Sibling Spillovers in Rural China: A Story of Sisters *

Cynthia Bansak† Xuan Jiang‡ Guanyi Yang§

September 6, 2021

Abstract

We study sibling spillover effects on the school performance of the elder sibling from the younger sibling using data on multi-children households in rural China. We use the variation in the younger sibling's schooling status to parse out the spillover effects and exploit the arbitrary school enrollment eligibility cutoff dates imposed by the Chinese Law of Compulsory Education as exogenous variation in the timing of school enrollment. We find a significant increase in school test scores of elder siblings when their younger siblings begin school. The strongest spillover effects occur when the younger sibling is a girl. Such increases in test scores come from a more intense academic atmosphere within a household when both children enroll in school and are not attributed to differential parental education investments or attitudes. Our findings suggest that policies promoting girls' education, pre-elementary school age education programs, and after school public resources can have multiplier effects through sibling spillovers.

JEL classification: E24, C68, J30.

Keywords: Human capital, peer effect, sibling spillover, rural China, sisters, girls, school enrollment, intra-household allocation, intra-household externality.

*We thank Shan Li, Zhiqiang Liu, Daniel Millimet, Juan Pedroza, Yang Song, and Xianfang Xiong for helpful comments on earlier drafts of this paper as well as participants at the 2020 CHLR International Symposium on Human Capital and Labor Markets, the 2020 SEA conference, and the 2019 APPAM meeting.

†Bansak: cbansak@stlawu.edu. Department of Economics, St. Lawrence University

‡Jiang: jiang.445@osu.edu. Department of Economics, The Ohio State University

§Yang: gyang@ColoradoCollege.edu. Department of Economics & Business, Colorado College

1 Introduction

Investment in children's human capital has lifetime impacts. Childhood interventions can reduce inequalities and promote intergenerational mobility (e.g. Keane and Wolpin, 1997; Heckman, 2008; Black, Devereux, et al., 2011; Huggett, Ventura, and Yaron, 2011; Yang, 2021). Despite the importance of investing in children, most of our understanding of children's human capital production is limited to observations at the household level and from parental resource allocations to their children (e.g. Yang and Bansak, 2020; Del Boca, Flinn, and Wiswall, 2013; Ramey and Ramey, 2010; Guryan, Hurst, and Kearney, 2008; Blau and Currie, 2006; Blau, 1999). This paper extends the analysis to *within household* dynamics and investigates an externality between siblings on school performance in multi-children households in rural China.

We find that an elder child's school performance improves significantly when their younger sibling begins school. The increase in school performance does not rely on changes of family resources allocated to the elder sibling, but results from a positive externality from the younger sibling's studying to the elder sibling's academic achievements. We refer to this externality as a sibling spillover effect. This positive spillover effect differs across sibling gender-pairs, and is the strongest among children with a younger sister. To the best of our knowledge, we are the first to examine a spillover effect in school performance from the younger sibling to an elder sibling.

The biggest challenge in identifying the sibling spillover is to disentangle it from factors outside of the sibship (or common family factors) and to identify the direction of impact between siblings.[1] We use the variation in the younger sibling's schooling status (started school or not) to parse out the impact of spillover effects *from the younger sibling to the elder one*. We exploit the arbitrary birth date cutoff imposed by the Chinese Law of Compulsory Education as an exogenous variation in schooling status. The law stipulates that children

[1] As Black, Breining, Figlio, Guryan, Karbownik, Nielsen, Roth, and Simonsen (2017) review, siblings growing up in the same household are the ultimate peers, sharing the same parents, similar genetics and experiences.

must be at least 6 years old or above on August 31st to be admitted into elementary school in the new school year. This arbitrary day of birth cutoff generates exogenous variations in the younger sibling's eligibility of school enrollment, allowing us to attribute changes in the elder sibling's school performance to that of the enrollment of younger sibling.

We use data from the Rural Household Survey (RHS) of the Longitudinal Survey on Rural Urban Migration in China (RUMiC) to conduct our analysis. Having an in-school younger sibling leads to a 6.12 percentage point increase in math scores for a student relative to a same-grade peer who has a younger sibling that is not yet eligible for school. Such an effect remains after controlling for differing gender ratios at the county-level, an approximation of the local son-preference culture[2], and for the annual education expenditures on the student. It is also robust to changes in the younger sibling's age range relative to the older sibling.

When further exploring the gender heterogeneity in sibling spillovers, we find that the second child being a girl creates a stronger effect on the spillover to the elder child's test scores. Having a younger sister in school leads to a 12 percentage point increase on the elder sibling's math score and a 11 percentage point increase on their Chinese score. Meanwhile, when the younger child is a boy, the spillover effect is not statistically significant.

We conjecture that the positive spillover is a result of a positive at-home externality that occurs when both siblings are studying under the same roof. When the younger child begins school, the elder child may experience an increase in sibling studying time relative to sibling play time, a heightened household attention to school performance, or more frequent household discussions on school matters. Elder siblings more exposed to this heightened academic environment at home may see this emphasis on schoolwork translate to a better performance in school. Though difficult to directly measure, we consider siblings with more time at home and a stronger home connection to experience a stronger spillover externality. We approximate the at-home time by investigating the different spillover effects between

[2]Male to female ratio at birth in China reaches the highest point in the first decade of 2000, and it remains high for many years. A major contribution to the imbalanced sex ratio is the son-preference culture (e.g. Jiang and Zhang, 2021; Chen and Zhang, 2019). The survey data we use were conducted in year 2009 and cover younger siblings who were born around the peak of the imbalanced sex ratio.

elder children attending boarding school and elder children attending day school. A child attending boarding school has the least interaction with the siblings at home. As a result, we find that the positive sibling spillover nearly disappears for an elder sibling in boarding school. Additionally, the positive spillover effect also diminishes for elder siblings attending a school that is further away from home compared to those who live closer. To further justify this potential mechanism of the positive spillover effects, we test for changes in parental resource allocation and parental attitudes towards supervision of the elder child when the younger sibling starts school and find no evidence that the increase in the elder child's school performance is due to increased parental resource allocation or change in attention devoted to the older child.

Overall, this paper joins others in providing a new perspective on sibling spillovers. Frameworks providing insight on human capital production among siblings within a family typically take one of three approaches: they assess the quantity-quality trade-off needed with multiple children (e.g. Becker, 1960; Becker and Lewis, 1973; Becker and Tomes, 1976; Blake, 1981; Hanushek, 1992; Liang and Gibson, 2018), they allow for birth order effects (e.g. Black, Grönqvist, and Öckert, 2018; Breining, Doyle, Figlio, Karbownik, and Roth, 2020; Lin, Pantano, and Sun, 2020), and most recently, they look for possible sibling interactions (e.g. Joensen and Nielsen, 2018; Qureshi, 2018; Black et al., 2017; Breining, 2014; Yi, Heckman, Zhang, and Conti, 2015). To date, the literature on sibling spillovers has largely focused on high-income countries and the impact of older children on younger children. We contribute to the literature by studying the spillover effect of younger siblings on the school performance of elder siblings in low income communities[3].

In low income economies, educational resources are often scarce and gender inequality in educational resource allocation tends to be larger (e.g. Ozier, 2018; Attanasio, Baker-Henningham, Bernal, Meghir, Pineda, and Rubio-Codina, 2018; Alsan, 2017; Martinez, Naudeau, and Pereira, 2017). Only one paper we know of has looked at sibling spillovers

[3]The World Bank categorizes China as lower middle income in 2009. The rural China household's average income in 2010 was within the low-income country threshold.

in China and this was on the spillover effect from the older to the younger child (Biavaschi, Giulietti, and Zimmermann, 2015). The findings of our paper reveal a strong sibling spillover in school work, driven by sisters, consistent with the result from Jakiela, Ozier, Fernald, and Knauer (2020). However, they examine the impact from an older sibling to a younger one while we examine the impact of younger sibling on an elder child. Our results suggest that policies geared towards daughters and sisters in low income communities like rural China should produce large spillovers and increases in human capital development over time.

2 Data

We use data from the Rural Household Survey (RHS) to conduct our analysis. The RHS is one of three independent surveys housed under the Longitudinal Survey on Rural Urban Migration in China (RUMiC). The RHS consists of interviews of only rural non-migrant residents, compared to the other two that includes migrants and urban dwellers.[4] We choose the RHS data because it is the most comprehensive data covering a large population in rural China. The survey spans nine provinces: Anhui, Chongqing, Guangdong, Hebei, Henan, Hubei, Jiangsu, Sichuan, and Zhejiang.[5] More importantly, it provides valuable information on the test scores of children in school, which is a reliable measure of school performance of Chinese students.[6] The 2008 and 2009 waves of RHS in RUMiC are the only publicly available waves and we use them to identify geographic information, individual demographic characteristics, family relationships, parental education, parental income, and schooling information for all children under 16 in surveyed households. The 2009 wave contains exam

[4]RUMiC is a collaboration project between the Australian National University, Beijing Normal University and the Institute for the Study of Labor (IZA). RUMiC consists of three independent surveys: the Urban Household Survey (UHS), the Rural Household Survey (RHS) and the Migrant Household Survey (MHS). Each of the three surveys include comprehensive information on household and personal characteristics, detailed health status, employment, income, training and education of adults and children, social networks, family and social relationships, life events, and mental health measures of the individuals.

[5]The data covers about 70 cities from these nine provinces. However, we can't identify city names due to data's confidentiality.

[6]Although self-reported, test scores are likely accurate due to the fact that most Chinese schools give each student a booklet that has their scores recorded for each semester during the school year (Biavaschi et al., 2015; Chen, Huang, Rozelle, Shi, and Zhang, 2014).

scores in Chinese language and math for all in-school children.

Another reason that RUMiC suits our research goals is that it covers a relatively large number of multi-children households. Over a quarter (27 percent) of the children in the RHS of RUMiC live in two-children household, second to single-child families (69 percent), leaving only a small share of children in households with three or more children. We focus our analysis on two-children households and check for the robustness of our main estimates on three-children households.[7]

Our main sample used for the analysis in this paper includes 671 individuals (elder children) from two-children households. Table 1 provides summary statistics split by whether a younger child is in school or not. The top panel of Table 1 describes the average characteristics of the elder child, the subject of interest in our paper. The bottom panel presents the younger child's characteristics and each parent's wage and educational attainment. The key dependent variables for the study are the elder sibling's Chinese score and Math score. We standardize the test scores to percentage terms to remove differences in scaling across locations. Even so, test scores might differ by school grade, school or school district. The RUMiC dataset provides no geographic identification disaggregated below city-level, so we do not observe school or school district information. Instead, we control for children's grade fixed effects, geographic location fixed effects, and family characteristics in all of our analysis to address this concern. The average scores for both Chinese and math are around 80 percent. The average scores are lower for elder siblings from families with a younger child in school. One reason might be that test scores tend to go down as one moves to a higher grade. In our sample, families with both children in school are spending more money on educational expenditures, and are more likely to have the elder sibling in boarding school and in a school further away from home.

We find no statistical difference in mother's and father's wage income between families

[7]Removing the households with more than two children also reduces the concern for the heterogeneity of family size to sibling peer effect (Chen, Chou, Wang, and Zhao, 2019). Our results remain when we relax the sample to include three-children households, accounting for 3 percent of all families in our sample.

Table 1: Summary Statistics

	Younger Sibling Not in School		Younger Sibling in School		
	Obs. 263		**Obs. 408**		
Variable	Mean	SD	Mean	SD	Difference
Elder Sibling:					
Age	11.278	3.022	15.007	2.262	-3.729***
Female	0.658	0.475	0.669	0.471	-0.011
Birthweight	3217.795	427.043	3230.686	447.014	-12.892
Chinese score	81.078	12.378	78.361	12.436	2.717***
Math score	83.069	11.115	80.003	13.219	3.066***
Distance to school (km)	4.521	7.648	10.601	37.584	-6.079**
Boarding school	0.319	0.467	0.519	0.5	-0.200***
Parents' Worry	0.681	0.467	0.686	0.465	-0.006
Annual edu expenses (yuan)	1093.966	2197.67	2060.673	3002.964	-966.707***
Younger Sibling and Parents:					
Younger sib's age	3.973	1.726	11.012	2.903	-7.039***
Younger sib is female	0.388	0.488	0.341	0.475	0.047
Younger sib' birthweight	3307.11	467.977	3284.828	479.934	22.282
Father's wage	1534.422	3213.169	1306.9	1993.444	227.523
Mother's wage	549.156	1959.935	384.064	643.573	165.092
Father Never Been to School	0.011	0.007	0.007	0.004	0.004
Father Literacy Class	0.011	0.006	0.007	0.004	0.004
Father Elementary School	0.122	0.020	0.174	0.019	-0.052*
Father Junior Middle School	0.677	0.0289	0.662	0.023	0.015
Father Senior Middle School	0.122	0.020	0.120	0.016	0.002
Father Specialized Secondary School	0.023	0.009	0.017	0.006	0.006
Father Polytechnic college	0.034	0.011	0.012	0.005	0.021*
Father Undergraduate	0	0	0	0	0
Mother Never Been to School	0.030	0.011	0.029	0.008	0.001
Mother Literacy Class	0.011	0.007	0.017	0.006	-0.006
Mother Elementary School	0.221	0.026	0.301	0.023	-0.081**
Mother Junior Middle School	0.631	0.029	0.603	0.024	0.028
Mother Senior Middle School	0.065	0.015	0.047	0.010	0.018
Mother Specialized Secondary School	0.027	0.010	0.002	0.002	0.024***
Mother Polytechnic college	0.011	0.007	0	0	0.011**
Mother Undergraduate	0.004	0.004	0	0	0.004

Notes: This table presents the summary statistics of the main variables that we used for analysis, separately by the schooling status of the younger siblings. Specifically, in the upper panel, we show the demographic characteristics, school characteristics, test scores, and parents' educational expense and worry of the elder sibling—the individuals of interest in our analysis. In the bottom panel, we show demographic information of the younger sibling, parent's wage and parents' educational attainments. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

with a younger child in school and those with a younger child not enrolled in school. There is no gender or birth-weight differences among elder and younger siblings between the two groups. We also do not find statistical difference in the parental attitude for the elder child, measured as parental worry, between the two groups. There is no significant difference in mother's and father's junior middle school completion rate — the most common educational attainment in our data — between the two groups. This suggests that the children and households with younger siblings are quite similar whether there is a young sibling in school or not.

3 Empirical strategy

We examine the impact of a younger sibling's schooling status on the educational outcomes of their older sibling, and refer to this as the sibship spillover effect. We regress the elder sibling's schooling performance on an indicator of whether the younger sibling is in school and control for a host of demographic and economic characteristics for both siblings, their parents and their location:

$$S_i^E = \alpha + \beta inSchool_i^Y + \Lambda X_i^E + \Gamma X_i^Y + \Pi X_i + \varepsilon_i \quad (1)$$

where E stands for the elder child, and Y stands for the younger child. Thus, S_i^E is the elder sibling's schooling performance, Chinese score or Math score, from household i. The variable $inSchool_i^Y$ is an indicator whether the younger sibling is in school. The coefficient on $inSchool_i^Y$, β, is our main coefficient of interest.

We include a number of controls for both siblings and household characteristics to absorb idiosyncratic variation. X_i^E is a vector of the elder sibling's characteristics, including the elder sibling's birth weight, gender, and grade fixed effects. X_i^Y is a vector of the younger sibling's characteristics, including birth weight, gender, and a linear trend of age. We also control for ethnicity and province fixed effects for the household, both parents' ages, wages, educational attainment, and educational expenses on the elder sibling in X_i.[8] We cluster all standard errors at the city level, the smallest locality level that we can identify.[9]

3.1 Identification

A main concern to the estimate, β, in Equation 3 is that the timing of the younger sibling's school enrollment may not be exogenous. For instance, parents may delay their younger child's schooling due to financial hardship and this may be correlated to the school performance of the elder child. Parents could also experiment on the timing of the younger child's school entrance based on their observation of the older child's performance and consider the age-school relationship in the enrollment decision. To account for such potential endogeneity on the spillover between the younger child's schooling and the older child's test scores, we take advantage of an arbitrary cutoff birth date for compulsory school entry age, stipulated by the Chinese Compulsory Education Law, and implement an instrumental variable indicating the younger child's eligibility to enroll in school based on the policy.

3.1.1 China's compulsory education and education in rural China

China passed its Compulsory Education Law in 1986 with the aim to establish universal education for all school-aged children. The universal education mandates nine years of schooling spanning from elementary school to junior high school.[10] Depriving school-aged children from enrollment by parents is considered a crime. Across China, schools have

[8]We impute zeroes for missing wages of parents and include an indicator for a missing wage in our regressions.

[9]Note that a city is the largest administrative division under a province and it covers both rural and urban areas.

[10]The elementary school enrolls students from age six (grade one) and ends at age twelve (grade six), with a curriculum focusing on Chinese, math and physical education. Urban elementary schools also include music, drawing, science, and morality and ethics. Some advanced urban schools introduce English courses. Junior high schools cover a more comprehensive curriculum, including Chinese, Mathematics, English, Biology, Politics, Geography, History, Physical Education as the main subjects that students have to take mid-term and final exams in each semester. Although we do not have test scores for subjects other than Chinese and math for the junior high students, one could argue that Chinese and math are two of the most important subjects in the sense of how much weight is given to these tests, even in the senior high school exams and college entrance exams.

September 1st as the official first day of a school year. The implementation of the Compulsory Education Law requires that children who have their sixth birthday before August 31st must enroll in an elementary school on September 1st of the same year. Children who reach six years old after August 31st must wait until the following school year for enrollment.

Importantly, the birth date of August 31st becomes an arbitrary cutoff for schooling among six-year-olds. Having a birth date before or after August 31st creates an exogenous variation in school start dates. Fang, Eggleston, Rizzo, Rozelle, and Zeckhauser (2012) document that there were variations in the enforcement of the school starting cutoff date in the early implementation of the Law. However, Zhang and Xie (2018) find that the actual birth date eligible for school entry is now largely in compliance with the August 31st cutoff. Meanwhile, Huang, Zhang, and Zhao (2020) show evidence of birth planning around the school entry date in certain areas. In Figure 1, however, we find that there is no evidence of birth planning around August 31st in our sample. Along these lines, it is also reasonable to assume that the exact birth date of one child is not correlated with the school performance of another child.

It is worth noting that for our data period, before enrolling in elementary school, children in rural China primarily stay within the household with the care and education provided by parents or grandparents rather than through nursery school, kindergarten (also known as "pre-school" in the US context)(Luo, Lyu, Rozelle, and Wang, 2020; Johnstone, Yang, Xue, and Rozelle, 2021; Sylvia, Warrinnier, Luo, Yue, Attanasio, Medina, and Rozelle, 2021). For the rest of this paper, we use the term *pre-school* to refer to the age period before children reach their age limit for elementary school, rather than referring to institutions like kindergarten or nursery school.

3.1.2 Instrumental variable analysis

Incorporating the arbitrary birth-date cutoff, we employ a two-stage estimation procedure using the arbitrary birth-date cutoff as an instrumental variable for the younger child's school

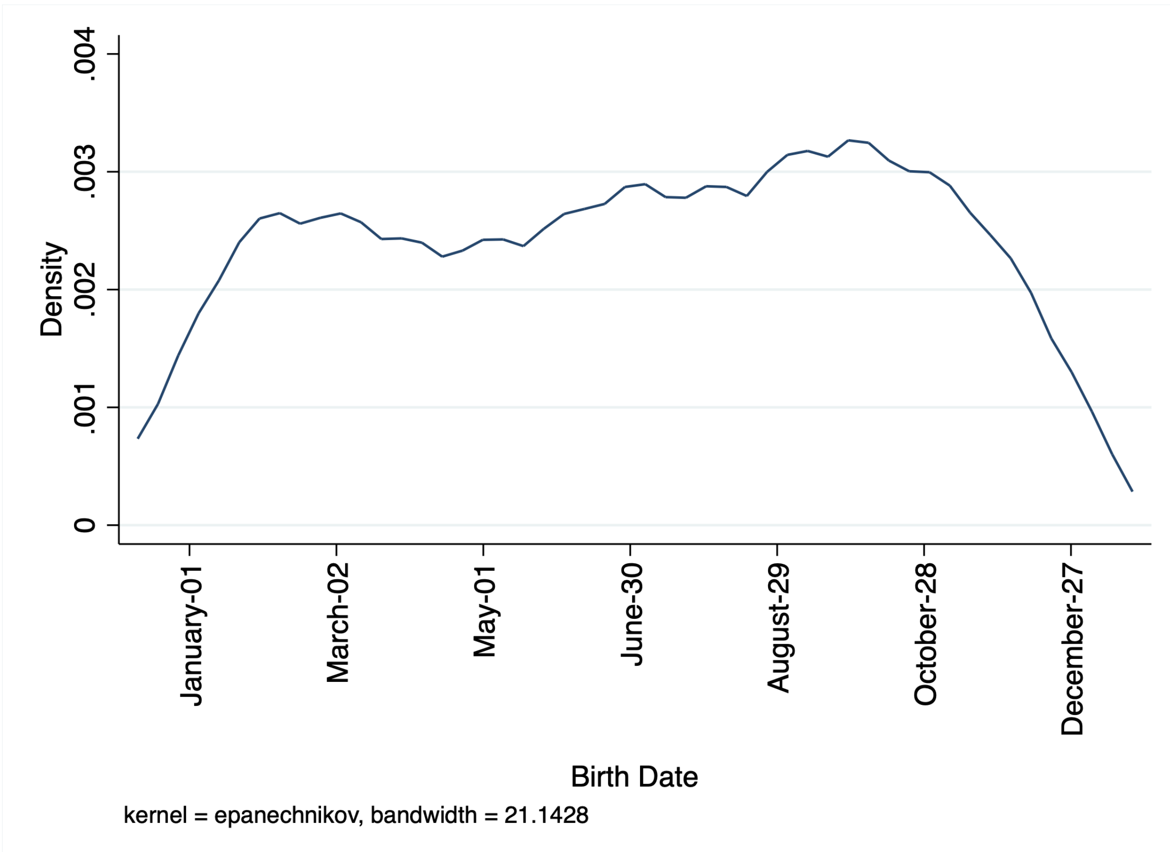

Figure 1: Density of Children's Birth Date

Notes: This figure plots the kernel density of birth dates (month and date) of all younger children in our sample. The purpose of this figure is to show there are no breaks in the density around August and September.

eligibility (or lack thereof). Our first stage estimation is specified as:

$$inSchool_i^Y = \alpha + \theta Ineligible_i^Y + \Lambda X_i^E + \Gamma X_i^Y + \Pi X_i + \varepsilon_i \tag{2}$$

where $Ineligible_i^Y$ is an indicator for the younger sibling's lack of eligibility of enrolling in school. $Ineligible_i^Y = 1$ identifies the younger children who had their sixth birthday after August 31st in the survey year; $Ineligible_i^Y = 0$ otherwise. We use birth date (year, month, date) of the younger child to construct the variable $Ineligible_i^Y$. Thus, θ provides the propensity of a child to be in school. We would expect θ to be negative as a six year old should not be in school if the child was born in the last four months of the year. Our primary parameter of interest then will be β^{IV} from the second stage regression:

$$S_i^E = \alpha + \beta^{IV} \widehat{inSchool}_i^Y + \Lambda X_i^E + \Gamma X_i^Y + \Pi X_i + \varepsilon_i \tag{3}$$

4 Results

In this section, we present our main results, the effects of sibship spillover and the heterogeneity across sibling gender composition. We further explore a potential mechanism associated with the spillover.

4.1 Sibship spillover

We estimate the impact of younger sibling's in-school status on the elder sibling's schooling performance, measured by Chinese and math test scores. We present the results in Table 2. The top panel of Table 2 reports the IV estimation results and the bottom panel presents the OLS estimates for comparison purposes. The odd-numbered columns have the standardized Chinese test score as the outcome variable and the even-numbered columns have the standardized math test score as the outcome variable. We control for the elder sibling's grade fixed effects (capturing both the elder sibling's age and academic standing), both sibling's birth weight (a commonly used proxy for health), a linear trend of the younger sibling's age, family characteristics including ethnicity and province fixed effects, both parent's age, income, and educational attainment in all columns. It is likely that the age distribution of older siblings with a younger child in school may differ from those with younger child not in school. The grade level fixed effects address this concern. Additionally, to tease out the potential confounding effect from the age gap between siblings, we control for it in a robustness check, shown in Table A.3. The results remain unchanged. Our instrument is strong, with a Kleibergen-Paap rk Wald F-statistic of 140 for our baseline model. We present our first-stage estimates in Table A.2.

The estimates in columns (1) and (2) of Table 2 show that having the younger sibling enrolled in school improves the elder child's test scores in mathematics by 5.86 percentage points, and it is statistically significant at the 5% level. The impact on the Chinese score has a relatively smaller magnitude and is not statistically significant.

Columns (3) and (4) add both sibling's gender and a county-level girl ratio to capture potential gender-specific educational resource allocation based on a son-preference culture rooted in rural China.[11] We approximate son preference by exploring the shares of girls in each county. The county-level girl ratio is calculated by using the total number of girls under the age of 18 divided by the total number of children under the age of 18. The estimates of interest are highly consistent with the ones in columns (1) and (2). We further control for the log of annual educational expenses spent on the elder sibling in Columns (5) and (6), capturing the possibility for parents to switch the allocation of resource dedicated to the elder sibling when the younger one begins school. This is our preferred specification and we find that having an in-school younger sibling will have a positive, but not significant, effect on Chinese test scores and a 6.12 percentage point significant increase in math scores for an

[11]A substantial literature documents the son-preference culture in Asian communities and its impact on resource allocation to children of opposite genders (e.g. Blau, Kahn, Brummund, Cook, and Larson-Koester, 2020; Kaul, 2018; Hong Chew, Yi, Zhang, and Zhong, 2017; Das Gupta, Zhenghua, Bohua, Zhenming, Chung, and Hwa-Ok, 2003). During the time of our survey data were collected, son-preference still prevailed, shown by the peak of the imbalanced sex ratio in China.

Table 2: Sibling Spillover Effects

	(1) Chinese	(2) Math	(3) Chinese	(4) Math	(5) Chinese	(6) Math
IV Estimates:						
Younger Sib in School	3.592	5.857**	3.610	5.856**	3.799	6.115**
	(2.333)	(2.757)	(2.390)	(2.728)	(2.786)	(3.064)
Elder Sib is Female			3.663***	2.873***	2.698***	1.812*
			(0.842)	(0.921)	(0.972)	(0.978)
Younger Sib is Female			0.457	0.214	0.653	-0.227
			(1.013)	(1.121)	(1.071)	(1.216)
County Children Female Ratio			-23.61	-11.49	-16.46	-2.765
			(17.39)	(19.61)	(15.50)	(19.20)
ln(Edu Expense)					-0.0965	-0.0907
					(0.466)	(0.546)
First Stage F-Stats	139.295	139.295	140.701	140.701	95.0327	95.0327
Observations	671	671	671	671	574	574
OLS Estimates:						
Younger Sib in School	0.876	1.327	0.726	1.215	1.114	0.960
	(1.556)	(1.640)	(1.577)	(1.654)	(1.868)	(2.000)

Notes: This table presents the IV and OLS estimates of the main analysis. The upper panel shows the IV estimates of three different specifications. The lower panel shows the corresponding OLS estimates. Each column is a separate regression. The dependent variable in odd-numbered columns is Chinese test score and the dependent variable in even-numbered columns is Math test score. The test scores are standardized to 100-point scale. The key variable of interest is a dummy variable of younger sibling enrolled in school. Columns (1) and (2) are the results of the baseline model, including both sibling's birth weight, younger sibling's age, elder sibling's school grade fixed effects, both parent's age, income, and education, the household's ethnicity, province fixed effects. Columns (3) and (4) are adding both sibling's gender and county level children girl ratio. Columns (5) and (6) further control for the log annual educational expense on the elder sibling. All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

older sibling, relative to a same-grade level peer who has a pre-school sibling.

The IV estimates show that the school enrollment of the second child has a statistically strong, and economically meaningful positive effect on the elder child's mathematics performance, but less so on the Chinese performance. This compares to the null effects estimated in the OLS regressions and suggests a downward bias to the OLS results. This downward bias could occur if parents chose to delay schooling of the younger child to focus on schooling of the elder child. In this case, the first-child preference would be negatively correlated with having the second child in school and positively correlated with the older child's test score. Meanwhile, the estimated impact of the control variables are similar in both economic and statistical significance in the OLS regressions compared to the IV regression model and the estimates are presented in Table A.1.

4.2 Robustness of results

Our instrument considers all children's sixth birth date after August 31, 2009 as ineligible for school enrollment and all with prior birth dates as eligible. One concern to our IV estimation is that the effect is driven by those with birth date further away from the cutoff date. In this sub-section, we narrow the age window of the younger siblings to check for the robustness of our results and present restricted sample results from our preferred specification in Table 3. We would ideally only include a narrow bandwidth of the younger sibling's birth date in our estimation for a local treatment effect. Unfortunately, this is not possible given the small sample size of our analytical dataset.

Columns (1) and (2) restrict the younger siblings to those aged between 4 and 9 years old in 2009; Columns (3) and (4) restrict the the younger sibling's ages to be within 4 and 8 in year 2009; Columns (5) and (6) restrict the younger sibling's age to fall between 5 and 9 years old in year 2009, and Columns (7) and (8) limit the age to be between 5 and 8 in year 2009. As the age band shrinks, the number of observations falls sharply. Notwithstanding this limitation, we find that the younger sibling's schooling status has a robust positive effect

Table 3: Robustness: Sibling Spillover Effects

	(1) Chinese Ages 4-9	(2) Math Ages 4-9	(3) Chinese Ages 4-8	(4) Math Ages 4-8	(5) Chinese Ages 5-9	(6) Math Ages 5-9	(7) Chinese Ages 5-8	(8) Math Ages 5-8
Younger Sib in School	3.926**	5.450***	2.760	5.602**	3.704*	5.914***	1.626	5.965**
	(1.833)	(2.071)	(2.121)	(2.403)	(2.000)	(2.046)	(2.579)	(2.728)
Elder Sib is Female	3.084**	1.753	2.041	1.250	3.546**	1.282	2.278	0.360
	(1.421)	(1.454)	(1.553)	(1.574)	(1.685)	(1.606)	(1.871)	(1.777)
Younger Sib is Female	2.013	2.293*	2.338*	2.307*	3.989***	4.593***	4.518***	4.895***
	(1.314)	(1.339)	(1.378)	(1.361)	(1.291)	(1.532)	(1.314)	(1.627)
County Children Female Ratio	-12.39	-2.920	6.947	16.13	-28.60	-29.47	-10.11	-10.49
	(18.43)	(18.30)	(21.84)	(19.98)	(19.89)	(18.22)	(25.21)	(20.44)
ln(Edu Expense)	0.0328	0.0952	-0.541	-0.473	0.265	0.706	-0.396	0.146
	(0.423)	(0.507)	(0.396)	(0.537)	(0.406)	(0.507)	(0.472)	(0.573)
Observations	243	243	209	209	195	195	161	161

Notes: This table presents the IV estimates from running the same specification in columns (5) and (6) in Table 2 on sub-samples with different age ranges of the younger siblings. Columns (1) and (2) show estimates from the sample with younger sibling's age ranging 4-9. Columns (3) and (4) show estimates from the sample with younger sibling's age ranging 4-8. Columns (5) and (6) are estimates from the sample with younger sibling's age ranging 5-9. Columns (7) and (8) are estimates from the sample with younger sibling's age ranging 5-8. All standard errors are clustered at the city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

on the elder sibling's math score in all estimations regardless of sample restrictions. The estimates on Chinese test score are also robust in terms of the magnitudes when restricting the sample. If anything, we gain significance for most of the estimates of Chinese test scores with this conservative specification.

Another potential concern with our identification strategy is that the spillover effect from the younger sibling to elder sibling might come from the age gap between siblings rather than a younger sibling's in-school effect. For example, the younger sibling may be older when entering school age, displaying a closer age gap to the elder sibling than the younger ones who are pre-school. Liu and Li (2016) and Zhang and Xie (2018) suggest that siblings of different age gaps may have varying school performance. As mentioned above, we have controlled siblings' age gap in our main estimation and the results remain robust (see Table A.3). To further address this concern, we run regressions on a sub-sample of older children with only pre-school younger siblings, and with the variable of interest as the *younger sibling's age*. We report the results in Table 4. The first two columns include linear controls for the elder sibling's age; the second two control for the elder sibling's age fixed effects; and the last two columns control for the elder sibling's grade fixed effects. These combinations of age controls were used to estimate an age gap effect in an exhaustive manner. In no case did we find any statistically significant relationship between the younger sibling's age and the older sibling's test scores and our falsification test rules out this competing explanation.

Table 4: Falsification: Is it a Sibling's Age Gap Story?

	(1)	(2)	(3)	(4)	(5)	(6)
	Chinese	Math	Chinese	Math	Chinese	Math
Younger Sib's Age	0.480	-0.0478	0.260	0.143	-0.138	0.138
	(0.632)	(0.353)	(0.530)	(0.341)	(0.412)	(0.358)
Observations	263	263	263	263	263	263

Notes: This table presents the results of regressions of elder sibling's test scores on the age of pre-school younger sibling. The variable of interest is the younger sibling's age. Columns (1) and (2) are controlling for a linear term of the elder sibling's age; columns (3) and (4) are controlling for elder sibling's age dummies. Columns (5) and (6) control for the elder sibling's grade dummies. All standard errors are clustered at the city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Story of sisters

In our dataset, we find that females students have relatively higher mean and lower standard deviations in both their Chinese and math scores (see the lower panel in Table 5). This confirms what has been found in the literature in that girls consistently outperform boys in school (e.g. Duckworth and Seligman, 2006; Goldin, Katz, and Kuziemko, 2006; Buchmann, DiPrete, and McDaniel, 2008; DiPrete and Jennings, 2012; Lundberg, 2017; Jiang, 2020). Compared to boys, girls begin school more prepared, spend more hours on homework, and have fewer disruptive behaviors (e.g. DiPrete and Jennings, 2012; Becker, Hubbard, and Murphy, 2010; Goldin et al., 2006). To examine whether gender differences in learning also affect sibling spillover effects, we tested and allowed for differential effects by gender of the younger sibling. We find that the sibling spillover is driven by girls.

We present these heterogeneity results of the spillover effects by gender of the younger sibling in the top panels in Table 5. We find striking positive spillover effects for which the younger sibling is a girl (see columns (1) and (2)). Having a younger sister in school leads to a 11 percentage point increase in the elder sibling's Chinese score and a 12 percentage point improvement in their math score. The results presented in the columns (3) and (4), where the younger brothers are attending schools, show null effects on the elder sibling's Chinese performance and statistically insignificant effects on the elder sibling's math performance.

Table 5: Heterogeneity of spillover by siblings gender pairs

	Younger Sib is Female		Younger Sib is Male	
	(1)	(2)	(3)	(4)
	Chinese	Math	Chinese	Math
Younger Sib in School	10.79*	11.80**	0.0365	3.343
	(5.560)	(5.623)	(3.386)	(3.450)
County Children Female Ratio	4.623	-7.352	-35.28*	-8.455
	(22.54)	(29.65)	(19.46)	(20.49)
ln(Edu Expense)	-0.472	-0.796	-0.0874	0.203
	(0.777)	(0.809)	(0.503)	(0.605)
Observations	207	207	367	367

Test Score Statistics	*Chinese*		*Math*	
	Mean	S.D.	Mean	S.D.
Younger Sister's Score:	81.3975	12.44738	83.10537	12.31402
Younger Brother's Score:	80.0117	12.02913	80.75125	13.3401
Elder Sister's Score:	80.81393	10.75539	82.26843	11.4093
Elder Brother's Score:	78.10908	12.78193	80.0179	13.6111

Notes: This table presents the IV estimates of the main regression by different subset of sample. Each column is a separate regression. The dependent variable is either Chinese test score or Math test score, in 100-point scale. The key variable of interest is a dummy variable of younger sibling enrolled in school. Control variables include both sibling's birth weight, younger sibling's age, elder sibling's grade fixed effects, both parent's age, income, and education, the household's ethnicity, province fixed effects, county level children girl ratio, and log total educational expenditure on the elder sibling. Column (1)-(2), (3)-(4), (5)-(6), and (7)-(8) are subsamples of different gender pairs, elder sister-younger brother, elder sister-younger sister, elder brother-younger brother, and elder brother-younger sister, respectively. All standard errors are clustered at the city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The lower panel shows summary statistics of scores by subsamples, which indicate that females in general have relatively higher mean and lower standard deviations in both test scores.

Our findings in Table 5 contribute to the sibling gender literature by showing that having a younger sister in school provides a strong and positive impact on the elder sibling's school performance, compared to having a younger brother being in school.

4.4 Home connections and potential mechanisms

As we find a strong positive impact from the second child's enrollment status on the older child's school performance, we hypothesize that this improvement is due to a positive at-home externality from both siblings studying together. When the younger child is enrolled in school, the older child would likely be exposed to a more intense academic atmosphere at home. This could be reflected as an increase in studying time among siblings at home, a heightened household attention to school performance, or to more frequent household discussions of school matters.

Conditional on the variables provided by our data, we infer such mechanisms through the variations on the elder sibling's home-school distance and whether the older sibling attends boarding school. Children spend more time at home if they do not attend boarding school. A shorter home-school distance may also suggest a tighter social connection between a child and family members and an increased amount of time studying together at home. Following our hypothesis, we test whether children who spend more time at home and have stronger social connections at home are more likely to be positively influenced by the intense home academic atmosphere when the younger sibling begins school. This would be evident by observing a large sibling spillover when the older child's school is closer to home.

To illustrate this mechanism, we add an indicator of whether the elder sibling is in a boarding school and an interaction between the boarding school indicator and an indicator of whether the younger sibling is in school to our main specification. The results are shown in columns (1)-(2) in Table 6. In columns (3)-(4), we replace the boarding school indicator with an indicator of whether the elder sibling's school distance is above the median, as a secondary definition of home-school distance.

The results in Table 6 support our hypotheses. In columns (1), elder children who are in boarding school experience significantly less sibling spillover effects in the Chinese scores from the younger sibling (4.1 percentage points less). This suggests that elder children in boarding school lose the opportunity to experience positive peer effects through a reduction

Table 6: Sibling spillover by elder child's boarding school status and home-school distance

	(1) Chinese	(2) Math	(3) Chinese	(4) Math
Younger Sib in School	5.646**	7.119**	5.266*	6.668**
	(2.831)	(3.538)	(2.806)	(3.388)
Younger Sib in School*Elder Sib in Boarding School	-4.070*	-3.382		
	(2.409)	(2.491)		
Elder Sib in Boarding School	1.803	1.163		
	(1.995)	(1.944)		
Younger Sib in School*Elder Sib in School > Median Distance			-3.930*	-1.403
			(2.272)	(2.248)
Elder Sib in School > Median Distance			1.475	0.737
			(1.690)	(1.480)
Observations	572	572	574	574

Notes: This table illustrates the potential mechanism of the sibling spillover effects by exploring the school type or distance to school of the elder sibling. The dependent variable is either Chinese test score or Math test score, in 100-point scale. The key independent variable in columns (1) and (2) is an interaction term of the indicator of the younger sibling's schooling status and the indicator of the elder sibling's school type is boarding school. The key independent variable in columns (3) and (4) is an interaction tern of the indicator of the younger sibling's schooling status and the indicator of the elder sibling's school distance is above the sample median.

of home time. Columns (3)-(4) show similar, although weaker, findings: elder children who attend schools that are farther from home experience a 3.9 percentage points reduction in the positive sibling's spillover in Chinese scores, relative to their counterparts who attend schools closer to home. The spillover reduction from elder sibling attending boarding school is stronger than that from elder sibling living at home by attending school further away. This is likely due to the fact that the child would have much less home time when attending a boarding school. We again find evidence that our spillovers are due to the role of sisters. In Table A.4, we estimate the same specifications on the subsample with only female younger siblings. As the spillover effects is stronger when one has a younger sister, the reduction in this positive spillover is even stronger when they are more likely to be apart from their younger sister.

Lastly, we address potential concerns that alternative channels such as a direct adjustment of educational resources or attention from parents to the elder child when the younger child starts school might explain the increase in performance, rather than the at-home externality we show above. It is well documented that a significant portion of human capital development is attributed to parental attention and monetary investment on children (e.g. Guryan et al., 2008; Blau and Currie, 2006; Yum, 2016; Del Boca et al., 2013; Yang and Bansak, 2020). To rule out changes in resources dedicated to the older child, we conduct additional tests in Table A.5 and do not find significant changes in education expenditure and parental attention to the elder child when the younger child begins school. Thus, we infer that the improvement in elder sibling's performance when the younger sibling starts school is not derived from changes in parental education spending or parental concerns or attention.

5 Conclusion

We find that having a younger sibling enrolled in school will significantly increase the elder sibling's test scores in both Chinese and math. We refer to this result as the positive sibling spillover effect from the younger sibling to the elder. The main driver of the positive spillover comes from the younger sibling being a female. This set of findings contributes to the literature of gender inequality in education and adds empirical evidence to the positive externalities of women's educational improvement. As more than 130 million girls are estimated to be out of school, there are clear gender inequalities in education worldwide (UNESCO, 2016). Studies have shown that better educated girls contribute more to economic development and increase mobility across generations (Evans and Yuan, 2019; Kwauk and Braga, 2017; World Bank, 2017). Our finding implies that investing in girls has an additional impact on their siblings. Thanks to these spillovers, policies that promote young women's education may have important effects on other children as well, suggesting a potential multiplier effect of a policy.

The potential mechanism of this spillover effect is that the more the in-school siblings interact with each other at home, the better the elder sibling performs. When the older child is away, the beneficial impact of having a younger sister at home diminishes. This mechanism also suggests that it could be beneficial to increase the time period in which spillovers occur by offering pre-school children earlier education programs. In this case, siblings would be in school together longer. This could be done by introducing pre-K programs such as Head Start in the US. In such programs, children younger than the compulsory enrollment birth date would have access to school readiness programs at an younger age. Sibling spillover effects could be larger if additional after school public services were made freely available, such as library access. They could enhance at-home academic culture and further facilitate sibling spillovers. These offerings could be targeted at low income families to reduce future income inequality.

References

Alsan, M. (2017). The gendered spillover effect of young children's health on human capital: evidence from turkey. Technical report, National Bureau of Economic Research.

Attanasio, O., H. Baker-Henningham, R. Bernal, C. Meghir, D. Pineda, and M. Rubio-Codina (2018). Early stimulation and nutrition: the impacts of a scalable intervention. Technical report, National Bureau of Economic Research.

Becker, G. S. (1960). *An Economic Analysis of Fertility, Demographic and economic change in developed countries*. Princeton University Press.

Becker, G. S., W. H. Hubbard, and K. M. Murphy (2010). Explaining the worldwide boom in higher education of women. *Journal of Human Capital 4*(3), 203–241.

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

Becker, G. S. and N. Tomes (1976). Child endowments and the quantity and quality of children. *Journal of political Economy 84*(4, Part 2), S143–S162.

Biavaschi, C., C. Giulietti, and K. F. Zimmermann (2015). Sibling influence on the human capital of the left-behind. *Journal of Human Capital 9*(4), 403–438.

Black, S. E., S. Breining, D. N. Figlio, J. Guryan, K. Karbownik, H. S. Nielsen, J. Roth, and M. Simonsen (2017). Sibling spillovers. Technical report, National Bureau of Economic Research.

Black, S. E., P. J. Devereux, et al. (2011). Recent developments in intergenerational mobility. *Handbook of Labor Economics 4*, 1487–1541.

Black, S. E., E. Grönqvist, and B. Öckert (2018). Born to lead? the effect of birth order on noncognitive abilities. *Review of Economics and Statistics 100*(2), 274–286.

Blake, J. (1981). Family size and the quality of children. *Demography 18*(4), 421–442.

Blau, D. and J. Currie (2006). Pre-school, day care, and after-school care: who's minding the kids? *Handbook of the Economics of Education 2*, 1163–1278.

Blau, D. M. (1999). The effect of income on child development. *Review of Economics and Statistics 81*(2), 261–276.

Blau, F. D., L. M. Kahn, P. Brummund, J. Cook, and M. Larson-Koester (2020). Is there still son preference in the united states? *Journal of Population Economics*, 1–42.

Breining, S., J. Doyle, D. N. Figlio, K. Karbownik, and J. Roth (2020). Birth order and delinquency: Evidence from denmark and florida. *Journal of Labor Economics 38*(1), 95–142.

Breining, S. N. (2014). The presence of adhd: Spillovers between siblings. *Economics Letters 124*(3), 469–473.

Buchmann, C., T. A. DiPrete, and A. McDaniel (2008). Gender inequalities in education. *Annu. Rev. Sociol 34*, 319–337.

Chen, C., S.-Y. Chou, C. Wang, and W. Zhao (2019). The effect of the second child on the anthropometric outcomes and nutrition intake of the first child: Evidence from the relaxation of the one-child policy in rural china. *The BE Journal of Economic Analysis & Policy 20*(1).

Chen, R. and L. Zhang (2019). Imbalance in china's sex ratio at birth: a review. *Journal of Economic Surveys 33*(3), 1050–1069.

Chen, X., Q. Huang, S. Rozelle, Y. Shi, and L. Zhang (2014). Effect of migration on children's educational performance in rural china. In *China's economic development*, pp. 206–224. Springer.

Das Gupta, M., J. Zhenghua, L. Bohua, X. Zhenming, W. Chung, and B. Hwa-Ok (2003). Why is son preference so persistent in east and south asia? a cross-country study of china, india and the republic of korea. *The Journal of Development Studies 40*(2), 153–187.

Del Boca, D., C. Flinn, and M. Wiswall (2013). Household choices and child development. *Review of Economic Studies 81*(1), 137–185.

DiPrete, T. A. and J. L. Jennings (2012). Social and behavioral skills and the gender gap in early educational achievement. *Social Science Research 41*(1), 1–15.

Duckworth, A. L. and M. E. Seligman (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of educational psychology 98*(1), 198.

Evans, D. K. and F. Yuan (2019). What we learn about girls' education from interventions that do not focus on girls. *World Bank policy research working paper* (8944).

Fang, H., K. N. Eggleston, J. A. Rizzo, S. Rozelle, and R. J. Zeckhauser (2012). The returns to education in china: Evidence from the 1986 compulsory education law. Technical report, National Bureau of Economic Research.

Goldin, C., L. F. Katz, and I. Kuziemko (2006). The homecoming of american college women: The reversal of the college gender gap. *Journal of Economic perspectives 20*(4), 133–156.

Guryan, J., E. Hurst, and M. Kearney (2008). Parental education and parental time with children. *Journal of Economic perspectives 22*(3), 23–46.

Hanushek, E. A. (1992). The trade-off between child quantity and quality. *Journal of political economy 100*(1), 84–117.

Heckman, J. J. (2008). Schools, skills, and synapses. *Economic inquiry 46*(3), 289–324.

Hong Chew, S., J. Yi, J. Zhang, and S. Zhong (2017). Risk aversion and son preference: Experimental evidence from chinese twin parents. *Management Science 64*(8), 3896–3910.

Huang, C., S. Zhang, and Q. Zhao (2020). The early bird catches the worm? school entry cutoff and the timing of births. *Journal of Development Economics 143*, 102386.

Huggett, M., G. Ventura, and A. Yaron (2011). Sources of lifetime inequality. *American Economic Review 101*(7), 2923–54.

Jakiela, P., O. Ozier, L. Fernald, and H. Knauer (2020). Big sisters.

Jiang, Q. and C. Zhang (2021). Recent sex ratio at birth in china. *BMJ Global Health 6*(5), e005438.

Jiang, X. (2020). Family planning and women's educational attainment: Evidence from the one-child policy. *Contemporary Economic Policy 38*(3), 530–545.

Joensen, J. S. and H. S. Nielsen (2018). Spillovers in education choice. *Journal of Public Economics 157*, 158–183.

Johnstone, H., Y. Yang, H. Xue, and S. Rozelle (2021). Infant cognitive development and stimulating parenting practices in rural china. *International Journal of Environmental Research and Public Health 18*(10), 5277.

Kaul, T. (2018). Intra-household allocation of educational expenses: Gender discrimination and investing in the future. *World Development 104*, 336–343.

Keane, M. P. and K. I. Wolpin (1997). The career decisions of young men. *Journal of political Economy 105*(3), 473–522.

Kwauk, C. and A. Braga (2017). Three platforms for girlsâ education in climate strategies. *Washington, DC: Brookings*.

Liang, Y. and J. Gibson (2018). Do siblings take your food away? using china's one-child policy to test for child quantity-quality trade-offs. *China Economic Review 48*, 14–26.

Lin, W., J. Pantano, and S. Sun (2020). Birth order and unwanted fertility. *Journal of Population Economics 33*(2), 413–440.

Liu, D. and X. Li (2016). Children born in july and august: a study on the age regulation in primary school and student's education access and development. *The Journal of Chinese Sociology 3*(1), 22.

Lundberg, S. J. (2017). Father absence and the educational gender gap.

Luo, R., Q. Lyu, S. Rozelle, and S. Wang (2020). Early child development and caregiver subjective well-being in rural china. *China Agricultural Economic Review*.

Martinez, S., S. Naudeau, and V. A. Pereira (2017). Preschool and child development under extreme poverty: evidence from a randomized experiment in rural mozambique. *World Bank Policy Research Working Paper* (8290).

Ozier, O. (2018). The impact of secondary schooling in kenya a regression discontinuity analysis. *Journal of Human Resources 53*(1), 157–188.

Qureshi, J. A. (2018). Siblings, teachers, and spillovers on academic achievement. *Journal of Human Resources 53*(1), 272–297.

Ramey, G. and V. A. Ramey (2010). The rug rat race. *Brookings Papers on Economic Activity*, 129.

Sylvia, S., N. Warrinnier, R. Luo, A. Yue, O. Attanasio, A. Medina, and S. Rozelle (2021). From quantity to quality: Delivering a home-based parenting intervention through chinaâs family planning cadres. *The Economic Journal 131*(635), 1365–1400.

UNESCO, I. (2016). Leaving no one behind: How far on the way to universal primary and secondary education. *Policy Paper 27/Fact Sheet 37*.

World Bank, W. (2017). *World development report 2018: Learning to realize education's promise*. The World Bank.

Yang, G. (2021). Best time for college? a tale of two endowments. *SSRN (June 28, 2021)*.

Yang, G. and C. Bansak (2020). Does wealth matter? an assessment of china's rural-urban migration on the education of left-behind children. *China Economic Review 59*, 101365.

Yi, J., J. J. Heckman, J. Zhang, and G. Conti (2015). Early health shocks, intra-household resource allocation and child outcomes. *The Economic Journal 125*(588), F347–F371.

Yum, M. (2016). Parental time investment and intergenerational mobility. Technical report, Working Paper Series.

Zhang, C. and Y. Xie (2018). Does the school cutoff date cause the disadvantage for children born in july and august? *The Journal of Chinese Sociology 5*(1), 4.

Appendix A Additional Tables and Figures

We present the OLS estimates of the impact of the younger sibling's enrollment status on test scores of the older child in Table A.1. When the younger sibling enters school, there is no statistically significant effect in any of the OLS regressions at the standard levels. Interestingly, compared to the IV regressions in Table 2, all other variables are similar in scale and level of significance.

Table A.1: Sibship spillover - OLS

	(1) Chinese	(2) Math	(3) Chinese	(4) Math	(5) Chinese	(6) Math
Younger Sib in School	0.876	1.327	0.726	1.215	1.114	0.960
	(1.556)	(1.640)	(1.577)	(1.654)	(1.868)	(2.000)
Elder Sib is Female			3.698***	2.928***	2.732***	1.878*
			(0.864)	(0.959)	(1.011)	(1.038)
Younger Sib is Female			0.430	0.171	0.624	-0.284
			(1.055)	(1.171)	(1.119)	(1.269)
County Children Female Ratio			-23.99	-12.11	-16.71	-3.233
			(18.07)	(20.23)	(16.49)	(20.16)
ln(Edu Expense)					-0.106	-0.108
					(0.483)	(0.559)
Observations	671	671	671	671	574	574

Notes: This table presents the OLS estimates of the main regression. Each column is a separate regression. The dependent variable is either Chinese test score or Math test score, in 100-point scale. The key variable of interest is a dummy variable of younger sibling enrolled in school. Column (1) and (2) are the results of the baseline model, including both sibling's birth weight and age, both parent's age, income, and education, the household's ethnicity, province fixed effects. Column (3) and (4) are adding both sibling's gender and county level children girl ratio. Column (5) and (6) further control for the yearly log educational expense on the elder sibling. Column (7) and (8) replace elder sibling's age with grade fixed effects. Column (9) and (10) narrow the age range of younger sibling to age 4-8. All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We show the first stage results in Table A.2, using the August 31st birth date cutoff through the compulsory education. The coefficients on the instrumental variable are all negative and significant, as expected. Children who are ineligible for school are far less likely to be enrolled in school. These results are robust across various samples at the 1 percent level of significance.

In Table A.3, we include the sibling age gap in the main regressions. The purpose is to

Table A.2: First Stage: Propensity of the Younger Sibling is in School

	(1)	(2)	(3)	(4)	(5)	(6)
Younger Sib Ineligible	-0.623***	-0.623***	-0.624***	-0.624***	-0.613***	-0.613***
	(0.0528)	(0.0528)	(0.0526)	(0.0526)	(0.0629)	(0.0629)
First Stage F-Stats	139.295	139.295	140.701	140.701	95.0327	95.0327
Observations	671	671	671	671	574	574

Notes: This table presents the first stage of the IV estimation and the Kleibergen-Paap rk Wald F-statistics, corresponding to our main table, Table 2. The dependent variable is an indicator of the younger sibling is enrolled in school.

make sure that the different age patterns between elder siblings with and without in-school younger siblings do not affect our results. Compared to Table 2, the coefficients on our key variables of interest remain relatively unchanged.

In Table A.4, we run similar regressions to those shown in Table 6 on a subsample older children who only have younger sisters. Again, we find evidence that younger sisters make a difference in the educational performance of older siblings. When the older sibling has less time interacting with their younger sister, the results show that the sibling spillover reduces significantly.

In Table A.5, we run the preferred specification of our main IV regression with the annual educational expense and an indicator of parent's worry as the dependent variable to address concerns that parents are adjusting their resources to the elder child when the younger child enters school. Though we control for the annual education expenditure in our main regressions, columns (1) and (2) provide additional evidence showing that educational expenditure on the elder sibling is not a function of when the second child begins school. We use an additional variable, an indicator of whether parents "worry" about the child, to measure the possible variation in parent's attention.[12] Although this measure is based on a subjective question, it is worth showing as supportive evidence. Columns (3) and (4) show that having a second child in school does not impact parental worry for the elder child.

[12]The dependent variable "worry" is an indicator created by the parents' response on whether they worry about the child's future, in particular, on the aspects of school performance, attending classes, completing homework, spending too much time in internet cafe, watching TV, or playing computer games, being bullied by others, having bad friends, and/or having girlfriend/boyfriend too early.

Table A.3: Robustness Check to Table 2: adding control of sibling's age gap

	(1)	(2)	(3)	(4)	(5)	(6)
	Chinese	Math	Chinese	Math	Chinese	Math
Younger Sib in School	3.400	5.640**	3.425	5.640**	3.715	5.900*
	(2.351)	(2.743)	(2.402)	(2.712)	(2.804)	(3.078)
Elder Sib is Female			3.541***	2.731***	2.685***	1.779*
			(0.820)	(0.892)	(0.968)	(0.965)
Younger Sib is Female			0.393	0.140	0.639	-0.262
			(1.025)	(1.138)	(1.071)	(1.214)
County Children Female Ratio			-22.70	-10.44	-16.16	-1.994
			(17.48)	(19.76)	(15.59)	(19.44)
ln(Edu Expense)					-0.0768	-0.0401
					(0.461)	(0.524)
Observations	671	671	671	671	574	574

Notes: This table presents the IV and OLS estimates of the main analysis. The upper panel shows the IV estimates of three different specifications. The lower panel shows the corresponding OLS estimates. Each column is a separate regression. The dependent variable in odd-numbered columns is Chinese test score and the dependent variable in even-numbered columns is Math test score. The test scores are standardized to 100-point scale. The key variable of interest is a dummy variable of younger sibling enrolled in school. Columns (1) and (2) are the results of the baseline model, including both sibling's birth weight, younger sibling's age, age gap between siblings, elder sibling's school grade fixed effects, both parent's age, income, and education, the household's ethnicity, province fixed effects. Columns (3) and (4) are adding both sibling's gender and county level children girl ratio. Columns (5) and (6) further control for the log annual educational expense on the elder sibling. All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The main estimates have no qualitative or statistical differences compared to our main estimates in Table 2.

Table A.4: Sibling spillover by elder child's boarding school status and home-school distance: Households with A Younger Sister Subsample

	(1) Chinese	(2) Math	(3) Chinese	(4) Math
Younger Sib in School	14.34***	15.87***	10.92**	13.99**
	(4.483)	(4.993)	(5.313)	(5.447)
Younger Sib in School*Elder Sib in Boarding School	-9.117***	-9.391***		
	(3.224)	(3.193)		
Elder Sib in Boarding School	4.094	3.839		
	(2.796)	(2.775)		
Younger Sib in School*Elder Sib in School > Median Distance			-2.847	-4.616
			(3.556)	(3.175)
Elder Sib in School > Median Distance			-1.210	1.570
			(2.489)	(2.545)
Observations	238	238	238	238

Notes: This table shows results on a same analysis as in Table 6 but subset the sample to households with a younger sister. The dependent variable is either Chinese test score or Math test score, in 100-point scale. The key independent variable in columns (1) and (2) is an interaction term of the indicator of the younger sibling's schooling status and the indicator of the elder sibling's school type is boarding school. The key independent variable in columns (3) and (4) is an interaction tern of the indicator of the younger sibling's schooling status and the indicator of the elder sibling's school distance is above the sample median.

Table A.5: Educational Expense and Parental Attention to the Elder when the Younger Starts School

	(1) 2009 Edu Expense	(2) 2008&2009 Edu Expense	(3) 2009 Parents' Worry	(4) 2008&2009 Parents' Worry
Younger Sib in School	-0.462	-0.225	-0.0659	0.0126
	(0.394)	(0.300)	(0.108)	(0.0699)
Observations	610	1485	671	1628

Notes: This table shows estimates from regressions with dependent variable as either parents' educational expenditure on or "worry" about the elder child. All regressions include the same set of independent variables in columns (5) or (6) in Table 2. In columns (1) and (2), we examine what happens to total education expense on the elder child when the second child enters school. In columns (3) and (4), we use self-reported parental worry as an indicator for changes in parental attention to the child. The odd-numbered columns include the 2009 sample, same as the one in our main regressions, and the even-numbered columns include both 2008 and 2009 waves, to show robust results. Again, we only have test scores for one year (2009) but have most of other variables for both years.