Sibling Spillover in Rural China: A Story of Sisters and Daughters

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April 6, 2020

Abstract

We find a strong positive sibling spillover effect in two-children households in rural China, as measured by an increase in the Chinese and Math test scores of elder siblings when their younger sibling starts school. We use the Chinese Law of Compulsory Education as an exogenous variation in the timing of school enrollment to control for the impact of simultaneous and unobserved out-of-sibship factors. The mechanism for the sibling spillover likely comes from an increase in studying interactions within the sibling pairs. The spillover is prompted by having a younger sister enter school and is the strongest when both children are daughters. However, the son-preference culture emphasized in certain regions negatively offsets the positive sister-led spillover.

JEL classification: E24, C68, J30.

Keywords: Human capital, peer effect, sibling spillover, school cutoff, son preference, intra-household allocation, rural China.

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1 Introduction

Investment in children's human capital has lifetime impacts (e.g. Keane and Wolpin, 1997; Heckman, 2008; Black, Devereux, et al., 2011; Huggett, Ventura, and Yaron, 2011; Yang, 2018). Most of our understanding of children's human capital production is limited to the family unit (e.g. Yang and Bansak, 2020; Del Boca, Flinn, and Wiswall, 2013; Guryan, Hurst, and Kearney, 2008; Ramey and Ramey, 2010; Blau and Currie, 2006; Blau, 1999). In families with more than one child, how are resources allocated across siblings? Is there any spillover effect when siblings interact with each other?

This paper investigates the sibling spillover effect on school performance in two-children households in rural China. We contribute to the literature of *within family* children's human capital development in three ways: First, we identify the sibling spillover effect by using the Chinese Compulsory School Law which creates an exogenous variation in school enrollment among younger siblings by birth date. Such design controls the direction of impact between siblings and allows us to differentiate the spillover effect among siblings from other out-of-sibship factors. To the best of our knowledge, we are the first to study the spillover effect in school performance from the younger sibling to an elder sibling in a developing economy. Second, we find the sibling spillover effect differs significantly across sibling gender-pairs. A positive spillover is particularly led by the younger sisters. And lastly, we find that the sister-led spillover effect fades away under strong son-preference culture.

We find a positive sibling spillover effect measured as an increase in Chinese and Math test scores for the elder sibling when their younger sibling begins elementary school. The increase in the elder child's school performance is not influenced by parental time or money inputs[1]. Moreover, sisters drive the positive spillover effect. The elder child benefits the most when the younger sibling is a girl; and the effects are even stronger when both children are daughters.

The mechanism behind the sibling spillover likely comes from an increase of shared sibling time on studying. Compared to a child who is not enrolled in school, the child who enrolls inevitably spends more time in studying. Such an extensive increase in the second child's study time spills over to the elder sibling, only when both children live at home, and the effect is stronger when the elder child attends a school closer to home. If the elder child attends a boarding school, the spillover effect fades away.

The biggest challenge in identifying sibship peer effect is to differentiate it from factors outside of the sibship and to control for the direction of impact between siblings[2]. We use

[1]These are the two channels which household resources pass on to children's human capital (e.g. Del Boca et al., 2013; Guryan et al., 2008; Ramey and Ramey, 2010; Blau, 1999).

[2]As Black, Breining, Figlio, Guryan, Karbownik, Nielsen, Roth, and Simonsen (2017) review, siblings

the Chinese Law of Compulsory Education as an exogenous variation in schooling. The law stipulates that children must be at least 6 years old or above on August 31 to be admitted into primary school in the new school year. This arguably arbitrary day of birth generates exogenous variations in the younger sibling's school eligibility and enrollment, allowing us to attribute changes in the elder sibling's school performance to the enrollment of younger sibling. We use this setup to parse out the direction of the impact of spillovers from the younger sibling to the elder sibling. Any common factors simultaneously and similarly impacting both siblings are thus taken out by the design.

When further exploring the gender story in sibling spillovers, we find that in areas with strong son-preferences, the sister-led sibling spillover diminishes, which reduces the estimated overall spillover in such areas. In particular, the spillover effect to the elder sibling on Chinese scores is significantly stronger in areas with relatively more balanced gender ratios which is an indicator of less son-preference. When the elder sibling is a female, there are even stronger impacts on both Chinese and Math scores in more gender-balanced areas. Such results are in line with Tsui and Rich (2002) who find that more gender-equal communities encourage daughters' takeup on math which can amplify the positive impact of sister-led spillover. While most of the literature on son-preference documents gender-based differential parental and social treatment and consequences on children[3], our results reveal a gender-based negative impact on within-sibship peer effect from son-preferences.

Our heterogeneity in results based on measures of son-preference reveals that if an unobserved out-of-sibship factor differently impacts siblings (in our case son-preference impacting siblings differently by gender), standard empirical strategies in then literature under the assumption that all out-of-sibship factors impact all siblings in the same way may not be enough[4]. Though son-preference is particularly severe in many developing nations, gender-based unequal treatments between sons and daughters manifest across developed and developing countries[5]. Given the prevalence of gender-bias, it is one of the outside factors that researchers cannot omit when assessing sibling effects.

growing up in the same household are the ultimate peers, sharing the same parents, similar genetics and experiences.

[3]Sen (1990), Tsui and Rich (2002), Hong Chew, Yi, Zhang, and Zhong (2017), Shrestha and Palaniswamy (2017), and Kaul (2018), among others show that son-preferred communities often possess gender-selection, gender-based parental care, gender-based education spending for young children. Chung and Gupta (2007) and Shi (2017), however, provide analyses suggesting that there has been a reduction (and even reverse) of son-preference culture in Korea and China in recent years.

[4]For example, if any out-of-sibship factors impacting siblings differently, the difference-in-difference design as in Black et al. (2017) and randomized policy experiment as in Joensen and Nielsen (2018) could be inadequate in separating the sibship spillover from the unobserved outside factor.

[5]Dahl and Lochner (2012), Blau, Kahn, Brummund, Cook, and Larson-Koester (2020), Lundberg (2017), Shi (2017), Sen (1990), and Almond, Edlund, and Milligan (2013) among many others provide evidence of son-preference across developing and developed countries.

Overall, this paper joins others in providing a new perspective in sibling spillovers in a developing economy. We add to the literature by studying the spillover effect in school performance and control the direction of impact from younger siblings to elder siblings. Only one paper we know has looked at sibling spillovers in China and this was from the older to the younger child (Biavaschi, Giulietti, and Zimmermann, 2015). 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; Black et al., 2017; Breining, 2014; Yi, Heckman, Zhang, and Conti, 2015). The findings of this paper reveal a strong sibling spillover in school work, driven by sisters and daughters, and distorted by a son-preference culture; policy geared towards daughters and sisters in developing communities like rural China may produce the largest spillovers and ultimately largest increases in human capital development overtime.

2 Data and policy background

We use data from the Longitudinal Survey on Rural Urban Migration in China (RUMiC), a large database spanning nine provinces in China. In particular, we test for and examine the spillover effects in the two publicly available waves (2008 and 2009) from one of the three independent surveys, the Rural Household Survey (RHS)[6]. Given the potentially large variation in access to resources that are linked to decisions about family size we aim to reduce this endogeneity by focusing on sibling pairs only (Zajonc, 1976; Price, 2008; Black et al., 2018). We restrict the sample to two-children households in the RUMiC and construct a dataset at the household level with the elder sibling as the key unit of observation.

Using the RUMiC, we examine sibling pairs in 2008 and 2009 and utilize the impact of the Chinese Law of Compulsory Education to give us variation in the enrollment likelihood of the younger sibling on the older sibling's outcomes. Here we are looking for a policy that requires certain children to be in school, while others are not eligible for school. In terms

[6]The survey is a collaboration project between the Australian National University, Beijing Normal University and the Institute for the Study of Labor (IZA). The Longitudinal Survey on Rural Urban Migration in China (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.

of our empirical strategy, we wanted policy that would affect years of schooling exogenously and would remove the endogeneity of educational attainment. We found that we could use part of the Chinese Law of Compulsory Education to construct our instrumental variable. What follows is an overview of the Chinese Law of Compulsory Education.

China's Compulsory Education Law was passed in 1986 and required nine years of schooling. It also had other key features. Namely, children were required to attend school when they were six years old; school was to be free; and children could not work when they were supposed to be in school (e.g. Fang, Eggleston, Rizzo, Rozelle, and Zeckhauser, 2012).

The most important part of this law as it relates to our study is the introduction of the school cutoff date in China. Such an entrance age requirement is common worldwide as many countries specify a minimum age and date before a child can enter school. For some, there is even variation in the cutoff months within the counrty (e.g. each US state can set it own starting date) (Dickert-Conlin and Elder, 2010). In the case of China, the rule is that a child must be 6 years old before August 31st to enter school starting on September 1st(e.g. Zhang and Xie, 2018).

We use this school cutoff date to create our instrumental variable that we hope sufficiently captures exogenous variation in schooling for those around the cutoff date; we use this variation in education of a younger sibling to test for sibling spillovers in educational outcomes of the older child. We are not the first to use this instrument, but we are the first to do so in this exact context. To be a valid instrument, the birth month is assumed to be exogenous. Many researchers assume this is the case as it has been found that there is little predictability in the timing of the exact birth month.

Furthermore, this instrument needs to be correlated with education but not correlated with the key outcome of interest which is the test score of the older child. We feel this exclusion restriction is met as it is unlikely that the birthday of the younger sibling has a direct impact of the education of the elder child. Note, some researchers, however, think there could be an impact on the test scores of the younger child under this cutoff restriction as the children born right before the cutoff will be relatively young for their grade and could possibly perform worse (Liu and Li, 2016; Zhang and Xie, 2018). This is called an age position effect. Since we are not looking at returns to education but a sibling spillover effect, we are less concerned with this potential bias from an age position effect. Instead, we believe that our instrument will provide the average difference between test scores of elder siblings with younger siblings in school and those without younger siblings in school or an average treatment effect.[7]

Table 1 provides a description of summary statistics split by whether a younger child is in school or not. We are able to collect a sample of about 650 families with two children and we show how their characteristics vary across the two groups and present patterns of our overall sample. To begin, the oldest child is about 11 years old when the younger sibling is not in school and 15 years old when the younger child is in school. The younger child's average age is 4 and 7, respectively, in these two groups.

For both groups, the composition of sibling pairs reflects a desire to have a boy. In our sample, 66% of the elder children are female, while 64% of the second or younger children are male. This shows a strong gender selection or son-preference for the two-children families in rural China.[8] Such gender mix is also prevalent in other countries (see discussion section on son preference). Therefore, we feel that we can extend the results of this work to non-Chinese contexts as well. The elder child has an average birth weight of about 3200 grams in both groups, compared to the younger child of 3300 grams – both of which are healthy levels and shows a slight upward trend.

The key dependent variables for the study are the elder sibling's Chinese score and Math score, calculated in terms of percentage. The average scores are both around 80 percent which are computed by taking the actual score and dividing by the max score[9] to put the score out of 100. There are differences across the groups as the average scores tend to go down as one ages. This has been found in this dataset by others and we control for age and grade level to address this pattern in our regression analyses (Akgüç, Giulietti, and Zimmermann, 2014). We also consider the possibility that we could be picking up an 'age gap' effect by construction of our instrumental variable and these controls. By controlling for the elder child's age, we are comparing elder children of the same age with and without younger children in school. If the younger child is not in school, there will be a bigger gap.

[7]For this to be the case, the policy needs to be implemented consistently and with few non-compliers around the cut off point. In theory, the greater the non-compliance, the more likely the IV will more to a local average treament effect (Zhang and Xie, 2018).

[8]As shown in previous studies, part of the imbalanced gender ratio is due to the gender selection induced by the One-Child Policy (OCP) implemented 1979-2015 (Ebenstein, 2010; Huang, Lei, and Zhao, 2016). This gender selection is further enhanced in rural areas due to some exceptions of the OCP towards rural population. The most restricted one child requirement was only applied to Han (the ethnic majority) families with an urban *Hukou*. As for rural families (both Han and non-Han), the policy allowed for many exceptions. Considering that most rural families make a living through labor-intensive agricultural activities, also where the son-preference is largely rooted, a rural Han couple could apply to have a second child a few years after their first birth if the only child is female or disabled. This is why a large proportion of rural families with two children have the elder child as female. Further, a rural non-Han family could have more than two children, depending on the population size of the ethnic minority group. The detailed implementation was specified at the local government level. Thus, the intensity of the OCP could be roughly ordered (Jiang, Jiang; Zhang, 2017; Wang et al., 2012).

[9]Most of the test scores are on a 100 scale but some are not.

Therefore, the in-school effect could also be impacted by the age gap. In the results section we look the relationship between the pre-school younger sibling's age and the test scores of older children to rule out these possible confounding effects on our identification strategy. In essence, we want to make sure that we are identifying the younger sibling's in-school effect but not the age-gap effect on the elder sibling's school performance.

The average distance between home and the elder child's school grows from 4 to 11 km when the younger child is in school and the likelihood of attending boarding school also rises from 32% to 52% when the younger child is in school. This reflects the age of the older child being more likely and eligible to attend a greater variety of schools. Turning to the parents, over two-thirds of parents worry about the future of their elder child [10]. Parents spend over 1111 RMB on the elder child in terms of total education expenditure annually when the younger child is not in school and this goes up to 2000 RMB when the younger child is in school. Again this reflects the aging of the older sibling. Total education expenditures include regular school fees, remedial class fees outside of school, and extra school selection/sponsorship fees. Lastly, we see higher wages for fathers than mothers. The father of the children typically earns an average monthly wage between 1300 and 1600 RMB, while mothers earn considerable less with an average monthly income ranging between 400 and 600 RMB for our two subsamples. Overall, in the far right column, one can see that about half of the characteristics are similar and the other half differ in terms of statistical significance for our sample split by whether the younger sibling is in school or not. When the latter is the case, it is not surprising to find that both siblings are older, the older child has greater educational expenses, lower test scores and travels farther to school. These are as expected and give us confidence in our dataset as representing the nature education in rural China.

In the table on parental education, we split our sample by mother and father and also by whether the younger child is in school. This table presents the highest level of education completed. Overall, educational attainment of the parents is limited to secondary education and indicates the possible powerful implications of compulsory education and other educational reforms that will be impacting future generations of Chinese youth. In our sample, about 66% of fathers' highest education attainment was completing junior middle school, with only 17% having completed senior middle school or higher. For mothers, average educational attainment is lower. About 60% of mothers stopped school by completing junior middle school, and very few completed senior middle school or higher. About one-third of

[10] "Worry" is an index 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.

mothers have an elementary school education or less.

Table 1: Summary Statistics

	Younger Sibling Not in School		**Younger Sibling in School**				
Variable	Obs	Mean	Obs	Mean	Difference	t-stat	Significance
Age	250	11.22	391	15.05	3.83	17.61	***
Female	250	0.66	391	0.66	0.01	0.23	
Birthweight	250	3223.72	391	3235.35	11.63	0.33	
Chinese score	237	81.75	373	78.61	-3.14	-3.30	***
Math score	237	83.22	373	80.34	-2.88	-2.98	***
Distance to school (km)	250	4.36	389	10.61	6.25	2.37	***
Boarding school	250	0.32	389	0.52	0.20	5.07	***
Parents' Worry	248	0.69	390	0.68	0.00	0.09	
Annual edu expenses (yuan)	250	1117.40	391	2051.42	934.02	4.44	***
Younger sib's age	250	4.05	391	11.14	7.09	39.27	***
Younger sib is female	250	0.39	391	0.34	-0.05	1.39	
Younger sib' birthweight	250	3314.40	391	3275.29	-39.11	-1.05	
Father's wage	250	1647.04	391	1303.66	-343.38	-1.37	
Mother's wage	250	563.35	391	379.79	-183.56	-1.40	

This table presents the summary statistics of the main variables that we used for analysis. Specifically, in the upper panel, we show the demographic characteristics, school characteristics, test scores, and parents' educational expense and worry of the elder sibling. In the lower panel, we show demographic information of the younger sibling and parent's wage. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Parents Education

Youngest Child NOT in School							
Father's Edu	Freq.	Percent	Cum.	Mother's Edu	Freq.	Percent	Cum.
Never been to school	3	1.2	1.2	Never been to school	8	3.2	3.2
Literacy class	2	0.8	2	Literacy class	2	0.8	4
Elementary school	30	12	14	Elementary school	59	23.6	27.6
Junior middle school	172	68.8	82.8	Junior middle school	155	62	89.6
Senior middle school	30	12	94.8	Senior middle school	16	6.4	96
Specialized secondary school	5	2	96.8	Specialized secondary school	7	2.8	98.8
Polytechnic college	8	3.2	100	Polytechnic college	2	0.8	99.6
Undergraduate (Bachelor's Degree)	0	0	100	Undergraduate (Bachelor's Degree)	1	0.4	100
Total	250	100		Total	250	100	
Youngest Child IN School							
Father's Edu	Freq.	Percent	Cum.	Mother's Edu	Freq.	Percent	Cum.
Never been to school	3	0.77	0.77	Never been to school	10	2.56	2.56
Literacy class	2	0.51	1.28	Literacy class	7	1.79	4.35
Elementary school	65	16.62	17.9	Elementary school	121	30.95	35.29
Junior middle school	263	67.26	85.17	Junior middle school	233	59.59	94.88
Senior middle school	46	11.76	96.93	Senior middle school	19	4.86	99.74
Specialized secondary school	7	1.79	98.72	Specialized secondary school	1	0.26	100
Polytechnic college	5	1.28	100	Polytechnic college	0	0	100
Total	391	100		Total	391	100	

This table presents both parents' educational attainment by two samples, the sample with a pre-school younger child, and the other sample with a younger child in school.

These summary statistics suggest that sibling effects could have powerful implications if older siblings are able to advance through years of schooling beyond those of their parents.

If this is the case, it provides greater credence to the findings that joint studying time is resulting in positive sibling spillover effects. In other words, the younger children may be more reliant on their older siblings for help with school work than from their parents. As a result, older children may be stepping into the informal role as tutor, mentor, and teacher to their younger sisters and brothers.

3 Empirical Strategy

Our goal in this study is to fill in a gap in the sibling spillover literature by exploring the impact of a younger sibling on an elder sibling's schooling performance while controlling for out-of-sibship common factors. In order to conduct this analysis, 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 of the parents and both siblings.

$$S_i^E = \alpha + \beta inSchool_i^Y + \Lambda X_i^E + \Gamma X_i^Y + \Pi X_i^P + \varepsilon_i \tag{1}$$

where E stands for elder, Y stands for younger and P stands for parents. Thus, S_{it}^E is the elder sibling's schooling performance, Chinese score or Math score, for person i. The variable $inSchool_i^Y$ is an indicator whether the younger sibling is in school. Thus the coefficient on $inSchool_i^Y$, β, is our main coefficient of interest.

Without any controls, it is an empirical question as to whether β is positive or negative. It could be negative due to a potential reason that families are dividing resources and chores across siblings and this 'resource constraint effect' dominates; or it could be positive due to the increased joint study time by having a younger sibling in school and this positive 'spillover effect' dominates.[11] We attempt to disentangle these effects and estimate the 'spillover effect' by controlling for the resource effects on the parents of having a second child in school. In particular, we control for parents wages, education, and educational expenses in X_i^P This vector of parents' characteristics also includes father's and mother's age and an indicator for a missing report of wage.

We also include a number of controls for both siblings. Specifically, X_i^E is a vector of the elder sibling's characteristics, including elder sibling's birth weight, gender, age and ethnicity. X_i^Y is a vector of the younger sibling's characteristics, including the same set of variables as X_i^E. We further add year and province fixed effects and cluster the regression at city level.

[11] When the younger sibling enters school, the older child may need to do more chores. If the younger sibling was doing all the chores before entering school, the new distribution of chores may be more equitable and take away time for studying for the older sibling.

One of the main threats to the unbiasedness of the OLS estimators is that the timing of school enrollment may not be exogenous. For instance, parents can choose to have the younger sibling starting school earlier or later based on reasons which might be correlated with our main variable of interest and unobserved by economists. For example, parents may delay their child's entrance into school due to financial hardships and this could also be reflected in the poor performance of elder children who are also working hard in the household to meet basic needs. Or they could delay the child's entrance, if they think the child would perform better if he/she is older. This could be reflected in better test scores. In this case, we could have endogeniety due to selection issues and omitted variables which would invalidate our hypothesis tests on β .

In order to address this concern, we exploit the Chinese Law of Compulsory Education and use the birth date enforced by the policy as an exogenous variation in school start times. The Law on Compulsory Education stipulates that all children who have their sixth birthday after August 31 may not attend primary school on September 1 that year. In other words, they are ineligible for primary school. Our first stage estimation is specified below.

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

where $Ineligible_i^Y$ is an indicator for the younger sibling's lack of eligibility of enrolling in school. $Ineligible_i^Y = 1$ for those who had their sixth birthday after August 31 in the survey year; $Ineligible_i^Y = 0$ otherwise. Thus, *theta* provides the propensity of a child to be in school. We would expect that *theta* to be negative as a six year old should not be in school if he or she was born in the last four months of the year.

4 Main Results

4.1 Test Scores - OLS

In this next section, we present our main results by first showing the OLS estimates of the impact of of younger sibling on test scores of the older child and then address the possible endogeneity of school enrollment through our instrumental variable estimation. As can be seen in Table 3, we find that when looking at test scores of the older child, there is a positive coefficient on the indicator variable that the younger sibling has entered school. This would mean that having a younger sibling in school boosts the test scores of the elder child. However, in these OLS results, this relationship is not statistically significant in any of the regressions at standard levels and one cannot conclude that test scores improved when both siblings are in school in these naïve regressions. This is not surprising as there can be endogeneities that bias the results upward or downward.

Turning to the other variables in the regressions in Table 3, we find many of the expected results. Column (1) and (2) are the results from the baseline regression, which include both sibling's birth weight (as a proxy of health at birth) and age, parental age, income, and education (categorized as below middle school, middle school, and high school and above), the household's ethnicity, and province fixed effects. Column (3) and (4) add both sibling's gender and a county-level girl ratio, in order to capture potential gender-specific educational resource allocation based on the rooted son-preference culture in rural China. The county-level girl ratio is calculated by using the total number of girls under age 18 divided by the total number of children under age 18. Column (5) and (6) further control for the yearly log educational expense on the elder sibling. Lining up with findings of many other studies, we see that girls perform better than boys on tests than their male counterparts. Scores for both Math and Chinese exams are 3 to 4 percentage points higher for girls. We also see that scores and the linear age term are inversely related. These negative coefficients are picking up the finding that test scores fall as one advances in grade level. Mother's educational attainment seems to play an important role in children's performance in both Chinese and Math; this is consistent with other studies that find that mother's human capital affects investment in the education of children. Specifically, some of the coefficients are positive and significant if the mother has finished junior middle school, and both test scores are significantly and positively related to having a mother who has finished high school or above. To conduct a more rigorous comparison of test scores, we replace the linear age term of elder sibling with grade fixed effects in Column (7) and (8). In this way, we are showing the difference in performance between two students in the same grade, one with an in-school sibling and the other with a pre-school sibling. The regression specification in column (7)/(8) is our preferred specification. Finally, Column (9) and (10) narrow the age range of younger siblings to age 4-8, so that we only estimate the average treatment effects from younger siblings aged 4 to 8. We will elaborate the reasons of doing so in the next section. Given the potential endogeneities in the key variable of interest, it is important to turn our focus to our IV estimates given in the next section.

4.2 Test Scores - IV

To identify potential causality between the younger child's school enrollment and the test score outcomes of the older sibling, we employed instrumental variables techniques. In the first appendix table, we show the first stage results using compulsory education as the IV. The coefficients on the IVs are all negative and significant indicating that if the law says you should not be in school, then you are less likely to be in school. These results are robust across various samples; enter in regressions at the 1 percent level of significance; and are economically significant as well. For example, in the overall group, the likelihood of being in school is about 60 percentage points lower if the law says you should not be in school compared to your slightly older counterparts who are eligible to enter in this academic year.

Our main findings of this study of sibling spillovers are presented in Table 4. In this table, we provide the IV estimates. For both Chinese and Math performance, the school enrollment of the second child has a statistically strong, and economically meaningful positive effect on the elder child. Thus, we find evidence of a positive spillover effect once we control for endogeneity and individual characteristics. In the baseline regression, shown in column (1) and (2), the elder child's Chinese test improves by 3.93 points and the Math test improves by 5.17 points in a 100 scale. In these regressions, having a younger sibling in school tends to help the older sibling in both Math and reading. The estimates are highly consistent when we add in controls for gender and the county level children's girl ratio, in column (3) and (4). After controlling for the log of total educational expense on the elder sibling in current year (2009), we lose the significance in the effect on Chinese scores, albeit the magnitude is almost unchanged, but the effect on math score is highly robust (see column (5) and (6)). Estimates of our preferred specification are shown in column (7) and (8), indicating that having a in-school younger sibling will have non-significant positive effect on Chinese scores and a 6.12 points significant increase in math scores for a student, relative to a same-grade peer who has a pre-school sibling. The impact of the other controls are similar in both economic and statistical significance to those presented in Table 3.

One concern of including all 9-year compulsory education and high school (vocational school) education students in the estimation is that we might invite potential confounding effects that are correlated with age or advances in schooling but failed to be captured by the compulsory education law. In order to address this concern, we narrow the age window of the younger siblings to be just around the cut-off age defined by the compulsory education law. We show the regression results from our preferred specification for this restricted sample in column (9) and (10) in both Table 3 and Table 4. Column (9) and (10) show that, among students who have a younger sibling who is aged 4 to 8, a student's math score will increase by 5.6 points if her sibling is in school. We see a non-trivial increase in Chinese score as well, although it is not significant. We acknowledge that this 4-8 age-range is arbitrarily chosen, even the ages are evenly distributed around the cutoff age.

To dive deeper into sub-age group comparisons, we show results on a number of different age groups of younger siblings as robustness checks (see Appendix Table A2. The general idea is to show an apples-to-apples comparison of school performance among those students whose younger sibling is just around the cut-off age (reached age 6 before August 31) to be legally enrolled in school. Briefly speaking, we find that the younger sibling's schooling status has a fairly robust positive effect on both the elder sibling's Chinese and math scores, even after we slightly move or slide the age window of the younger sibling. This is essentially a fuzzy regression discontinuity design where the young sibling's age is the running variable relative to the school cutoff and August 31st is the threshold. Due to small sample sizes, we are unable to do this more formally and are instead changing the bandwidth to show the robustness of our findings.[12]

As a further robustness check of our identification strategy, we examined whether there was an age gap effect driving the results. This could occur when controlling for age and looking for an in school effect. To rule this out as the main mechanism of younger siblings on older siblings, in that there is a bigger age gap, we looked directly to test whether age matters for older sibling's test scores. We run the main regressions on a sub-sample of children with pre-school younger siblings, with a variable of interest as the younger sibling's age. Results are shown in Table A3. The six regressions presented in the table show the coefficients on the younger sibling's age when various measures of the older sibling's age are controlled for and the dependent variable is Chinese or Math score. The first two columns include linear controls for age; the second two have age dummies; and the last two columns have grade level dummies for the older child. 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. These findings suggest that the impact of the younger child on the older child is from other channels such as the joint studying channel.

The strong positive impact from the younger child's enrollment to the elder child's school academic performance suggests a sibling spillover effect. We hypothesize that the mechanism at work is coming from the older child's increased focus on study when the younger sibling enters school. The older child will need to spend more time dedicated to studying with the younger child, to help with after school obligations for the younger sibling and to possibly act as positive role model. Compared to those with a younger sibling at home, an older

[12] We also developed an alternative strategy for identifying exogenous shocks in educational attainment for younger children. While our main IV uses the timing of the mandatory start date or the school age cutoff, we also designed an IV that captures legal years of education for each child in our sample. This IV is constructed to remove any endogeneity from additional parental choice for children over the age of 6 and we use it as it a robustness check for our main design. It is possible that despite the mandatory 9 years of education, that parents are not following the compulsory education laws. To address this, we construct a 'legal years' of school IV that measures how many years a child should have and use that as a predictor of being in school. Our first stage shows that this instrument is a good predictor of being in school and also provides evidence that a younger child in school boosts the test scores of the elder child. The results in the second stage confirm our main IV results although the positive connection is a bit weaker. These tables are available upon request.

sibling with a younger sibling in school will likely see aggregate study time increase within the family and can benefit from this shift in intensity of school work by devoting less time to unproductive activities or idleness. As noted above, positive spillover effects needed to dominate other possible negative factors with having a second child in school and we find evidence that they do when we control for educational expenses and resources of the household as shown in Table 4. Moving to our next section, we aim to determine who is benefiting from these spillover effects in terms of gender and under varying degrees of son preference.

4.3 Heterogeneity – Gender Pairs

In order to consider possible mechanisms through which these positive outcomes were occurring, we examine whether the impact was stronger for certain gendered pairs of siblings. As we show in Tables 3 and 4, girls tend to do better in school. Large number of studies have documented the gender differences in children's school performances. In particular, girls consistently outperform boys (e.g. Duckworth and Seligman, 2006; Goldin, Katz, and Kuziemko, 2006; Buchmann, DiPrete, and McDaniel, 2008; DiPrete and Jennings, 2012; Lundberg, 2017). We further explore the heterogeneity of results across sibship gender pairs.

Table 5 presents our preferred IV regressions for four subsamples of sibling pairs. They are elder sister-younger brother; elder sister-younger sister; elder brother-younger brother; and elder brother-younger sister pairs. Although the sample sizes are smaller, we still find striking positive effects on sibling pairs with a younger sister (column (3) and (4) and column (7) and (8)). Specifically, column (1) and (2) show that an elder sister would receive no spillover effect from a younger brother going to school. Column (5) and (6) show that the younger brother also has no impact on an elder brother's Chinese score but has a fairly large effect on math score, albeit it is not statistical significant. Column (3)-(4) and (7)-(8) jointly show that having a younger sister in school has a positive impact on the elder sister's Chinese score and on her Math scores with large magnitudes. Again, the insignificance in the elder brother and younger sister pair is probably due to the small sample size.

Following the literature on the gender gap of children in school performance and early human capital development, Table 5 also provides suggestive evidence of our hypothesis that spillover effects occur when two children are in school. However, they are concentrated in pairs where the younger child is a girl. This mechanism may be due to the findings that girls have a better affinity to school work. They begin school with more advanced learning skills that are developed at very early ages; they typically perform more homework hours on average (regardless of a number of factors); and they are found to possess fewer disruptive

Table 3: Impact of younger sibling in school on elder sibling's test score - OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Chinese	Math	Chinese	Math	Chinese	Math	Chinese	Math	Chinese	Math
	(100)		Chinese (100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Younger Sib in School	1.253	1.452	1.112	1.360	1.515	1.272	1.114	0.960	0.0431	0.626
	(1.735)	(1.671)	(1.745)	(1.684)	(1.901)	(2.035)	(1.868)	(2.000)	(1.939)	(1.744)
Father_age	-0.153	-0.147	-0.174	-0.164	-0.184	-0.103	-0.175	-0.145	-0.478	-0.556*
	(0.184)	(0.179)	(0.181)	(0.176)	(0.173)	(0.172)	(0.168)	(0.177)	(0.363)	(0.308)
Mother_age	-0.0716	-0.0109	-0.0736	-0.0132	-0.0745	0.0576	-0.133	-0.0165	0.0382	0.262
	(0.197)	(0.203)	(0.192)	(0.202)	(0.194)	(0.214)	(0.182)	(0.222)	(0.336)	(0.329)
Father Junior Middle School	0.685	-0.929	0.752	-0.846	-0.315	-0.886	-0.496	-1.014	-4.509*	-3.095
	(1.539)	(1.282)	(1.491)	(1.332)	(1.627)	(1.432)	(1.686)	(1.467)	(2.415)	(2.520)
Father Senior Middle School and Above	2.173	1.546	2.189	1.602	1.410	-0.190	1.356	-0.0907	-2.303	-2.699
	(2.001)	(1.732)	(1.874)	(1.672)	(2.146)	(1.789)	(2.118)	(1.856)	(3.406)	(3.261)
Mother Junior Middle School	1.559	0.799	1.271	0.606	2.030*	1.271	2.064*	1.357	5.890***	4.994***
	(0.955)	(1.051)	(1.047)	(1.141)	(1.082)	(1.165)	(1.114)	(1.154)	(1.761)	(1.851)
Mother Senior Middle School and Above	3.494*	3.794*	3.173*	3.491*	3.870*	5.335**	4.115**	5.469***	6.095*	6.336*
	(1.833)	(1.938)	(1.892)	(1.925)	(1.982)	(2.047)	(1.869)	(1.944)	(3.303)	(3.609)
Elder Sib's Age	-0.955***	-0.583**	-0.885***	-0.535*	-0.412*	-0.478*				
	(0.284)	(0.279)	(0.275)	(0.285)	(0.240)	(0.267)				
Younger Sib's Age	0.132	-0.192	0.0853	-0.216	-0.232	-0.290	-0.206	-0.384		
	(0.295)	(0.258)	(0.285)	(0.254)	(0.285)	(0.280)	(0.284)	(0.281)		
Elder Sib is Female			3.632***	2.845***	2.794***	1.915*	2.732***	1.878*	2.052	1.270
			(0.919)	(0.941)	(1.035)	(1.018)	(1.011)	(1.038)	(1.702)	(1.704)
Younger Sib is Female			0.309	0.218	0.649	-0.293	0.624	-0.284	2.012	1.710
			(1.094)	(1.149)	(1.105)	(1.231)	(1.119)	(1.269)	(1.489)	(1.484)
County Children Female Ratio			-22.67	-10.14	-16.34	-1.668	-16.71	-3.233	5.501	13.48
			(18.43)	(20.11)	(16.85)	(20.42)	(16.49)	(20.16)	(24.23)	(22.17)
ln(Edu Expense)					-0.283	-0.0643	-0.106	-0.108	-0.570	-0.526
					(0.421)	(0.464)	(0.483)	(0.559)	(0.455)	(0.597)
Observations	671	671	671	671	574	574	574	574	209	209

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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Impact of younger sibling in school on elder sibling's test score - IV

	(1) Chinese (100)	(2) Math (100)	(3) Chinese (100)	(4) Math (100)	(5) Chinese (100)	(6) Math (100)	(7) Chinese (100)	(8) Math (100)	(9) Chinese (100)	(10) Math (100)
Younger Sib in School	3.930*	5.174**	3.943*	5.222**	4.159	5.881**	3.799	6.115**	2.760	5.602**
	(2.294)	(2.628)	(2.303)	(2.594)	(2.573)	(2.970)	(2.786)	(3.064)	(2.121)	(2.403)
Father_age	-0.164	-0.162	-0.185	-0.179	-0.186	-0.105	-0.175	-0.144	-0.500	-0.596**
	(0.179)	(0.176)	(0.176)	(0.173)	(0.167)	(0.164)	(0.160)	(0.167)	(0.320)	(0.275)
Mother_age	-0.0645	-0.000999	-0.0661	-0.00301	-0.0786	0.0505	-0.135	-0.0204	0.0190	0.227
	(0.197)	(0.200)	(0.192)	(0.199)	(0.190)	(0.207)	(0.178)	(0.214)	(0.306)	(0.302)
Father Junior Middle School	0.719	-0.881	0.786	-0.800	-0.352	-0.950	-0.512	-1.043	-4.905**	-3.821*
	(1.521)	(1.261)	(1.469)	(1.305)	(1.590)	(1.389)	(1.633)	(1.413)	(2.171)	(2.318)
Father Senior Middle School	2.198	1.580	2.211	1.633	1.333	-0.324	1.314	-0.171	-2.772	-3.558
	(1.956)	(1.695)	(1.826)	(1.630)	(2.082)	(1.736)	(2.043)	(1.796)	(3.154)	(3.140)
Mother Junior Middle School	1.497	0.713	1.213	0.526	1.967*	1.162	1.970*	1.177	5.803***	4.834***
	(0.951)	(1.022)	(1.036)	(1.106)	(1.054)	(1.111)	(1.080)	(1.076)	(1.634)	(1.800)
Mother Senior Middle School	3.687**	4.063**	3.384*	3.778**	4.066**	5.677***	4.286**	5.796***	6.250**	6.620**
	(1.777)	(1.906)	(1.838)	(1.899)	(1.909)	(2.029)	(1.784)	(1.898)	(2.943)	(3.307)
Elder Sib's Age	-0.968***	-0.601**	-0.900***	-0.557**	-0.438*	-0.524**				
	(0.281)	(0.275)	(0.272)	(0.279)	(0.239)	(0.261)				
Younger Sib's Age	-0.111	-0.530*	-0.170	-0.564*	-0.471	-0.705*	-0.456	-0.865**		
	(0.322)	(0.314)	(0.321)	(0.313)	(0.354)	(0.363)	(0.374)	(0.372)		
Elder Sib is Female			3.604***	2.807***	2.768***	1.869*	2.698***	1.812*	2.041	1.250
			(0.904)	(0.913)	(1.009)	(0.977)	(0.972)	(0.978)	(1.553)	(1.574)
Younger Sib is Female			0.339	0.260	0.677	-0.244	0.653	-0.227	2.338*	2.307*
			(1.057)	(1.109)	(1.068)	(1.198)	(1.071)	(1.216)	(1.378)	(1.361)
County Children Female Ratio			-22.12	-9.396	-15.84	-0.791	-16.46	-2.765	6.947	16.13
			(17.81)	(19.57)	(16.05)	(19.61)	(15.50)	(19.20)	(21.84)	(19.98)
ln(Edu Expense)					-0.256	-0.0167	-0.0965	-0.0907	-0.541	-0.473
					(0.418)	(0.469)	(0.466)	(0.546)	(0.396)	(0.537)
Observations	671	671	671	671	574	574	574	574	209	209

Notes: This table presents the IV 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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

behaviors (e.g. DiPrete and Jennings, 2012; Becker, Hubbard, and Murphy, 2010; Goldin et al., 2006). With a younger sister more absorbed in study times and attention to school, it provides a stronger positive impact to the elder siblings' school performance than having a younger brother beginning school. While girls are already better performing in school, the girl-girl pair shows a constantly strong effect in both Math and Chinese school subjects.

4.4 Heterogeneity – Son Preference

However, it is well-known that there has been a son preference in many countries including China in the past. A substantial literature documents the son-preference culture in Asian communities, and shows that there are impacts on the family structure and resource allocations to children of opposite genders (e.g. Blau et al., 2020; Kaul, 2018; Hong Chew et al., 2017;Das Gupta et al., 2003). For example, parents may invest more in their sons if they believe they will take care of them in later life. If there is a strong son preference in our data, we may find heterogeneity in our results with a possible bias when aggregating our sibling pairs. To address possible son preference we have already looked at sibling pairs and found that the elder boy-young boy pair and elder daughter-younger son pairs show no effect of having the young son in school on the elder sibling's test scores. While these parents may have had the desire to have a younger son, there does not appear to be an impact (negative or positive) on the older child's test scores. Thus, any son preference in our gendered pairs is not manifested in test scores.

Another channel we explored was to split our sample by counties that had above and below median shares of girls. As mentioned earlier, the county-level girl ratio is calculated by using the total number of girls under age 18 divided by the total number of children under age 18. In the 2009 RUMiC data, we find that the median girl ratio at county level is 0.483. This can be interpreted as only 48.3 percent of children under 18 are girls. This imbalance has been widely documented in China. What we do here, however, is to split our sample by above (less son preference) and below the median (more son preference) to see if there are differential spillover effects. We believe, while only a rough approximation, that this division gives us an indication of which counties have a greater tendency to have a son-preference bias.

In our empirical work, we estimate our main IV regression specifications, similar to those in Table 4 and compare subsamples in counties below and above the median girl ratio. Table 6 presents the results with Column(1) and (2) being subsamples living in counties with more severe son-preference and Columns (3) and (4) have the higher girl ratios. Interestingly, the strong and positive effect on Chinese scores only shows up in the sample with less

Table 5: Heterogeneity by siblings gender pairs

	Elder F + Younger M		**Elder F + Younger F**		**Elder M + Younger M**		**Elder M + Younger F**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Chinese (100)	Math (100)	Chinese (100)	Math (100)	Chinese (100)	Math (100)	Chinese (100)	Math (100)
Younger Sib in School	0.306	1.324	12.01**	13.75**	0.0137	7.747	16.61	16.56
	(4.006)	(3.931)	(5.620)	(6.347)	(8.831)	(11.78)	(15.40)	(13.63)
Father_age	0.332	0.178	-0.817**	-0.424	0.303	0.220	-1.488***	-1.390**
	(0.218)	(0.216)	(0.405)	(0.400)	(0.584)	(0.633)	(0.524)	(0.675)
Mother_age	-0.322	0.110	0.00387	-0.280	-0.471	-0.739	2.180*	1.231
	(0.197)	(0.297)	(0.441)	(0.423)	(0.582)	(0.547)	(1.157)	(1.159)
Father Junior Middle School	1.016	2.433	-1.300	-0.877	3.814	-2.666	-11.77**	-11.03***
	(1.877)	(2.047)	(3.112)	(2.464)	(3.975)	(4.325)	(4.583)	(4.279)
Father Senior Middle School and Above	2.013	1.684	4.771	3.103	9.386	2.336	-12.20	-12.78*
	(2.228)	(2.348)	(4.170)	(3.912)	(6.166)	(6.749)	(7.424)	(6.894)
Mother Junior Middle School	3.047**	1.258	-0.417	0.515	-1.515	-2.092	6.321	2.958
	(1.316)	(1.378)	(2.359)	(2.164)	(2.395)	(2.940)	(4.297)	(4.925)
Mother Senior Middle School and Above	4.831**	4.217	-3.086	7.438**	-2.559	0.742	27.14*	22.12*
	(2.338)	(2.660)	(4.239)	(3.241)	(5.414)	(4.216)	(13.96)	(12.14)
Younger Sib's Age	-0.0450	-0.0528	-0.996	-1.525**	-0.139	-1.151	-1.895	-2.354
	(0.458)	(0.452)	(0.666)	(0.773)	(0.843)	(1.116)	(1.885)	(1.733)
County Children Female Ratio	-28.82	-9.057	14.23	2.624	-61.19**	-39.28	-53.94	1.545
	(18.96)	(21.74)	(26.27)	(31.24)	(24.40)	(30.14)	(41.68)	(42.48)
ln(Edu Expense)	0.241	0.604	-0.0595	-1.266	-0.395	-0.126	-1.653	-1.023
	(0.500)	(0.656)	(0.807)	(0.892)	(0.928)	(1.065)	(1.354)	(1.224)
Observations	263	263	121	121	104	104	86	86

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 city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

son-preference. The positive effects on math scores are not different between two samples. Meanwhile, the coefficients on the dummy variable of elder sibling being female are only significant in the less son-preference sample. We can posit that these results are being generated by investments in daughters. In terms of the size of the effect, for those living in less son-preference communities, the peer effect boosts Chinese scores by 6.51 points compared the overall result of 3.80 in Table 4.

Table 6: Heterogeneity: son-preference culture

	More Son-Preference		**Less Son-Preference**	
	(1)	(2)	(3)	(4)
	Chinese (100)	Math (100)	Chinese (100)	Math (100)
Younger Sib in School	0.461	5.003	6.512*	5.255
	(3.755)	(3.872)	(3.463)	(4.433)
Elder Sib is Female	1.596	1.631	2.835**	2.336**
	(1.296)	(1.304)	(1.180)	(1.114)
Younger Sib is Female	-0.911	-1.789	2.139	1.462
	(1.132)	(1.460)	(1.448)	(1.533)
Observations	322	322	252	252

Notes: Estimates in column (1) and (2) are from a subsample of county-level girl ratio less than the median (more son-preference) and estimates in column (3) and(4) are from a subsample of county-level girl ratio more than the median (less son-preferencee). All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.5 Mechanisms

In this section, we explore possible mechanisms that may or may not be behind the sibling spillover effect that we have found in our IV results in Tables 4 – 6. As we have found a strong positive impact from the second child's school enrollment on the older child's school performance, we hypothesize that this improvement is due to peer effects or role modeling which keep the older child more engaged in school. When the second child is enrolled in school, the older child will likely spend more time in an academic environment both at school and after school compared to the period when the younger child was too young to enter school.

We expect that there will be increased contact hours between the siblings as they study together. If this is the case, the proximity of the siblings will be a factor in the test score improvement. We find that to be the case and present these results in Table 7. Specifically, we find in our IV results that examine whether sibling pairs are more likely to be near each other that the older child is less likely to be attending boarding school once the younger child enters school. Thus, they are both more likely to be living at home. Recall, we use our instruments to address possible biases when looking at the impact of school enrollment on school distance and boarding school status. Column (1) shows that when the younger sibling begins to school, the elder siblings are more likely to attend school 1.27 kilometers closer to home than otherwise. However, this estimate is not statistically significant. Column (2) shows that the elder sibling is 17 percentage points less likely to attend boarding school when both members of the sibling pair are in school. This effect is strong in terms both the magnitude and significance. Though it is beyond the scope of this paper to explore the mechanism behind such results, Table 7 shows that with younger siblings starting school, the elder sibling is more likely to be closer home and staying home overnight

Table 7: Impact on school distance and boarding school status

	(1) Distance to School (km)	(2) Boarding School
Younger Sib in School	-1.270	-0.171***
	(5.517)	(0.0633)
Observations	1582	1582

Notes: Each column is a separate regression. The dependent variable in column (1) is the elder siblign's distance to school from home, in kilo-meter. The dependent variable in column (2) is an indicator of the elder sibling goes to a boarding school. All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Next, we show that the test scores effects are linked directly to distance measures between siblings and we explore the gender-specific effects by splitting the sample by sibling gender pairs. To do so, we add an interaction with whether the older sibling is in boarding school and an indicator whether the younger sibling is in school, in Panel A, Table 8. In Panel B, we add an interaction with whether the elder sibling goes to a school above median distance (among all other schools) and whether the younger sibling is in school. In both panels, we estimate the main regression on both the full sample and the subsample with only female younger siblings. The results suggest that distance and gender matter.

The greater the proximity benefits older siblings if the younger sibling is a girl. Specifically, older sibling's scores are worse if they are in boarding school and the younger sister has entered school. This assessment of a possible transmission mechanism provides some evidence that sibling effects are operating through increased joint study time. As seen in Panel A, the coefficient on the interaction of younger sibling enrolled in school and elder sibling attending boarding school is negative for both Chinese scores (reduction of 4.11 points) and Math scores (reduction of 3.44 points). The reduction effects are even stronger when the younger child is a girl, reduction of 13.3 points for Chinese scores and 14.17 points for Math scores. Thus, elder children in boarding school lose the opportunity of to assert their positive peer effects and role modeling through a lack of sibling contact hours. It is interesting to note that attending a boarding school only increases scores when the younger child is girl.

Panel B shows consistent although weaker findings. It takes into account the median distance from school and adds an above median distance indicator which is interacted with younger sibling in school. These results are weaker in that only one of the four interactions is significant. Nonetheless, the coefficient is negative and significant for Chinese scores when using the biggest sample. The negative sign captures the possibility that attending attending a school far away – farther than the median distance – significantly weakens the positive spillover effects from the younger sibling enrollment.

4.6 Parental Investment

Studies attribute a significant portion of human capital development to parental time and monetary investment on children (Yang and Bansak, 2020; Guryan et al., 2008; Blau and Currie, 2006; Yum, 2016; Del Boca et al., 2013). In this section, we want to assess or rule out whether parents change their behavior to increase or decrease investments in the human capital of their children. If they increase their investments, our findings of sibling effects could be masking the additional positive effects of additional time spent with children or funding. If parents reduce time and money, our findings of a positive sibling effect must be greatly offsetting negative parental inputs.

When a young child enters school, parents may change their time inputs with their elder child. The amount and direction is not clear; parents may spend less time caring for the elder sibling when the younger child needs more parental supervisions or they may spend more time with the older child if schooling frees up time that was previously spent caring for the younger child. Any change of parental care time on the elder sibling may create bias to our estimates of sibling spillover effects.

In Table 9, we use self-reported parental worry as an indicator for changes (or desire for changes) in parental time inputs. It is reasonable to consider that an increase in parental worry will result in an increase from the demands of parental supervision needed on the second child's study time when the younger child enters school. When we control for the same variables as in our main regressions and utilize an IV for younger sibling enrollment, we find no significant results or effect of having a second child in school on parental worry for the elder child. Thus, it does not appear that time inputs of parents is influencing the size of the sibling effect. We conclude that the improvement in elder sibling's test scores when the younger sibling begins elementary school enroll is not derived from changes in parental supervision.

In our last set of results, we examine what happens to resource allocation when a second

Table 8: Effects by elder sibling's school type: boarding or non-boarding

	All Siblings		Younger Sibling is Female	
	(1)	(2)	(3)	(4)
	Chinese (100)	Math (100)	Chinese (100)	Math (100)
Panel A: Boarding School				
Younger Sib in School	5.674**	7.163**	18.96***	19.22***
	(2.839)	(3.544)	(5.939)	(6.392)
Younger Sib in School*Elder Sib in Boarding School	-4.105*	-3.442	-13.30***	-14.17***
	(2.408)	(2.491)	(4.159)	(4.307)
Elder Sib in Boarding School	1.830	1.212	4.409*	4.709**
	(1.995)	(1.952)	(2.599)	(2.357)
Panel B: Above Median Distance				
Younger Sib in School	5.266*	6.668**	12.33**	14.16**
	(2.806)	(3.388)	(5.962)	(6.277)
Younger Sib in School*Elder Sib in School > Median Distance	-3.930*	-1.403	-3.775	-5.443
	(2.272)	(2.248)	(4.370)	(3.917)
Elder Sib in School > Median Distance	1.475	0.737	0.434	0.929
	(1.690)	(1.480)	(3.243)	(2.744)
Observations	574	574	207	207

Notes: The key independent variable in panel A is a dummy of the elder sibling goes to a boarding school. The key independent variable in panel B is a dummy of the elder sibling's school distance is above median. Each column is a separate regression. The first two columns show results from the full sample and the last two columns show results from a subsample with only female younger sibling households.

Table 9: Total Educational Expense on the elder sibling

	(1) 2008&2009 Sample	(2) 2009 Sample
Panel A: Educational Expenses on the Elder		
Younger Sib in School	-678.5*	-909.6
	(382.5)	(596.9)
Observations	1485	641
Panel B: Parent's Worry about the Elder		
Younger Sib in School	0.0362	0.00765
	(0.0717)	(0.106)
Observations	1626	702

Notes: Each column is a separate regression. The dependent variable in Panel A is the total educational expense on the younger sibling. The dependent variable in Panel B is an indicator of the whether parents are worried about the elder sibling. "Worry" is an index 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.Column (1)'s sample is both 2008 and 2009 and column (2) is only using sample from 2009, which is consistent with the sample of the main results (recall that we only have test scores in the 2009 survey). All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

child enters school. What we find is not surprising. When a second child enters school, the spending on the older child declines. Table 9 quantifies this decline across two separate samples and shows a decline in spending of about 700 to 900 RMB on the first born child when the second child starts school. We include two years of data in one sample since we are able to utilize this bigger sample due to the availability of the expenditure variable in both survey years. Despite cuts in funding for older children, they still see their test scores rise when their younger sibling enters school. Again, we find more evidence of a positive sibling effect.

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, even when spending on the elder sibling's education is reduced. This suggests the positive spillover effect from the younger sibling to the elder can more than offset cuts in educational expenditures. The main driver of the positive spillover comes from the younger sibling being a female. Our further explorations of the intensity of son preference at the county level suggests that areas with less son-preference have stronger positive sibling spillover effects; furthermore, there are additional positive effects if the younger sibling is a girl.

It is not surprising that the younger sister has the strongest positive influence on the elder sibling, given that girls in our sample have significantly higher test scores than boys. Families with less son-preference could possibly magnify this positive effect as educational resources will be equally allocated to girls. Future studies on peer effects on school performance should take gender composition into consideration. This set of findings contributes to the literature of gender inequality in education and adds empirical evidence to the positive externalities of women's education improvement. Thanks to these spillovers, policies that promote young women's education may well have important effects on other children as well, suggesting a potential multiplier effect of a policy.

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Table A1: First Stage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Chinese (100)	Math (100)	Chinese (100)	Math (100)	Chinese (100)	Math (100)	Chinese (100)	Math (100)	Chinese (100)	Math (100)
Ineligible	-0.6278***	-0.6278***	-0.6290***	-0.6290***	-0.6218***	-0.6218***	-0.6135***	-0.6135***	-0.6454 ***	-0.6454***
	(0.0516)	(0.0516)	(0.0517)	(0.0517)	(0.0609)	(0.0609)	(0.0633)	(0.0633)	(0.0663)	(0.0663)
F-stat	149	149	149	149	105	105	95	95	99	99
Observations	671	671	671	671	574	574	574	574	209	209

Notes: This table presents the first stage of IV estimates and F-stats.

Table A2: Robustness

	(1) Chinese (100)	(2) Math (100)	(3) Chinese (100)	(4) Math (100)	(5) Chinese (100)	(6) Math (100)	(7) Chinese (100)	(8) Math (100)	(9) Chinese (100)	(10) Math (100)	(11) Chinese (100)	(12) Math (100)
Younger Sib in School	3.926**	5.450***	2.760	5.602**	2.699	4.764	3.704*	5.914***	1.626	5.965**	2.095	5.622
	(1.833)	(2.071)	(2.121)	(2.403)	(3.306)	(3.740)	(2.000)	(2.046)	(2.579)	(2.728)	(3.944)	(4.245)
Elder Sib's Birth Weight	0.000166	0.00330*	-0.000378	0.00404*	-0.000354	0.00441*	0.000180	0.00211	-0.000419	0.00293	0.00107	0.00527*
	(0.00169)	(0.00188)	(0.00186)	(0.00213)	(0.00201)	(0.00228)	(0.00202)	(0.00224)	(0.00240)	(0.00248)	(0.00305)	(0.00298)
Younger Sib's Birth Weight	-0.00571***	-0.00633***	-0.00502***	-0.00704***	-0.00503***	-0.00637***	-0.00468***	-0.00380**	-0.00369*	-0.00434**	-0.00440**	-0.00396*
	(0.00123)	(0.00178)	(0.00160)	(0.00190)	(0.00153)	(0.00196)	(0.00137)	(0.00162)	(0.00212)	(0.00207)	(0.00206)	(0.00212)
Father_age	-0.443	-0.605**	-0.500	-0.596**	-0.619*	-0.738**	-0.881**	-1.078***	-1.035***	-1.148***	-1.291***	-1.438***
	(0.308)	(0.276)	(0.320)	(0.275)	(0.364)	(0.309)	(0.369)	(0.281)	(0.361)	(0.258)	(0.416)	(0.317)
Mother_age	-0.120	0.178	0.0190	0.227	0.150	0.380	0.229	0.407	0.440	0.473	0.673	0.691
	(0.269)	(0.276)	(0.306)	(0.302)	(0.327)	(0.329)	(0.382)	(0.337)	(0.409)	(0.403)	(0.465)	(0.476)
Father Junior Middle School	-4.757**	-3.935*	-4.905**	-3.821*	-3.469*	-2.168	-3.859	-4.091*	-4.314*	-4.149	-1.582	-1.247
	(2.192)	(2.074)	(2.171)	(2.318)	(2.025)	(2.515)	(2.627)	(2.390)	(2.289)	(2.647)	(2.276)	(3.184)
Father Senior Middle School	-1.550	-3.117	-2.772	-3.558	-2.075	-2.559	0.541	-2.086	-0.583	-2.474	0.831	-0.719
	(2.876)	(2.851)	(3.154)	(3.140)	(2.882)	(2.974)	(3.454)	(3.360)	(3.486)	(3.762)	(3.172)	(3.701)
Mother Junior Middle School	5.487***	4.758***	5.803***	4.834***	4.614**	3.716	5.218**	4.550**	5.892***	4.595**	4.024*	3.182
	(1.824)	(1.779)	(1.634)	(1.800)	(2.038)	(2.278)	(2.072)	(2.081)	(1.727)	(1.911)	(2.364)	(2.435)
Mother Senior Middle School	6.298**	7.262**	6.250**	6.620**	4.116	4.034	5.457*	5.580	6.068**	4.627	3.059	1.085
	(2.893)	(3.342)	(2.943)	(3.307)	(3.206)	(3.744)	(3.000)	(3.622)	(2.962)	(3.699)	(3.321)	(4.584)
Elder Sib is Female	3.084**	1.753	2.041	1.250	2.560	1.251	3.546**	1.282	2.278	0.360	2.968	0.532
	(1.421)	(1.454)	(1.553)	(1.574)	(1.619)	(1.737)	(1.685)	(1.606)	(1.871)	(1.777)	(1.975)	(2.025)
Younger Sib is Female	2.013	2.293*	2.338*	2.307*	2.593*	1.959	3.989***	4.593***	4.518***	4.895***	5.739***	5.261***
	(1.314)	(1.339)	(1.378)	(1.361)	(1.504)	(1.569)	(1.291)	(1.532)	(1.314)	(1.627)	(1.404)	(1.871)
County Children Female Ratio	-12.39	-2.920	6.947	16.13	8.174	16.26	-28.60	-29.47	-10.11	-10.49	-12.14	-20.28
	(18.43)	(18.30)	(21.84)	(19.98)	(21.19)	(23.39)	(19.89)	(18.22)	(25.21)	(20.44)	(24.73)	(26.39)
ln(Edu Expense)	0.0328	0.0952	-0.541	-0.473	-0.516	-0.524	0.265	0.706	-0.396	0.146	-0.277	0.250
	(0.423)	(0.507)	(0.396)	(0.537)	(0.434)	(0.561)	(0.406)	(0.507)	(0.472)	(0.573)	(0.526)	(0.629)
Observations	243	243	209	209	181	181	195	195	161	161	133	133

Notes: This table presents the IV estimates of the main regression of different samples. Column (1) and (2) are from sample with younger sibling aged 4-9; column (3) and (4) are from sample with younger sibling aged 4-8, which is identical to the last two columns of Table 2 and 3. Column (5) and (6) are from sample with younger sibling aged 4-7. Column (7) and (8) are from sample with younger sibling aged 5-9. Column (9) and (10) are from sample with younger sibling aged 5-8. Column (11) and (12) are from sample with younger sibling aged 5-7. All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Falsification Test: Is it a Sibling's Age Gap Story?

	(1)	(2)	(3)	(4)	(5)	(6)
	Chinese (100)	Math (100)	Chinese (100)	Math (100)	Chinese (100)	Math (100)
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. Column (1) and (2) are controlling for a linear term of the elder sibling's age; column (3) and (4) are controlling for elder sibling's age dummies. Column (5) and (6) control for the elder sibling's grade dummies. All standard errors are clustered at city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.