<0.1$; ** $p<0.05$; *** $p<0.01$.

Table 4 Placebo Test: Older Cohorts

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	**-0.004**		**-0.000**	
	(0.003)		**(0.003)**	
Father's word (math) test	0.266***		0.183***	
	(0.046)		(0.046)	
Mother's word (math) test * Exposure		**0.006***		**0.005**
		(0.003)		**(0.003)**
Mother's word (math) test		0.129***		0.134***
		(0.049)		(0.050)
Exposure	0.061	0.053	0.019	0.026
	(0.038)	(0.036)	(0.037)	(0.035)
Control variables	YES	YES	YES	YES
Cohort FE & Birth month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Province-specific time trends	YES	YES	YES	YES
Survey year FE	YES	YES	YES	YES
Observations	3,247	3,272	3,247	3,273
R-squared	0.182	0.176	0.188	0.189

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. In Columns (1) and (2), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (3) and (4), they are fathers' and mothers' age-standardized math test scores. The control variables include children's gender and ethnicity and parents' age and educational level.
* p<0.1; ** p<0.05; *** p<0.01.

Table 5 Placebo Test: Urban Sample

VARIABLES	(1) Child's word test	(2) Child's math test	(3) Child's word test	(4)	(5) Child's math test	(6)
Father's word (math) test * Exposure			**0.000**		**-0.002**	
			(0.004)		**(0.004)**	
Father's word (math) test	0.118***	0.118***	0.158***		0.132***	
	(0.026)	(0.036)	(0.032)		(0.043)	
Mother's word (math) test * Exposure				**0.003**		**0.003**
				(0.003)		**(0.003)**
Mother's word (math) test	0.156***	-0.003		0.176***		-0.002
	(0.026)	(0.036)		(0.029)		(0.040)
Exposure	-0.062***	-0.066**	-0.067***	-0.058**	-0.064**	-0.066**
	(0.024)	(0.028)	(0.024)	(0.024)	(0.028)	(0.028)
Control variables	YES	YES	YES	YES	YES	YES
Cohort FE & Birth month FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Province-specific time trends	YES	YES	YES	YES	YES	YES
Survey year FE	YES	YES	YES	YES	YES	YES
Observations	1,662	1,662	1,662	1,662	1,662	1,662
R-squared	0.188	0.196	0.167	0.177	0.197	0.191

Source: CFPS 2010, 2014, 2018.

Notes: Robust standard errors are in parentheses. In Columns (1), (3), and (4), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (2), (5), and (6), they are fathers' and mothers' age-standardized math test scores. The control variables include children's gender and ethnicity and parents' age and educational level.

* p<0.1; ** p<0.05; *** p<0.01.

Table 6 Free Education and the IGT of Cognition: Mechanism of Educational Attainment

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Child's years of schooling		Completing junior high school		Completing senior high school	
Father high cognition * Exposure	**-0.065*****		**-0.005*****		**-0.007*****	
	(0.012)		**(0.002)**		**(0.002)**	
Father high cognition	0.803***		0.095***		0.066***	
	(0.131)		(0.018)		(0.021)	
Mother high cognition * Exposure		**-0.069*****		**-0.004****		**-0.007*****
		(0.012)		**(0.002)**		**(0.002)**
Mother high cognition		1.067***		0.089***		0.118***
		(0.136)		(0.018)		(0.022)
Exposure	0.100	0.122*	0.010	0.010	-0.012	-0.01
	(0.072)	(0.072)	(0.010)	(0.010)	(0.011)	(0.011)
Control variables	YES	YES	YES	YES	YES	YES
Cohort FE & Birth month FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Province-specific time trends	YES	YES	YES	YES	YES	YES
Survey year FE	YES	YES	YES	YES	YES	YES
Observations	4,866	4,866	4,866	4,866	4,866	4,866
R-squared	0.285	0.289	0.186	0.186	0.275	0.278

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. The father (or mother) is considered to have high cognition if his (or her) average scores on the age-standardized word and math cognitive tests exceed the sample median. The control variables include children's gender and ethnicity and parents' age and educational level.
* p<0.1; ** p<0.05; *** p<0.01.

Table 7 Free Education and Children's Years of School: Gender Heterogeneity

	(1)	(2)	(3)	(4)
	Boys		Girls	
VARIABLES	Dependent variable: Child's years of school			
Father high cognition * Exposure	**-0.074***		**-0.050***	
	(0.016)		**(0.017)**	
Father high cognition	0.864***		0.693***	
	(0.172)		(0.203)	
Mother high cognition * Exposure		**-0.061***		**-0.078***
		(0.016)		**(0.019)**
Mother high cognition		1.007***		1.107***
		(0.183)		(0.206)
Exposure	0.134	0.124	0.123	0.190*
	(0.093)	(0.092)	(0.114)	(0.113)
Control variables	YES	YES	YES	YES
Cohort FE & Birth month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Province-specific time trends	YES	YES	YES	YES
Survey year FE	YES	YES	YES	YES
Observations	2,191	2,191	2,675	2,675
R-squared	0.343	0.349	0.268	0.269

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. The father (or mother) is considered to have high cognition if his (or her) average scores on the age-standardized word and math cognitive tests exceed the sample median. The control variables include children's gender and ethnicity and parents' age and educational level.
* p<0.1; ** p<0.05; *** p<0.01.

Table 8 Free Education and Children's Years of School: Regional Heterogeneity

	(1)	(2)	(3)	(4)
	Low fiscal expenditure		High fiscal expenditure	
VARIABLES	Dependent variable: Child's years of school			
Father high cognition * Exposure	**-0.084*** **		**-0.032** **	
	(0.017)		**(0.016)**	
Father high cognition	1.004***		0.534***	
	(0.200)		(0.175)	
Mother high cognition * Exposure		**-0.084*** **		**-0.048*** **
		(0.017)		**(0.017)**
Mother high cognition		1.324***		0.827***
		(0.203)		(0.183)
Exposure	0.013	0.013	0.110	0.152
	(0.103)	(0.100)	(0.102)	(0.103)
Control variables	YES	YES	YES	YES
Cohort FE & Birth month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Province-specific time trends	YES	YES	YES	YES
Survey year FE	YES	YES	YES	YES
Observations	2,555	2,555	2,311	2,311
R-squared	0.309	0.314	0.251	0.254

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. The father (or mother) is considered to have high cognition if his (or her) average scores on the age-standardized word and math cognitive tests exceed the sample median. The control variables include children's gender and ethnicity and parents' age and educational level. The *Low/High fiscal expenditure* columns refer to provinces with government fiscal expenditures on education in 2005 that were lower/higher than the sample median.
* p<0.1; ** p<0.05; *** p<0.01.

Table 9 Free Education and the IGT of Cognition: Mechanism of Budget Constraints

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable=	Child's word test		Child's math test		Child's word test		Child's math test	
Parental=	Father	Mother	Father	Mother	Father	Mother	Father	Mother
Panel A: household assets	Low household asset in 2010				High household asset in 2010			
Parental word (math) test * Exposure	-0.015***	-0.012***	-0.010***	-0.010***	-0.010**	-0.005	-0.006	-0.006
	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
Observations	2,348	2,348	2,348	2,348	2,037	2,037	2,037	2,037
Panel B: provincial GDP per capita	Low provincial GDP in 2005				High provincial GDP in 2005			
Parental word (math) test * Exposure	-0.016***	-0.009***	-0.010***	-0.005	-0.008*	-0.006	-0.006	-0.010***
	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
Observations	2,657	2,657	2,657	2,657	2,209	2,209	2,209	2,209
Panel C: sibling child vs. only child	Child with sibling				Only child			
Parental word (math) test * Exposure	-0.012***	-0.009***	-0.009***	-0.009***	-0.009	0.003	-0.006	0.001
	(0.003)	(0.002)	(0.003)	(0.003)	(0.007)	(0.006)	(0.006)	(0.005)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
Observations	4,136	4,136	4,136	4,136	730	730	730	730

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. In Columns (1), (2), (5), and (6), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (3), (4), (7), and (8), they are fathers' and mothers' age-standardized math test scores. We control for cohort FE, birth month FE, province FE, province-specific time trends, survey year FE, and other control variables for all the regressions. The control variables include children's gender and ethnicity, and parents' age and educational level. The *Low/high household assets in 2010* columns refer to household assets per capita of children in 2010 lower/higher than the sample median. The *Low/High provincial GDP in 2005* columns refer to provinces whose local GDP per capita in 2005 was lower/higher than the sample median.
* p<0.1; ** p<0.05; *** p<0.01.

Table 10 Free Education and the IGT of Cognition: Mechanism of Children's Social Contact

	(1)	(2)
VARIABLES	Child's time of social contact and social service	
Father high cognition * Exposure	**-0.015****	
	(0.007)	
Father high cognition	-0.003	
	(0.035)	
Mother high cognition * Exposure		**-0.013***
		(0.008)
Mother high cognition		0.053
		(0.036)
Exposure	0.026	0.022
	(0.024)	(0.025)
Control variables	YES	YES
Cohort FE & Birth month FE	YES	YES
Province FE	YES	YES
Province-specific time trends	YES	YES
Survey year FE	YES	YES
Observations	1,895	1,895
R-squared	0.099	0.099

Source: CFPS 2010.

Notes: Robust standard errors are in parentheses. The father (or mother) is considered to have high cognition if his (or her) average scores on the age-standardized word and math cognitive tests exceed the sample median. The control variables include children's gender and ethnicity, and parents' age and educational level.

* p<0.1; ** p<0.05; *** p<0.01.

Appendix Tables

Appendix Table 1 Implementation Dates of Free Education Policy in Each Province

Province	Implementation date
Fujian	2006.3
Gansu	2006.3
Guangxi	2006.3
Guizhou	2006.3
Shaanxi	2006.3
Shanghai	2006.3
Sichuan	2006.3
Tianjin	2006.3
Yunnan	2006.3
Beijing	2006.9
Guangdong	2006.9
Jiangsu	2006.9
Zhejiang	2006.9
Anhui	2007.3
Chongqing	2007.3
Hebei	2007.3
Heilongjiang	2007.3
Henan	2007.3
Hubei	2007.3
Hunan	2007.3
Jiangxi	2007.3
Jilin	2007.3
Liaoning	2007.3
Shandong	2007.3
Shanxi	2007.3

Source: Tang et al. (2020).

Appendix Table 2 Controlling for Confounding Factors

Panel A: provincial characteristics in 2005

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.010***		-0.009***	
	(0.003)		(0.003)	
Mother's word (math) test * Exposure		-0.007***		-0.007***
		(0.002)		(0.003)
Cohort dummy*Provincial characteristics in 2005	YES	YES	YES	YES
Other control variables	YES	YES	YES	YES
Observations	4,866	4,866	4,866	4,866

Panel B: 1986 Compulsory Educational Law in China (CELC)

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.013***		-0.012***	
	(0.003)		(0.003)	
Mother's word (math) test * Exposure		-0.007**		-0.010***
		(0.003)		(0.003)
Parental word (math) test * Parental Exposure_CELC	YES	YES	YES	YES
Other control variables	YES	YES	YES	YES
Observations	4,856	4,840	4,856	4,840

Panel C: school closures and mergers

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.013***		-0.012***	
	(0.003)		(0.003)	
Mother's word (math) test * Exposure		-0.007**		-0.010***
		(0.003)		(0.003)
Cohort dummy*school closures and mergers	YES	YES	YES	YES
Other control variables	YES	YES	YES	YES
Observations	4,866	4,866	4,866	4,866

Source: CFPS 2010, 2014, 2018.

Notes: Robust standard errors are in parentheses. In Columns (1) and (2), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (3) and (4), they are fathers' and mothers' age-standardized math test scores. We control for cohort FE, birth month FE, province FE, province-specific time trends, survey year FE, and other control variables for all the regressions. In Panel A, provincial characteristics in 2005 are measured by GDP per capita, the ratio of rural residents, and the population in 2005. The control variables include exposure, children's gender and ethnicity and parents' age and educational level.

* p<0.1; ** p<0.05; *** p<0.01.

Appendix Table 3 Robustness Check: Other Regression Specifications

Panel A: including both father's and mother's cognitive skills

	(1)	(2)
VARIABLES	Child's word test	Child's math test
Father's word (math) test * Exposure	-0.010***	-0.007**
	(0.003)	(0.003)
Mother's word (math) test * Exposure	-0.005**	-0.004
	(0.002)	(0.003)
Other control variables	YES	YES
Observations	4,866	4,866

Panel B: Tobit model

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.013***		-0.008***	
	(0.003)		(0.003)	
Mother's word (math) test * Exposure		-0.009***		-0.006**
		(0.002)		(0.003)
Other control variables	YES	YES	YES	YES
Observations	4,866	4,866	4,866	4,866

Source: CFPS 2010, 2014, 2018.

Notes: Robust standard errors are in parentheses. In Panel A, in Column (1), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Column (2), they are fathers' and mothers' age-standardized math test scores.

In Panel B, in Columns (1), (3) and (4), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (2), (5), and (6), they are fathers' and mothers' age-standardized math test scores. We control for cohort FE, birth month FE, province FE, province-specific time trends, survey year FE, and other control variables for all the regressions. The control variables include exposure, children's gender and ethnicity and parents' age and educational level.

* p<0.1; ** p<0.05; *** p<0.01.

Appendix Table 4 Robustness Check: Heterogeneity of Staggered DID

Panel A: excluding sample in staggered periods

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.011***		-0.008**	
	(0.003)		(0.003)	
Mother's word (math) test * Exposure		-0.007***		-0.006**
		(0.002)		(0.003)
Other control variables	YES	YES	YES	YES
Observations	4,030	4,030	4,030	4,030

Panel B: reform year is 2006

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.010***		-0.009**	
	(0.004)		(0.004)	
Mother's word (math) test * Exposure		-0.009***		-0.010***
		(0.003)		(0.003)
Other control variables	YES	YES	YES	YES
Observations	2,360	2,360	2,360	2,360

Panel C: reform year is 2007

	(1)	(2)	(3)	(4)
VARIABLES	Child's word test		Child's math test	
Father's word (math) test * Exposure	-0.014***		-0.010**	
	(0.004)		(0.004)	
Mother's word (math) test * Exposure		-0.006		-0.004
		(0.004)		(0.004)
Other control variables	YES	YES	YES	YES
Observations	2,506	2,506	2,506	2,506

Source: CFPS 2010, 2014, 2018.
Notes: Robust standard errors are in parentheses. In Columns (1) and (2), the independent variables are fathers' and mothers' age-standardized word test scores, whereas in Columns (3) and (4), they are fathers' and mothers' age-standardized math test scores. We control for cohort FE, birth month FE, province FE, province-specific time trends, survey year FE, and other control variables for all the regressions. The control variables include exposure, children's gender and ethnicity and parents' age and educational level.
* p<0.1; ** p<0.05; *** p<0.01.