Additional Returns to Investing in Girls' Education: Impact on Younger Sibling Human Capital

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Abstract

This paper estimates the effect of oldest sister's education on child human capital development. In many developing countries, oldest sisters share significant childcare responsibilities in the household and can influence younger siblings' learning. I propose a model that predicts competing effects of increasing oldest sister's schooling on younger sibling human capital. Using an identification strategy that exploits the gender segregation of schools in Pakistan, I find that oldest sister's schooling significantly improves younger brothers' literacy and schooling. These results indicate that evaluations of programs targeting girls' education that ignore these spillovers on younger siblings systematically underestimate total benefits.

JEL codes: I21, D13, J13, J16

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1 Introduction

While there is a large literature documenting the beneficial impact of maternal schooling on child development, surprisingly little is known about the effects of an older sister's schooling. For example, past studies have shown that maternal education improves birth outcomes (Currie et al., 2003), nutrition (Thomas et al., 1991), education (Haveman and Wolfe, 1995), and test scores (Rosenzweig and Wolpin, 1994; Moore and Schmidt, 2007). Yet girls often play a significant role in raising their younger siblings as well. The role of older sisters may be particularly important in developing countries where they share considerable childcare responsibilities within the household (Levison and Moe, 1998; Ilahi, 2001; Edmonds, 2006). As a childcare provider, the education of the older sister has the potential to meaningfully influence younger sibling learning and development.

This paper is, to the best of my knowledge, the first to estimate the effect of oldest sister's education on the human capital acquisition of younger siblings. I analyze the effect of oldest sister's schooling in rural Pakistan where 75% of mothers and 40% of fathers have no schooling. In many households, the oldest sister is one of the first family members to acquire any schooling. Thus, it is not surprising that the oldest sister is an important source of help with studies at home. Only one out of five children who receive help with studies from a family member get it from a parent. When parents are not the ones helping with studies, the oldest sister fulfills that role 70% of the time. Given the low education of parents and the oldest sister's role as a tutor, one might expect oldest sister's schooling to generate meaningful spillovers within the family.

A key way in which oldest sister's schooling differs from mother's schooling is that mother's schooling is usually completed before children are born while oldest sister's schooling is ongoing when the child is young. This creates a tradeoff for oldest sister's schooling which does not exist for mother's schooling because oldest sister's schooling requires time in school

which can crowd out time spent with the younger sibling. While increasing oldest sister's schooling improves the quality of the time she spends with the younger sibling (quality effect), it can reduce the time spent with the younger sibling (quantity effect). Because increases in oldest sister's schooling are associated with a positive quality effect and a negative quantity effect, the net impact on younger sibling human capital is theoretically ambiguous.

Evaluating the effect of oldest sister's education is not straightforward. There are likely important differences in observed and unobserved characteristics across households that have daughters with different amounts of education. The gender segregation of government schools in Pakistan provides plausibly exogenous variation in oldest sister's schooling stemming from variation in distance from the home to the nearest girls school. Distance to girls school is associated with a significant reduction in girls' schooling in Pakistan.[1] Concerns about girls' safety and adherence to cultural norms of *purdah* drive this penalty imposed by distance to school which is only observed for girls and not for boys.[2]

Accordingly, I use distance to the closest girls school as a source of quasi-experimental variation in oldest sister's schooling and estimate the effect of oldest sister's schooling on younger brother outcomes.[3] I condition on a flexible characterization of household location which arguably accounts for the determinants of boys' human capital. These household location controls include distance to the closest boys school, distance to the closest private school, distance to the village center and village fixed effects.

Although concerns have been raised about the validity of the distance instrument in the U.S. (Carneiro and Heckman, 2002; Cameron and Taber, 2004), I show that the condi-

[1] This has been documented by Alderman et al. (2001) and Andrabi et al. (2007) in Pakistan, and Burde and Linden (2013) and Muralidharan and Prakash (2014) in neighboring Afghanistan and India, respectively.

[2] *Purdah* is the social and religious custom of seclusion of females from males. Adherence to *purdah* is apparent in the gender-segregation of schools (Kim et al., 1999). While this segregation allows for analyzing the effect of oldest sister's education on younger brothers, the effect of older brother's education on younger sisters can not be analyzed because distance to boys school does not significantly predict boys' education.

[3] While the impacts of oldest sister's education on younger brothers and sisters are of theoretical interest, I do not use this strategy to estimate the effects on younger sisters since they attend girls schools as well.

tional instrument utilizing the gender segregation of schools in rural Pakistan does not suffer from the issues affecting these usual applications using distance. I show that conditional on the household location controls, distance to girls school is not significantly related with household characteristics including parents' schooling and literacy, household wealth and household composition. When using this conditional instrumental variables (IV) strategy, oldest sister's schooling is also not significantly related to her *older* brother's human capital. While it is theoretically possible that an older brother may be influenced by his younger sister's schooling, such an effect should be significantly smaller than the effect of oldest sister's schooling on her younger brothers to whom she is a childcare provider, tutor and role model. It is informative that I do not find any positive effects of oldest sister's schooling on older brother outcomes because threats to instrument validity include unobserved household determinants of boys' human capital that are related to proximity to girls school. If conditional on the household location controls, distance to girls school was still correlated with unobserved determinants such as how much parents value education or better neighborhoods, one would expect to see that reflected in findings of positive associations for older brothers. The fact that I find no significant effects of oldest sister's schooling on older brothers, therefore, provides further support for the validity of the research design.

I find that oldest sister's schooling has significant, beneficial effects on younger brothers' human capital. An additional year of schooling completed by the oldest sister increases the younger brothers' schooling by 0.23 years or 8 percent relative to the mean. It also increases the probability of a primary school-aged younger brother being able to read and write by 5.3 percentage points (13%) and 6.4 percentage points (20%), respectively. The oldest sister schooling effects I find are the same order of magnitude of maternal education. While oldest sister's schooling has a net positive effect, I provide suggestive evidence that oldest sister's schooling is associated with both a positive quality effect and a negative quantity effect.

These results may interest a variety of researchers and policymakers. First, the find-

ing of significant effects of oldest sister's education broadens our understanding of human capital production by highlighting the role that siblings play.[4] Second, these results call into question the validity of sibling fixed effects estimators because inter-sibling comparisons can be confounded by the presence of sibling spillover effects. Third, these results have important implications for the evaluation of programs targeting girls' education including gender-targeted conditional cash transfer programs such as the Female Secondary School Stipend Programme in Pakistan. Cost-benefit analyses of such programs that ignore spillover effects on siblings likely underestimate the total benefits of these programs. This underestimation of benefits is significant because unlike the effects of maternal education that accrue to the future generation, this study highlights benefits from girls' education that accrue contemporaneously to the current generation.

This paper is organized as follows. Section 2 develops a simple model to illustrate how oldest sister's schooling might affect younger brother human capital. Sections 3 and 4 describe the data and institutional background. Section 5 describes the empirical model and identification strategy. Section 6 presents results and section 7 concludes.

2 Model

Following Becker's modeling of parents' time investment as an input into children's human capital production, I assume time spent with the oldest sister is an input into younger sibling human capital (Becker, 1964).[5] Time spent with a more educated oldest sister can raise the human capital of younger siblings through a positive quality effect for several reasons. Zajonc and Markus (1975) first noted that the older sibling's intellectual development provided an opportunity for teaching younger children. Several studies in child development and

[4]Past studies analyzing the influence of siblings have focused on the effect of the number and sex composition of siblings on education (Butcher and Case, 1994; Kaestner, 1997; Black et al., 2005).

[5]I focus on the *oldest* sister's schooling because the oldest sister is responsible for looking after younger siblings. Edmonds (2006) shows that in Nepal, the oldest girl works 10 hours more than the next oldest girl because of the oldest girl's comparative advantage in home production and caring for younger children.

psychology have shown that older siblings can teach new cognitive concepts to their younger siblings (Brody, 2004). Similar to the language benefits for children of educated mothers (Brooks-Gunn and Markman, 2005), children may also benefit from the language skills of their educated oldest sisters (Pine, 1995). A more educated oldest sister is capable of helping a younger child with studies and the quality of the help given is also likely better. Given the role of the oldest sister as a childcare provider and tutor in rural Pakistan, the potential for younger sibling learning is immense.

Given the oldest sister's role in childcare, the effect of oldest sister's schooling might be similar to that of maternal schooling. Unlike mother's schooling, however, oldest sister's schooling is often ongoing when the child is young. Increasing the oldest sister's schooling requires enrollment in school and school work which can compete with time spent with the younger sibling, particularly when the sibling is of pre-school age and spends most of his time at home. I denote this potential negative effect of increasing oldest sister's schooling on time spent with the younger sibling, and hence human capital, the quantity effect.

2.1 Theoretical Predictions

Consider a household with parents and two children, an older girl and a younger boy.[6] Parents maximize a utility function which is concave in period 1 consumption and children's period 2 utility.[7] In period 1, parents have wealth, W_p, and decide how much to consume, C, and the allocatation of their children's time between schooling, y_i and household production, $x_i = 1 - y_i$ (i equals s for the oldest sister and b for the younger brother). With instruction time in the school day fixed, y_i can be interpreted as years of schooling.

The oldest sister's human capital is a positive, concave function of her years of schooling: $H_s = f(y_s)$. The younger brother's human capital, $H_b = g(y_b, x_s, H_s)$ is a function of his

[6] I model the relationship between oldest sister and younger brother, and not that between oldest sister and younger sister because I empirically estimate the former relationship only.

[7] As a simplification, parents are assumed dead in period 2 but changing this does not alter the predictions.

years of schooling, the time the oldest sister spends at home, and the human capital of the oldest sister. The oldest sister's time at home, x_s, is an input with the implicit assumption that time at home is also spent with the younger brother.[8] The oldest sister's human capital raises the younger brother's human capital through the quality effect discussed earlier.

The productivity of time in household production, p_s and p_b, varies by gender. Since government schools are free, the gender-specific cost of schooling, d_s and d_b, capture distance to girls and boys school which are interacted with y_i to allow the cost incurred to vary with years of schooling. In period 2, the children are adults whose utility is a function of wealth, W_i, which is their human capital, H_i, times the gender-specific wage rate, r_i.[9] Parents derive utility from their children's period 2 utility according to altruism parameters, a_s and a_b. Due to son preference, reliance on sons in old age, and daughters moving out of their parents' house and into the husband's household upon marriage, it is likely that a_s is less than a_b.

The parents' objective function is to maximize the following utility $U(C) + a_s V(W_s) + a_b V(W_b)$ subject to the budget constraint $C + d_s y_s + d_b y_b = W_p + p_s(1 - y_s) + p_b(1 - y_b)$.[10] Parents choose y_b^* to satisfy the following first-order condition:

$$a_b V_{w_b} r_b g_{y_b} = (p_b + d_b) U'(c) \qquad (1)$$

This yields the standard result that parents choose younger brother's schooling, y_b^*, so that the utility gain due to his increased wealth associated with a marginal increase in y_b equals the increase in the disutility associated with increased schooling costs. These costs include foregone household production and the distance cost of schooling.

[8]The oldest sister's household responsibilities include looking after younger siblings, and even if she is working on other chores, time at home is spent potentially interacting with them.

[9]The labor force participation rate for women in Pakistan 10 years and older is 21% (Federal Bureau of Statistics, 2009). Since girls usually do not work, non-pecuniary returns to education such as marriage market returns and benefits for grandchildren are more important

[10]$U', V_{w_s}, V_{w_b}, f_{y_s}, g_{y_b}, g_{x_s}, g_{H_s}$ are positive, and $U'', V_{w_s w_s}, V_{w_b w_b}, f_{y_s y_s}, g_{y_b y_b}, g_{x_s x_s}$, and $g_{H_s H_s}$ assumed to be negative. Parameters $W_p, a_s, a_b, r_s, r_b, p_s, p_b, d_s$, and d_b are exogenously determined. I assume the Inada conditions to get interior solutions for C, y_s, and y_b.

The marginal benefit and cost of oldest sister's schooling also include spillover effects on the younger brother. An increase in the oldest sister's schooling increases not only her wealth but also the wealth of the younger brother because of the quality effect which raises younger brother human capital. The costs of increasing oldest sister's schooling include foregone household production, the distance cost and the negative quantity effect due to a reduction in time spent with the younger brother. Without knowledge of the relative magnitudes of the positive quality effect and the negative quantity effect, the net impact of oldest sister's schooling on younger brother human capital is ambiguous.

The first-order condition choosing y_s^* implies that:

$$a_s V_{w_s} r_s f_{y_s} + a_b V_{w_b} r_b [g_{H_s} f_{y_s} - g_{x_s}] = (p_s + d_s) U'(c) \qquad (2)$$

If $g_{H_s} f_{y_s} - g_{x_s} > 0$, the quality effect overrides the quantity effect and oldest sister's schooling has a net positive spillover on younger brother human capital. Even if $a_s = 0$ so parents derive no utility from the sister's utility, it can still be optimal for them to invest in her schooling if it benefits the younger brother. If this spillover is positive and parents ignore it in their schooling allocation decision, they will under-invest in the oldest sister's schooling.[11]

The model also informs us about the effect of distance cost of girls' schooling, d_s, on younger brother schooling i.e. the identifying variation used in the empirical analysis. It predicts that a change in distance to girls school has three potential effects on younger brother's schooling: a spillover effect because oldest sister's schooling is an input into younger brother's human capital, an income effect and a substitution effect. As discussed in section 6.4, I expect the theoretical income and substitution effects to be negligible in this context so the IV estimates using distance should mostly capture the spillover effect.

[11] See Appendix A.1 for proof of this proposition. Section 7 shows evidence suggesting that parents might not be internalizing the spillovers in their investment decisions. If this is the case, the younger brother will still be affected by the spillovers in the human capital production function allowing for their identification.

3 Data and Sample Characteristics

The data comes from the Learning and Educational Achievement in Punjab Schools (LEAPS), which is a longitudinal survey of 1800 households in Punjab province (home to 56% of Pakistan's population). Data was collected for 112 rural villages in the three districts of Attock, Faisalabad, and Rahim Yar Khan from 2003-2006.[12] A random sample of households was selected from each village, and all the schools in these villages were surveyed. The data contains GPS co-ordinates of all the surveyed households and schools, and village centers which allows for the construction of distance measures between these points.

Educational attainment in rural Punjab is low and characterized by significant gender gaps. Low perceived returns and high cost of girls' schooling contribute to low education for girls (Strauss and Thomas, 1995). Figure 1 shows age-specific enrollment rates for boys and girls in the LEAPS data: there is an 8 percentage point gender gap in enrollment for primary school-aged children (6-12 year olds) which widens to 14 percentage points for children 13-18 years old. Primary school comprises grades 1-5, middle school grades 6-8 and high school grades 9 and 10. Twenty-nine percent of girls complete zero years of schooling compared to 12.6% of boys. Many children, particularly girls, drop out after completing primary school.

The analysis sample includes households with at least one girl and a younger boy. I restrict the sample to households where the oldest sister is between 8 and 30 years old in the first round. Oldest sister's schooling is observed only if she is still living with her parents. Since girls move out of their parents' household upon marriage, much older girls living with their parents are potentially selected. To avoid any such endogeneity, I use the oldest sister among the children still living in the household in addition to imposing this age restriction. I also estimate results using alternative criteria and find that the results are unaffected.

[12]The districts represent the North, Middle and South regions of Punjab. Villages were randomly selected from a list of villages with less than 20 schools and at least one private school. While the LEAPS has four rounds, I exclude round 2 because an abridged survey was administered which does not include all the required information.

Descriptive statistics for households in the analysis sample are shown in Panel A of Table 1. The average household has eight members including five children. The average oldest sister and younger brother are 16 and 10 years old, respectively. Sixty-two percent of fathers have had some schooling compared to just 23% of mothers. Average expenditures per capita are about one USD a day.[13]

I analyze the effect of oldest sister's schooling on younger brother schooling, and literacy and numeracy. Measures of literacy and numeracy are derived from the mother's response to the following questions asked for each child:[14]

Can *name* read a postal letter or newspaper in any language?

Can *name* write a postal letter in any language?

Can *name* add or subtract?

Can *name* count?

The progression of these skills by grade is shown in Figure 2. While these measures seem rudimentary, the level of skill of children is low: only one in two (three) children in grade 3 (median age is 9 years) is able to read (write). These skills are mostly acquired by the end of primary school though since 92 percent of children in grade 5 can write, 97 percent can read, and almost all can add and count. Therefore, I examine the effects of oldest sister's schooling on these outcomes for primary school-aged (5-12 years old) younger brothers only.[15] For analyses of years of schooling, I use a sample of 5-18 year old younger brothers.[16] For boys of primary school-age, average enrollment rates are close to 90 percent but fall sharply after primary school indicating greater room for improvement and potential influence from oldest sister's schooling.

[13]At the time of the survey, one USD was approximately 60 Pakistani rupees.

[14]One might worry that the mother's response varies with her schooling. Appendix Table B.1 regresses the mother's response on her schooling and the child's test score (language and Math scores are available for a subsample of children which allows me to control for the direct effect of mother's schooling on child capability) and shows that mothers with different schooling do not respond to these questions differently.

[15]The average child in kindergarten and grade 5 is 6 and 12 years old, respectively.

[16]The typical younger brother is still enrolled so the schooling outcome is schooling completed up till then.

4 Schools in Rural Punjab

Children in rural Punjab attend either government schools or private schools. Government schools are virtually free and gender segregated at all levels of instruction while private schools are relatively expensive and co-educational. The average annual fee charged by government and private schools in 2003 was Rs.10 (USD 0.16) and Rs.870 (USD 14), respectively. Over 75 (70) percent of enrolled children (girls) attend government schools in my sample.

The average village in the sample has 7 schools including 2 government boys schools, 1.7 government girls schools, and 3 private schools. These figures count schools offering classes at all levels which overstates the choice of schools available. Half of the villages have only one government girls school at any level while the remaining villages typically have two government girls schools - one offering primary instruction only and the other offering primary and middle school classes. Figures for government boys schools are similar.

Most government boys schools were built in the 1950s while the construction of government girls schools followed one or two decades later. The median government boys and girls schools were built in 1951 and 1972, respectively. Andrabi et al. (2010) document guidelines for construction of government schools which include a village population requirement (at least 1000 people) and the provision of land for the school by the village. Government schools were built on common land known as the *shamlaat*, which was typically located on the outskirts of the villages where land was cheaper. The median government boys (girls) school is located 0.94 km (0.62 km) from the village center while the median private school is 0.38 km away. The placement of private schools near the village centers reflects both the higher competition from government schools in the village outskirts and the location of wealthier households close to the village center.[17] For instance, the probability of a household owning land decreases significantly by 4.3 percentage points and the likelihood of the father having

[17] Andrabi et. al (2010) document the relationship between household wealth and distance to village center, and the historical settlement patterns which led to it.

any schooling declines by 3 percentage points for every kilometer from the village center.

Panel B of Table 1 shows that the average household is located 0.64 km (0.69 km) from the closest government girls (boys) school.[18] The averge distance to the village center is 0.63 km. Since boys and girls schools were built several years apart, they are usually not located next to each other. The average (median) distance between the closest government girls and closest government boys school is 0.56 (0.38) km.

5 Identification Strategy

5.1 Distance Penalty for Girls' Schooling

The gender segregation of government schools in Pakistan enables a nuanced use of distance to girls school as a conditional instrument for oldest sister's schooling. Distance to school imposes a significant penalty on girls' schooling, and, unlike developed countries, this impact of distance has little to do with household income (Andrabi et al., 2007). Distance to school poses a barrier to girls' schooling in many developing countries because of the risk of sexual harassment (Colclough et al., 2000; Hunt, 2008; Leach and Sitaram, 2007; Odaga and Heneveld, 1995). Additionally, *purdah* norms in rural Pakistan severely limit female mobility outside the house, particularly for girls who have reached the age of puberty. Families risk inviting damage to a girl's reputation or honor (*izzat*) if she travels unchaperoned because she may come into unsupervised contact with males.

Therefore, girls are not allowed to walk to school alone: they must walk to school with friends which provides safety in numbers or be accompanied by a household member. Ninety-eight percent of children in the sample walk to school. Forty-three percent of girls walk to school with a sister, 37% with a friend, and 11% with a brother. Only 2% of girls are walked to school by a parent. Young boys do not go to school alone either but the fraction

[18]Distance is calculated as the length of the shortest curve between two geographical co-ordinates using the geodist package. This measures distance as a crow flies which likely understates actual travel distance.

accompanied to school falls as they become older and capable of looking after themselves. In contrast, the fraction of girls accompanied to school does not decline with age.[19]

While concerns about a girl's safety and chastity intensify as she gets older, it also becomes harder to ensure that somebody accompanies her to school. A girl can walk to school with school-going girls from the neighborhood when enrolled in primary school. However, girls' enrollment falls sharply after primary school so that girls enrolled in secondary school have fewer options for neighboring girls to walk with. Furthermore, the gender segregation of government schools and placement of boys and girls schools in different parts of the village limits the possibility of girls walking to school with their brothers. It is unsurprising, therefore, that only 11% of girls are accompanied to school by a brother.

Since families have to ensure that somebody accompanies a girl to school for safety reasons and compliance with cultural norms, distance to school imposes a large penalty on girls' schooling which is not observed for boys' schooling. Panel A of Table 2 shows the relationship between distance to school and schooling and enrollment outcomes for boys and girls.[20] Households that are far from schools tend to be remotely located and are, therefore, also far from other amenities and earnings opportunities. I account for this by adding a control for distance from the household to the village center in the second column for each outcome. Distance to village center is associated with less schooling for both boys and girls. Once I control for distance to village center, distance to boys school is not significantly related to boys' schooling or enrollment. This is not the case for girls though. Controlling for distance to village center attenuates the coefficient on distance to school but distance

[19] Ninety-four percent of children - both boys and girls - under the age of ten walk to school with somebody but there is a significant, 14 percentage point gender gap in the rates of accompaniment for teenagers.

[20] All regressions control for child age dummes, household characteristics, parents' education, wealth and assets, and district-by-year fixed effects. Household characteristics controls include a quadratic in number of boys aged 0-12, boys aged 13-18, girls aged 0-12, girls aged 13-18, and household size; indicators for language spoken at home and month of interview. Parents' education controls include indicators for mother and father having any schooling, years of schooling, and indicators for whether these are missing; and wealth and asset controls include indicators for whether the family owns the house, and whether they own any land.

to school remains an important predictor of girls' schooling and enrollment. An increase in distance to girls school of one kilometer is associated with a significant 5.4 percentage point (8 percent) reduction in the probability of a girl being enrolled.

Panel B of Table 2 estimates the distance penalty for children under 13 years of age and those aged 13 and older, separately. While there is no significant distance penalty for young or old boys, the penalty for girls is driven primarily by the older girls. While the distance penalty on schooling for younger girls is small and not statistically distinguishable from zero, an increase in distance to girls school of one km is significantly associated with a 4.1 percentage point (5 percent) reduction in younger girls' enrollment. The penalty for older girls is significantly larger, as one would expect given both the reduced options for neighborhood girls to walk to school with and the heightened safety and chastity concerns following puberty. An increase in distance to girls school of 1 km is associated with a 7.3 percentage point (16 percent) reduction in enrollment and 0.4 fewer years of schooling completed for older girls. In contrast, the analogous results for older boys indicate a 0.8 percentage point *higher* likelihood of enrollment and 0.072 fewer years of schooling, which is neither statistically nor economically significant.

5.2 Empirical Model

The model to estimate effects of oldest sister's schooling on younger brothers is:

$$Y_i = \beta_0 + \beta_1 \, Oldest \; Sister's \; Schooling_{\,i} + X_i \, \beta_2 + \epsilon_i \qquad (3)$$

where i indexes younger brothers; Y_i is a measure of human capital; $Oldest\ Sister's\ Schooling_{\,i}$ is the oldest sister's years of schooling (or categories); X_i a vector of child and family determinants and ϵ_i unobserved determinants of the outcome. Estimates of Equation 3 using OLS will likely be biased because there are unobserved differences between households with oldest sisters with different schooling. For example, households that educate the oldest sisters may

value education more and therefore invest more in the education of all children.

To address this problem, I exploit the gender segregation of government schools and use distance to girls school as a source of plausibly exogenous variation in oldest sister's schooling. The first stage regression to predict oldest sister's schooling is:

$$Oldest\ Sister's\ Schooling_{\,i} = \alpha_0 + \alpha_1\ Distance\ to\ Girls\ School_{\,i} + X_i\ \alpha_2 + \nu_i \qquad (4)$$

where $Distance\ to\ Girls\ School_{\,i}$ measures whether distance from the household to the closest government girls school exceeds one km, and ν_i represents unobserved determinants of oldest sister's schooling. The second stage is the same as equation (3) with predicted oldest sister's schooling replacing actual schooling. This approach utilizes cross-sectional variation in distance to the girls school to generate variation in oldest sister's schooling.[21]

This IV strategy is valid if the exclusion restriction is satisfied conditional on the covariates i.e. $Cov(\epsilon_i, Distance\ to\ Girls\ School_{\,i} |\ X_i) = 0$. Since boys can not attend girls schools, distance to girls school can only affect younger brothers through how it varies with other factors. Households located far from girls schools are far from boys schools and remotely located in general. The first concern can be addressed by controlling for distance to the closest government boys school and the closest private school while distance to the village center accounts for household location with respect to village amenities. The core conditioning variables in X_i include distance to the closest government boys school, distance to the closest private school, distance to the village center, district-by-year fixed effects and village fixed effects.[22] I control for distance flexibly using indicators for categories of distance to the closest government boys school, the closest private school, the village center and their

[21] There is no variation in the instrument over time during the course of the panel.

[22] This builds on the approach in Andrabi et al. (2010) who use distance to government school conditional on distance to village center as an instrument for private school attendance, and Kondylis and Manacorda (2012) who control for distance to infrastructures and village fixed effects.

pair-wise interactions.[23] X_i also includes dummies for the oldest sister's age and the yougner brother's age; and the household characteritsics, parents' education, and wealth and asset controls described in footnote 20. In this specification, identification comes from comparing households within the same village that are equidistant to the closest boys schools and village center, share the values of the remaining controls but differ (only) by the distance to the closest girls school. This residual variation in distance to girls school is arguably exogenous to younger brother outcomes and I provide supportive evidence in the next section.

Unlike developed countries where proximity to schools influences household location, land is the main determinant of household location in these agrarian villages. People reside on and make a living from land that has been passed down in their family: 60% of fathers work in agriculture, half the families own land, and 94% own the house they live in. This dependence on land also results in low mobility. Only 2.4% of rural residents report having migrated within the last 10 years. Conditional on in-migrating, 0.4% report schooling as the reason for moving (Pakistan Demographic and Health Survey, 2013). The main margin of mobility for rural households is to have an adult male member migrate to the city which does not affect children's proximity to school.[24] Therefore, rural households have limited capacity to systematically locate their children closer to schools. These households also place low value on girls' education making endogenous location based on distance to girls schools, conditional on the other controls, even more unlikely.

The IV estimate captures the local average treatment effect (LATE) of oldest sister's schooling for households that educate the oldest sister more due to their proximity to the girls school. These are likely relatively disadvantaged households where oldest sister's schooling can plausibly have a larger effect compared to relatively advantaged households. This suggests that the LATE estimated by IV will be larger than the average treatment effect.

[23]Categories include under 0.25 km, 0.25-0.5 km, 0.5-0.75 km, 0.75-1 km, 1-1.5 km and more than 1.5 km.
[24]There is almost no out-migration among children (Mansuri, 2006).

5.3 Evidence of the Validity of the Exclusion Restriction

I assess the validity of the research design in Table 3 which shows the relationship between various household characteristics and distance to girls school, with and without the core conditioning controls. The first column shows coefficients from a bivariate regression of each covariate on an indicator for whether distance from the household to the closest government girls school exceeds 1 km. As expected, households that are far from girls schools are different from those that are located close to them, e.g. households that are far from girls schools have significantly less educated parents. These results illustrate the problem with using the unconditional distance IV highlighted by Carneiro and Heckman (2002) and Cameron and Taber (2004) who showed that distance to college is correlated with ability (AFQT).

The second column in Table 3 adds controls for the core conditioning variables, i.e. the household location controls and village fixed effects.[25] This signficantly attenuates the estimates - while 16 of the 24 covariates are significantly related to distance to girls school in the unconditional specification, only one is significant in the conditional specification. This significant coefficient suggests that households located more than a km from the closest girls school have slightly fewer girls aged 0-12 than those located close by. Finding that one of 24 tested covariates in the conditional specification is significantly associated with distance to girls school can occur due to chance. Importantly, distance to girls school is not significantly related to parents' schooling and literacy, household wealth/assets, language and composition. The evidence overall shows that household covariates are balanced in distance to girls school, supporting the validity of the conditional IV strategy.

[25]Since the left-hand side variables are covariates in X_i, I only control for the core conditioning variables which are a subset of X_i keeping the controls consistent across all regressions. Controlling for all the other covariates in X_i except for the one on the left-hand side yields similar results.

6 Results

OLS estimates of the effects of oldest sister's schooling on younger brother outcomes are presented in table 4. These estimates are positive and statistically significant, conditional on the controls for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth and assets, and district-by-year fixed effects. An additional year of oldest sister's schooling is associated with 0.15 more years of schooling for the younger brother; a 2.8 and 2.1 percentage point increase in the ability to read and write, respectively; and a 2.0 and 1.4 percentage point increase in the ability to add and count, respectively.

Table 5 presents estimates using the preferred IV strategy. The first stage estimates in the second row show that distance to girls school is a strong instrument for oldest sister's schooling. Conditional on the controls in X_i, oldest sisters in households that are more than a km away from the closest girls school receive 1.3-1.5 fewer years of schooling compared to oldest sisters in households that are within a km of the girls school.[26] IV estimates also indicate that oldest sister's schooling has positive effects on younger brother education. An increase in the oldest sister's schooling of one year significantly increases younger brothers' schooling by 0.23 years. It increases the likelihood of younger brothers being able to read and write by 5.3 and 6.4 percentage points, respectively. The coefficients for the effect of oldest sister's schooling on younger brothers' ability to add and count are positive, larger than OLS estimates, but lack statistical significance. Compared to the means of younger brother outcomes, these effects represent an 8 percent increase in younger brothers' schooling; 13 and 20 percent increase in ability to read and write; and 7 and 4 percent increase in ability to add and count, respectively. An additional year of schooling for the oldest sister is a third of a standard deviation improvement in schooling and a 25% increase relative to the mean.

The IV effects of oldest sister's schooling in Table 5 are larger than the OLS effects

[26] A more flexible specification of distance to girls school using the multiple categories used for the other distance controls has a relatively weaker first stage but yields very similar IV results.

in Table 4 although the estimates are not statistically different from each other.[27] This is in line with findings in the returns to schooling literature (Card 2000, 2001) and the returns to parental education literature (Currie and Moretti, 2003, and Carneiro, Meghir and Parey, 2012 for instance). The IV estimates might be larger than OLS estimates because IV captures a LATE for a subpopulation with larger returns and because most general forms of measurement error in the measure of oldest sister's schooling would bias the OLS estimates downward but yield consistent IV estimates.[28]

6.1 Threats to the Identification Strategy

The IV estimates presented identify causal effects of oldest sister's schooling under the assumption that conditional on the controls, distance to girls school does not affect younger brother human capital independently of how it changes oldest sister's schooling. While this is inherently untestable, I present two sets of results in support of this identification condition. First, I show evidence indicating that the core conditioning variables are a sufficient set of controls after which distance to girls school is arguably exogenous to younger brother outcomes. Second, I use the identification strategy to analyze effects for older brothers to evaluate the potential for remaining endogeneity.

Table 6 presents IV results but includes only the core conditioning variables instead of the full controls in X_i that additionally include household characteritsics, parents' education, and wealth and asset controls. The estimated effects of oldest sister's schooling are very similar to those from Table 5. The similarity of estimates with and without these important controls suggests that the core conditioning variables adequately capture all aspects of household location that are relevant for determining younger brother human capital. This

[27] The Hausman test shows that one of the six estimates - writing - is different at the 10% signficance level.

[28] A more general measurement issue is that schooling is a proxy for education. Consider two oldest sisters who complete the same schooling but one attends school regularly while the other does not. Since proximity to school likely improves attendance and, therefore, education, the IV estimate would have improved signal-noise ratio while OLS might be attenuated because of noise in how well schooling captures education.

finding is not surprising given the balance shown in Table 3. Yet it is reassuring since it confirms that the lack of a significant relationship between the instrument and covariates represents true balance as it pertains to the determinants of younger brother outcomes and is not merely driven by large standard errors.

Theoretically, the oldest sister's education matters because she provides child care, is a tutor and a role model to her younger brothers. Since all of these mechanisms are tied to the role of the oldest sister as an *older* sibling, there should be no sizable impact of the oldest sister's schooling on her older brothers' human capital. While an older brother may benefit from interacting with a more educated younger sister, any such effect should be considerably smaller than the effect of the oldest sister on her younger brothers.[29] If the empirical strategy used yields sizable, positive effects of oldest sister's schooling on her older brother's learning instead, this would be indicative of endogeneity. Table 7 uses OLS to estimate the relationship between oldest sister's schooling and older brother human capital and finds significant, positive associations for all outcomes that are similar in size to the OLS estimates for effects on younger brothers. Table 8 presents IV estimates where, unlike the OLS results, oldest sister's schooling does not have a statistically or economically significant effect on any of her older brother's outcomes.[30] If conditional on the controls, distance to the girls school was still correlated with unobserved determinants of boys' human capital such as how much parents value education or better neighborhoods, one would expect to see that reflected in positive effects for older brother outcomes as well. The fact that I do not find a positive relationship between oldest sister's schooling and older brother's human capital suggests that it is unlikely that unobservables related to the instrument are driving the results for younger brothers.

[29] Any spillover on older brothers will also likely be small because older brothers work and spend most of their time outside the home and therefore have limited interaction with younger sisters.

[30] I can not reject the one-tailed hypothesis that the estimates for learning outcomes are non-positive. The estimate for schooling, though still negative, is less precise.

6.2 Additional Specification Tests

Table 9 shows IV estimates using indicators for whether the oldest sister has any schooling, and whether she has completed primary schooling. Twenty-five (forty-five) percent of oldest sisters have no schooling (primary schooling). The results are similar to those using oldest sister's years of schooling with significant, positive effects for reading, writing and schooling and positive but statistically insignificant effects for adding and counting. The effects of having an oldest sister with any schooling are not statistically different from the effects of having a primary-educated oldest sister although the latter are slightly larger.

Since girls move out of the household upon marriage, oldest sisters observed living with their parents, and, therefore, in the analysis sample, are potentially selected. Table 10 includes estimates using a sample limited to oldest sisters aged less than 20 years old.[31] The similarity of these results to those for the full sample suggests that potential selection of co-resident oldest sisters is not driving the results. I also find that distance to girls school is not significantly related to the co-residence of the oldest sister.

6.3 Heterogeneity of effects

Next I explore heterogeneity in the effects of oldest sister's education by mother's education. Given the low labor force participation for mothers (10%), the main mechanisms for the impact of maternal education are the mother's role as the primary caregiver and her time spent with children. Given that oldest sisters also look after younger siblings and do not work outside the home, oldest sister's schooling is likely a close substitute for mother's education.

Table 11 shows that distance has a much larger effect on oldest sister's schooling in households with uneducated mothers: the first stage effects in households with uneducated mothers are 160-270% larger than the effects for households with educated mothers.[32] While

[31] Only 15.6 percent of the oldest sisters aged 15-19 years old were married in the sample.

[32] The mother is uneducated if she has no schooling and educated if she has any schooling. When a mother is educated, the father is educated 99% of the time.

counterfactual outcomes are unobserved, it is likely that households with educated mothers value education highly and, therefore, educate the oldest sister regardless of distance to girls school. In households with educated mothers, 95 (63) percent of oldest sisters have some schooling (primary schooling) compared to 69 (39) percent in households with uneducated mothers. It seems plausible that households with educated mothers are more likely to be "always takers" and less responsive to the instrument.

Table 11 shows that IV estimates will be disproportionately based on households with uneducated mothers because these households comply more with the instrument compared to households with educated mothers. The weak instrument for households with educated mothers renders IV estimation infeasible. Table 12, therefore, shows IV estimates of the effects of oldest sister's schooling in households with uneducated mothers only. The results are similar to those for the full sample but lack statistical significance because of larger standard errors and slightly smaller point estimates. That these results are not significantly different from those for the full sample suggests that IV estimation in the full sample is identifying effects for complier households that are typically comprised of uneducated mothers.[33]

6.4 Mechanisms

Based on the theoretical framework in section 2, distance-induced increases in oldest sister's schooling can affect younger brother schooling through three potential channels: a human capital spillover effect, an income effect and a substitution effect. Households that are closer to the girls school face a lower distance cost of girls' schooling than those located farther which can theoretically free up resources and increase younger brother education through a positive income effect. Households that are closer to the girls school but equidistant to the

[33]Since IV estimation is infeasible for households with educated mothers, Appendix Table B.2 reports OLS estimates for households with uneducated mothers and educated mothers separately. While OLS estimation is not credible, the pattern of these results also suggests heterogeneity by mother's education. The results show that the effects of oldest sister's schooling on younger brother schooling, reading, adding and counting are considerably larger in households with uneducated mothers relative to households with educated mothers.

boys school face a relatively higher distance cost of boys' schooling compared to households that are far from the girls school. This can theoretically reduce younger brother's education through a substitution effect leading to a negative relationship between distance-induced increases in oldest sister's schooling and younger brother education. While distance-induced increases in oldest sister's schooling theoretically entail these positive income and negative substitution effects, I expect these effects to be negligible in this context since the distance cost of girls' schooling is essentially a social norm cost. The monetary cost includes only the opportunity cost of the time spent walking to the girls school and since a trivial fraction of parents walk the girls to school, it does not entail foregone adult earnings. Back-of-the-envelope calculations suggest that increasing distance to girls school by one kilometer can reduce annual household production by 3% at most so the theoretical income and substitution effects are likely negligible.[34] The finding of sizable, positive effects of oldest sister's schooling on younger brother outcomes suggests I am picking up a positive effect that exists separately from any income or substitution effects.

While the arguably small income and substitution effects are unlikely to explain the positive effects of oldest sister's schooling on younger brother human capital, the oldest sister schooling effects are consistent with several mechanisms. It could be that younger brothers learn from or are motivated by their more educated oldest sisters. Parents may also increase younger brothers' schooling in response to the oldest sister's higher schooling because they are averse to inequality among their children. While I am unable to empirically distinguish these mechanisms, I discuss some suggestive evidence on their expected contributions.

It is not clear that parents strive for equal schooling across their children because

[34]This calculation assumes it takes 30 minutes to walk this distance and that the girl and accompanying household member account for two-thirds of household production. I account for the number of school days on which this cost is incurred and assume generously that all time spent walking to school would have been spent in household production. For the 40% of households where the girl walks with a friend, only the girl is forgoing household production so the cost would be half this amount. Furthermore, all empirical specifications include controls for wealth and assets so any effect on income will be muted.

boys receive more schooling than girls: on average, boys complete 5.9 years of schooling compared to 4.4 years for girls. In order for the effects to reflect a parental response, one would have to posit more complicated preferences over inequality such that parents increase younger brother's schooling when oldest sister's schooling increases because they want to maintain some gap between boys and girls. The results are not consistent with either of these preference structures because then one would expect parents to also increase older brother's schooling in response to increased oldest sister's schooling but I do not find evidence for this. I also find that proximity to girls school lowers younger brother's schooling relative to the oldest sister's schooling instead of raising it. These results suggest that a parental investment response to increased oldest sister's schooling is unlikely to play a meaningful role in the spillover effects found for younger brothers. In order to assess the learning mechanism, I analyzed whether increases in oldest sister's schooling affect the likelihood that the oldest sister helps the younger brother with his studies but lack statistical power in this analysis.[35]

6.5 Identifying the quantity and quality effect of oldest sister's schooling

Having found that the net effect of oldest sister's schooling on younger brother human capital is positive, I explore empirical evidence for the quantity and quality effects posited by the model. The predicted negative quantity effect arises if increasing oldest sister's schooling reduces time spent with the younger brother. Since time spent with the younger brother is not measured, I test whether the effect of oldest sister's schooling varies with whether it was acquired before the younger brother was enrolled in school. If the younger brother is not enrolled in school, the sister's time at school could potentially have been spent with the younger brother at home. If the younger brother is enrolled in school, however, increases in oldest sister's schooling do not reduce time spent with the younger brother since he is not at home during school hours either. Oldest sister's schooling only competes with time spent

[35]While the point estimate suggests that increasing oldest sister's schooling by one year is associated with a 10 percent higher likelihood of the oldest sister helping, the effect is not statistically significant.

with the younger brother when he is of pre-school age suggesting that the negative quantity effect should only affect oldest sister's schooling that is acquired when the younger brother is of pre-school age. The positive quality effect, however, should be associated with schooling acquired prior to the younger brother's enrollment as well as after. Based on this, the net effect of oldest sister's schooling acquired before the younger brother's enrollment (pre-enrollment schooling) should be smaller than the impact of schooling acquired afterwards (post-enrollment schooling). Table 13 shows the effect of pre-enrollment schooling and post-enrollment schooling separately using distance to girls school and distance to girls school interacted with age gap as instruments, controlling for the age gap between the oldest sister and younger brother. In line with my hypothesis, the estimated effect of pre-enrollment schooling - while still positive - is consistently and considerably smaller than the effect of post-enrollment schooling. While the effects are statistically significantly smaller for writing and schooling only, the pattern of smaller effects for pre-enrollment schooling across all outcomes appears consistent with a negative quantity effect.[36]

6.6 Do parents internalize the effects of oldest sister's schooling?

Next I test whether parents seem to internalize the spillovers from oldest sister's schooling in their schooling investment decisions. Assuming that parents have greater incentive to invest in the oldest sister's schooling when the value of the spillover from her schooling is higher, I compare the schooling of oldest sisters who have a younger brother (who could benefit from her schooling) to oldest sisters who do not have one. I also relate oldest sister's schooling to the number of younger brothers she has who can potentially benefit from her. I analyze the relationship between oldest sister's schooling and whether she has a younger brother and

[36]While it is possible that different effects for pre-enrollment and post-enrollment schooling are related to differential effects by age of the younger brother, this does not seem likely. Cunha and Heckman (2007) find that earlier, pre-school investments in the sensitive periods of development are more effective than later investments. Table 13 finds *smaller* effects in the pre-school years, and, therefore, exists despite any such heterogeneity. The pattern of smaller effects for pre-enrollment schooling for all outcomes, even though these are likely to have different sensitive periods, further suggests it is likely not driven by age heterogeneity.

number of younger brothers after controlling for the number of her older brothers, number of younger sisters, number of older sisters, age of the oldest sister, household characteristics, parents' education, wealth and assets, and district-by-year fixed effects. Table 14 finds no evidence for a meaningful relationship between oldest sister's years of schooling and these two measures of the potential spillover value. While this analysis is only suggestive given the potential endogeneity of family size and composition, the results are consistent with parents appearing not to internalize the spillovers from oldest sister's schooling. If parents indeed fail to internalize the positive spillovers from oldest sister's schooling, this would lead to inefficiently low levels of girls' education from a societal standpoint.

6.7 How important are these spillover effects?

To put the spillover effects into context, I compare them to estimates of the effect of mother's schooling. I find that an additional year of schooling for the oldest sister increases younger brother schooling by 0.23 years. Behrman (1997) finds that the median impact of mother's schooling on children's schooling in the literature is 0.23 years with a range of 0.02 to 0.65 years. To compare estimates within my sample, I regress younger brother's schooling on mother's schooling and get coefficients between 0.06 and 0.1 years.[37] While this exercise only yields associations that enable a rough comparison, it suggests that the effect of oldest sister's schooling is important even relative to the effect of mother's schooling.

The finding of positive effects of oldest sister's schooling on younger brother human capital suggests that we are significantly underestimating the returns to investment in girls' education. I perform back-of-the-envelope calculations to estimate the returns to the oldest sister's schooling for the younger brother's earnings. I compare the lifetime earnings benefits for the younger brother from an additional year of oldest sister's schooling to the

[37]Appendix Table B.3 shows estimates of effects of oldest ister's schooling and mother's schooling using OLS (and IV for the oldest sister), and robustness to excluding controls for father's schooling and wealth/assets because these are potential channels through which mother's schooling can affect the outcome.

lifetime earnings benefits for the oldest sister herself. I find that ignoring the spillover on younger brothers would lead us to understimate the earnings returns to girls' education by 125 percent.[38]

7 Conclusion

In this study, I investigated whether oldest sister's schooling is an important input into younger brother human capital. I find that oldest sister's schooling has significant, positive effects on younger brother's schooling and literacy in rural Pakistan. These findings have important implications for evaluating the returns to investment in girls' education. The results indicate that we are currently underestimating the benefits of this investment including programs such as the Female Secondary School Stipend Programme, a gender-targeted conditional cash transfer program in Pakistan. Cost-benefit analyses of such programs that consider only effects on the girls and their children but ignore effects on younger siblings will considerably underestimate their total benefits.

Future research should consider an expanded role of siblings in affecting a child's development. In particular, studies can explore the potential role of older brothers in influencing younger sibling learning. While it is not possible to explore the effect of older brother's education in my data, the effects of older brother's education are likely theoretically different from that of older sister's education for several reasons. Older brothers usually do not look after younger siblings like older sisters do. Instead, older brothers in developing countries are much more likely to be working outside the home for pay. While this may decrease the interaction that older brothers have with their younger siblings compared to older sisters, older brother's education may affect the human capital of younger siblings by increasing household income instead.

[38] I assume that the increase in individual earnings from an additional year of schooling is 8% (Duflo (2001) estimates returns between 6.8% and 10.6%). Details are in Appendix B.

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Table 1: Summary Statistics

	Mean	Std Dev	N
Panel A: Household characteristics			
Household size	7.769	2.754	1,241
Number of children (age 0 to 18 years)	4.583	1.892	1,241
Number of boys (age 0 to 18 years)	2.333	1.226	1,241
Number of girls (age 0 to 18 years)	2.251	1.415	1,241
Father has any schooling	0.621	0.485	1,109
Father's years of schooling	4.399	4.143	1,109
Mother has any schooling	0.234	0.424	1,216
Mother's years of schooling	1.432	2.715	1,216
Father is literate	0.542	0.498	1,090
Mother is literate	0.216	0.411	1,187
Own any land	0.470	0.457	1,241
Own house	0.943	0.198	1,241
Reside in permanent/brick house	0.488	0.352	1,241
Reside in semi-permanent house	0.400	0.314	1,241
Reside in mud brick house	0.113	0.228	1,241
House has piped water	0.147	0.187	1,241
House has a water motor pump	0.198	0.254	1,241
House has other or missing source of water	0.655	0.220	1,241
Expenditure per capita (PKR/month)	1,939.436	3,940.852	1,241
Age of oldest sister	16.334	4.280	1,162
Age of younger brother	10.420	4.680	1,230
Urdu speaking	0.181	0.286	1,241
Punjabi speaking	0.625	0.382	1,241
Siraiki speaking	0.194	0.327	1,241
District: Attock	0.334	0.472	1,241
District: Faisalabad	0.385	0.487	1,241
District: Rahim Yar Khan	0.281	0.450	1,241
Panel B: Household distance variables			
Distance to girls school	0.641	0.644	1,204
Distance to boys school	0.685	0.714	1,223
Distance to private school	0.652	0.785	1,217
Distance to center	0.634	0.826	1,226

Note: The universe is households with an oldest sister aged $8-30$ in round 1 and at least one younger brother. At the time of the survey, 1 USD = 60 Pakistani rupees on average. Panel B shows distance from the household to the closest government girls' school, the closest government boys' school, the closest private school and the village center, measured in kilometers.

Table 2: Distance Penalty on Schooling and Enrollment for Boys and Girls

	Boys				Girls			
	Years of Schooling		Enrollment		Years of Schooling		Enrollment	
Panel A: Boys and girls aged 5-18 years old								
Distance to girls/boys school	-0.120*	-0.056	-0.013	-0.002	-0.282***	-0.219***	-0.069***	-0.054***
	(0.065)	(0.071)	(0.011)	(0.012)	(0.071)	(0.080)	(0.014)	(0.016)
Distance to center		-0.104*		-0.016		-0.093		-0.027**
		(0.055)		(0.010)		(0.064)		(0.013)
Mean of outcome	3.251		0.751		3.010		0.644	
Observations	6,950	6,950	6,947	6,947	7,569	7,569	7,498	7,498
R^2	0.557	0.558	0.243	0.244	0.463	0.466	0.321	0.324
	Age < 13	Age ≥ 13	Age < 13	Age ≥ 13	Age < 13	Age ≥ 13	Age < 13	Age ≥ 13
Panel B: Boys and girls 5-13 and 13-18 years old								
Distance to girls/boys school	-0.052	-0.072	-0.005	0.008	-0.062	-0.389***	-0.041**	-0.073***
	(0.050)	(0.139)	(0.012)	(0.021)	(0.057)	(0.144)	(0.020)	(0.022)
Distance to center	-0.077*	-0.123	-0.025**	-0.005	-0.032	-0.265**	-0.022	-0.035**
	(0.044)	(0.104)	(0.011)	(0.018)	(0.044)	(0.112)	(0.017)	(0.017)
Mean of outcome	1.832	5.266	0.854	0.603	1.808	4.480	0.783	0.466
Observations	4,078	2,872	4,106	2,841	4,165	3,404	4,201	3,297
R^2	0.553	0.240	0.136	0.244	0.524	0.333	0.225	0.292

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Panel A shows the relationship between distance to the closest government girls' (boys') school, and years of schooling and probability of enrollment in school for girls (boys) aged 5-18 years old. Panel B shows the relationship separately for those younger than age 13, and those 13 years or older. All regressions control for age of the child, household characteristics, parents' education, wealth and asset controls, and district-by-year fixed effects. Robust standard errors are clustered at the household level.

Table 3: Distance to Girls School and Household Covariates

Covariates	Without controls	With controls	Mean	N
Household size	0.315	0.248	7.70	3,932
	(0.195)	(0.294)		
Number of boys age 0 to 12	0.200**	0.177	1.46	3,932
	(0.078)	(0.118)		
Number of boys age 13 to 18	0.023	0.119	0.75	3,932
	(0.051)	(0.077)		
Number of girls age 0 to 12	-0.078	-0.265**	1.43	3,932
	(0.080)	(0.118)		
Number of girls age 13 to 18	-0.104**	-0.048	0.86	3,932
	(0.045)	(0.075)		
Father has any schooling	-0.070*	-0.014	0.62	3,493
	(0.036)	(0.057)		
Father's years of schooling	-0.760**	0.018	4.41	3,493
	(0.295)	(0.471)		
Mother has any schooling	-0.139***	-0.030	0.23	3,854
	(0.024)	(0.038)		
Mother's years of schooling	-0.915***	-0.276	1.43	3,854
	(0.148)	(0.230)		
Father is literate	-0.083**	-0.007	0.54	3,433
	(0.037)	(0.057)		
Mother is literate	-0.128***	-0.026	0.22	3,761
	(0.024)	(0.037)		
Own any land	0.162***	0.073	0.48	3,807
	(0.030)	(0.047)		
Own house living in	-0.005	-0.012	0.94	3,807
	(0.013)	(0.022)		
Live in a kiln brick house	-0.067***	-0.041	0.48	3,807
	(0.024)	(0.036)		
Live in a kiln and mud brick house	0.006	0.002	0.41	3,807
	(0.022)	(0.034)		
Live in a mud brick house	0.061***	0.040	0.11	3,807
	(0.017)	(0.028)		
House has piped water	0.040***	-0.002	0.15	3,932
	(0.013)	(0.019)		
House has a water motor pump	-0.113***	-0.015	0.20	3,932
	(0.014)	(0.023)		
House has other source of water	0.073***	0.017	0.65	3,932
	(0.014)	(0.022)		
Urdu speaking	0.002	0.022	0.18	3,932
	(0.019)	(0.021)		
Punjabi speaking	-0.218***	-0.025	0.63	3,932
	(0.027)	(0.034)		
Siraiki speaking	0.216***	0.003	0.19	3,932
	(0.027)	(0.031)		
Age of oldest sister	0.326	0.212	16.28	3,709
	(0.321)	(0.522)		
Age of younger brother	0.046	0.495	10.71	7,538
	(0.394)	(0.560)		

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The first column shows coefficients from a bivariate regression of each covariate on an indicator that distance to girls' school is greater than 1 km. The second column additionally controls for the core conditioning variables which include indicators for distance to village center categories, distance to boys school categories, distance to private school categories, and their pair-wise interactions; district-by-year fixed effects; and village fixed effects. Robust standard errors are clustered at the household level.

Table 4: OLS Estimates of the Effects of Oldest Sister's Schooling on Younger Brother Human Capital

	Read	Write	Add	Count	Schooling
Oldest sister's years of schooling	0.028***	0.021***	0.020***	0.014***	0.153***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.014)
Mean of outcome	0.410	0.325	0.642	0.780	2.942
Observations	3,553	3,542	3,523	3,561	5,333
R^2	0.398	0.372	0.403	0.317	0.618

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, and district-by-year fixed effects. Robust standard errors are clustered at the household level.

Table 5: IV Estimates of the Effects of Oldest Sister's Schooling on Younger Brother Human Capital

	Read	Write	Add	Count	Schooling
Second stage IV results					
Oldest sister's years of schooling	0.053*	0.064**	0.043	0.030	0.228**
	(0.029)	(0.030)	(0.027)	(0.025)	(0.103)
First stage results					
Distance to closest girls school	-1.281***	-1.293***	-1.313***	-1.291***	-1.524***
	(0.341)	(0.340)	(0.342)	(0.340)	(0.312)
F statistic	14.13	14.47	14.78	14.46	23.88
Mean of dependent variable	0.409	0.324	0.642	0.778	2.940
Number of observations	3,438	3,430	3,411	3,447	5,162
R^2	0.448	0.402	0.448	0.373	0.660

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level.

Table 6: IV Estimates of the Effects of Oldest Sister's Schooling on Younger Brother Human Capital: Only Core Conditioning Controls

	Read	Write	Add	Count	Schooling
Second stage IV results					
Oldest sister's years of schooling	0.060**	0.066**	0.051*	0.035	0.184*
	(0.028)	(0.029)	(0.027)	(0.024)	(0.105)
First stage results					
Distance to closest girls school	-1.281***	-1.293***	-1.313***	-1.291***	-1.524***
	(0.341)	(0.340)	(0.342)	(0.340)	(0.312)
F statistic	13.80	14.13	14.70	14.11	19.25
Mean of dependent variable	0.410	0.325	0.642	0.779	2.935
Number of observations	3,450	3,442	3,423	3,459	5,201
R^2	0.417	0.371	0.419	0.354	0.645

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for the core conditioning variables which include indicators for distance to village center categories, distance to boys school categories, distance to private school categories, and their pair-wise interactions; district-by-year fixed effects; and village fixed effects. Robust standard errors are clustered at the household level.

Table 7: OLS Estimates of the Effects of Oldest Sister's Schooling on Older Brother Human Capital: Falsification Test

	Read	Write	Add	Count	Schooling
Oldest sister's years of schooling	0.029***	0.029***	0.011***	0.009***	0.282***
	(0.005)	(0.005)	(0.003)	(0.003)	(0.043)
Mean of outcome	0.774	0.742	0.944	0.959	5.800
Observations	3,010	3,007	3,009	3,010	3,229
R^2	0.174	0.187	0.078	0.068	0.315

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses.
The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the older brother, household characteristics, parents' education, wealth/asset controls, and district-by-year fixed effects. Robust standard errors are clustered at the household level.

Table 8: IV Estimates of the Effects of Oldest Sister's Schooling on Older Brother Human Capital: Falsification Test

	Read	Write	Add	Count	Schooling
Second stage IV results					
Oldest sister's years of schooling	-0.014	-0.004	0.020	-0.007	-0.083
	(0.064)	(0.064)	(0.030)	(0.025)	(0.471)
First stage results					
Distance to closest girls school	-0.782**	-0.779**	-0.782**	-0.783**	-0.796**
	(0.367)	(0.368)	(0.367)	(0.367)	(0.343)
F statistic	4.54	4.49	4.54	4.56	5.38
Mean of dependent variable	0.772	0.739	0.943	0.957	5.809
Number of observations	2,894	2,891	2,893	2,894	3,096
R^2	0.333	0.356	0.256	0.194	0.450

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses.
The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the older brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level.

Table 9: IV Estimates of the Effects of Oldest Sister having any Schooling and having Primary Schooling

	Read	Write	Add	Count	Schooling
Panel A: Effect of oldest sister having any schooling					
Second stage IV results					
Indicator oldest sister has any schooling	0.349*	0.423**	0.283	0.198	1.647**
	(0.197)	(0.201)	(0.188)	(0.167)	(0.787)
First stage results					
Distance to closest girls school	-0.193***	-0.197***	-0.200***	-0.196***	-0.211***
	(0.054)	(0.053)	(0.054)	(0.054)	(0.049)
F statistic	12.93	13.63	13.45	18.74	19.01
Mean of dependent variable	0.409	0.324	0.642	0.778	2.940
Number of observations	3,438	3,430	3,411	3,447	5,162
R^2	0.421	0.374	0.434	0.367	0.639
Panel B: Effect of oldest sister having primary schooling					
Second stage IV results					
Indicator oldest sister has primary schooling	0.467*	0.566*	0.378	0.268	2.233*
	(0.283)	(0.301)	(0.260)	(0.235)	(1.167)
First stage results					
Distance to closest girls school	-0.144***	-0.147***	-0.150***	-0.145***	-0.156***
	(0.053)	(0.053)	(0.053)	(0.053)	(0.048)
F statistic	7.41	7.75	7.97	7.54	10.55
Mean of dependent variable	0.409	0.324	0.642	0.778	2.940
Number of observations	3,438	3,430	3,411	3,447	5,162
R^2	0.396	0.309	0.417	0.355	0.611

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level.

Table 10: IV Estimates of the Effects of Oldest Sister's Schooling for Oldest Sisters aged less than 20 years old

	Read	Write	Add	Count	Schooling
Second stage IV results					
Oldest sister's years of schooling	0.029	0.061**	0.035	0.020	0.231*
	(0.029)	(0.031)	(0.032)	(0.030)	(0.132)
First stage results					
Distance to closest girls school	-1.222***	-1.229***	-1.251***	-1.227***	-1.270***
	(0.358)	(0.355)	(0.358)	(0.357)	(0.339)
F statistic	11.66	11.96	12.20	11.83	14.04
Number of observations	2,855	2,848	2,833	2,862	3,786
R^2	0.473	0.421	0.469	0.397	0.680

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
The analysis sample includes oldest sisters who are less than 20 years old. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level.

Table 11: Heterogeneity in First Stage Impact of Distance on Oldest Sister's Schooling by Maternal Education

	Read	Write	Add	Count	Schooling
Panel A: Households with uneducated mothers					
First Stage					
Distance to girls' school	-1.440***	-1.455***	-1.475***	-1.452***	-1.656***
	(0.211)	(0.211)	(0.212)	(0.211)	(0.181)
F-statistic on distance to girls' school	46.48	47.43	48.27	47.25	83.87
Observations	2597	2591	2574	2605	3946
Panel B: Households with educated mothers					
First Stage					
Distance to girls' school	-0.381	-0.401	-0.426	-0.381	-0.635
	(0.379)	(0.379)	(0.381)	(0.380)	(0.331)
F-statistic on distance to girls' school	1.01	1.12	1.25	1.01	3.68
Observations	721	720	719	722	1025

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Panel A shows the first stage IV results for the sample of households with uneducated mothers or mothers with no schooling while Panel B shows the first stage results for the sample of households with educated mothers, i.e. mothers who have any schooling. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level.

Table 12: IV Estimates of the Effects of Oldest Sister's Schooling in Households with Uneducated Mothers

	Read	Write	Add	Count	Schooling
Second stage IV results					
Oldest sister's years of schooling	0.045	0.049	0.022	0.023	0.173
	(0.035)	(0.035)	(0.033)	(0.030)	(0.132)
First stage results					
Distance to closest girls school	-1.440***	-1.455***	-1.475***	-1.452***	-1.656***
	(0.211)	(0.211)	(0.212)	(0.211)	(0.181)
F statistic	46.48	47.43	48.27	47.25	83.87
Mean of dependent variable	0.388	0.306	0.623	0.762	2.844
Number of observations	2,597	2,591	2,574	2,605	3,946
R^2	0.450	0.426	0.477	0.404	0.642

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
The analysis sample includes households with uneducated mothers only. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level.

Table 13: IV Estimates of the Positive Quality and Negative Quantity Effects of Oldest Sister's Schooling

	Read	Write	Add	Count	Schooling
Pre-enrollment years of schooling	0.037*	0.028	0.021	0.016	0.001
	(0.021)	(0.021)	(0.019)	(0.019)	(0.082)
Post-enrollment years of schooling	0.086	0.130*	0.060	0.045	0.529***
	(0.063)	(0.067)	(0.057)	(0.053)	(0.160)
Observations	3,385	3,377	3,360	3,395	5,084
P-value for one-sided inequality test	0.219	0.066	0.237	0.296	0.000
Mean of dependent variable	0.412	0.326	0.645	0.781	2.947

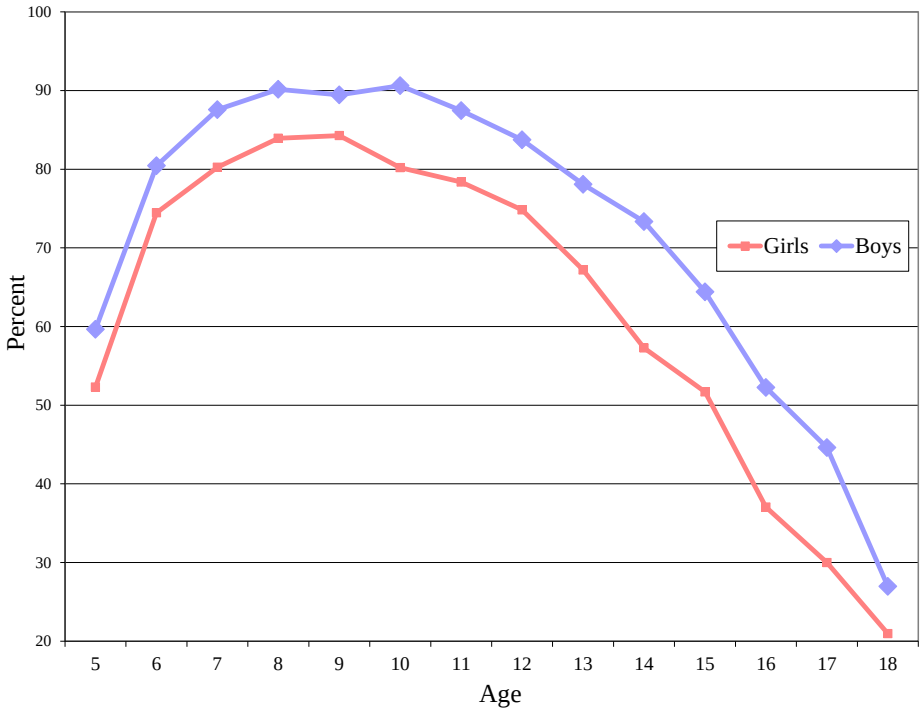
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects. Robust standard errors are clustered at the household level. The instruments used for pre-enrollment and post-enrollment schooling are distance to the closest girls' school and its interaction with age gap. P-values shown are for one-sided tests of the null hypothesis that coefficient on pre-enrollment years of schooling $\geq$ coefficient on post-enrollment years of schooling.

Table 14: Do Parents Internalize Spillovers? OLS Estimates relating Oldest Sister's Schooling and Potential Spillover Value

	oldest sister's years of schooling	
	(1)	(2)
Has a younger brother	0.069	
	(0.244)	
Number of younger brothers		-0.042
		(0.079)
Mean of outcome	4.020	4.020
Observations	3,623	3,623
R^2	0.320	0.321

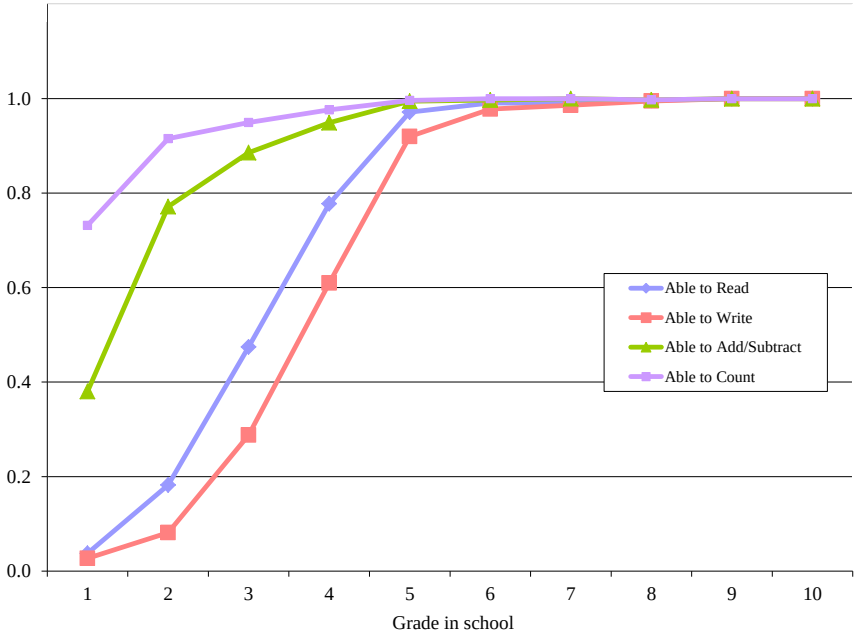
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
The OLS regression in specification 1 relates oldest sister's years of schooling to whether she has a younger brother, and the OLS regression in specification 2 relates oldest sister's years of schooling to the number of her younger brothers. All regressions control for number of older brothers, number of younger sisters, number of older sisters, age of the oldest sister, household characteristics, parents' education, wealth/asset controls, and district-by-year fixed effects. Robust standard errors are clustered at the household level.

Figure 1: Enrollment-age profiles for Boys and Girls in rural Punjab



Note: The figure shows the percent of boys and girls in the LEAPS sample that are currently enrolled in school by age.

Figure 2: Distribution of Literacy and Numeracy Capabilities by Grade



Note: The figure shows the fraction of children that are reported as capable of reading, writing, adding, and counting by grade that the child is currently enrolled in. The sample includes children who are currently enrolled in grades 1-10 in school.

A Model Appendix

A.1 Spillover and Investment in Oldest Sister's Schooling

Proposition. *Let parents' investment in oldest sister's schooling be y_s^{**} when net externality of the oldest sister's schooling on younger brother is positive, and parents take this externality into account when making the schooling decision. Let y_s^{***} denote parents' investment in oldest sister's schooling if they fail to internalize the spillover effect on younger brother. It can be shown that parents will under-invest in the oldest sister's schooling if they fail to internalize the net positive externality i.e. y_s^{***} is lower than y_s^{**}.*

Consider the case where the net externality of the oldest sister's schooling on younger brother human capital is positive so that $g_{H_s} f_{y_s} - g_{x_s} > 0$ i.e. the positive quality effect of increasing oldest sister's schooling outweighs the associated negative quantity effect. Suppose parents are unaware of the spillover effects of oldest sister's schooling on younger brother, and do not internalize the spillover associated with sister's schooling in deciding about schooling investments. Such parents would choose y_s^{***} to satisfy the following first-order condition where they only consider the private benefits and costs of the oldest sister's schooling:

$$a_s V_{w_s} r_s f_{y_s} = (p_s + d_s) U'(c) \qquad (4)$$

When parents internalize the spillover of the oldest sister's schooling on younger brother human capital, they will choose y_s^{**} as indicated by the following condition:

$$a_s V_{w_s} r_s f_{y_s} + a_b V_{w_b} r_b [g_{H_s} f_{y_s} - g_{x_s}] = (p_s + d_s) U'(c) \qquad (5)$$

Compared to (4), this equation has an additional positive term on the left-hand side because parents are aware that the positive spillover from oldest sister's schooling increases their utility by increasing the younger brother's human capital and wealth. In order to equalize the marginal utility from investment in sister's schooling with its marginal cost, parents will increase the investment in oldest sister's schooling. This has the effect of decreasing the first term on the left-hand side in equation (5) since $f_{y_s y_s}$ is negative, and hence equalizes the left-hand side with the right-hand side. The equilibrium investment in oldest sister's schooling in this case, y_s^{**}, is therefore higher than y_s^{***}.

A.2 Comparative static predictions

Comparative static with respect to distance to girl's school

Comparative statics of schooling with respect to distance cost of girl's schooling are derived with and without spillovers. In a model without any spillovers, the SOCs are as follows:
MB of y_b with respect to $y_b = a_b V''(W_b) r_b^2 g_{y_b}^2 + a_b V'(W_b) r_b g_{y_b y_b}$. Let this equal Y.
MB of y_s with respect to $y_s = a_s V''(W_s) r_s^2 f_{y_s}^2 + a_s V'(W_s) r_s f_{y_s y_s}$. Let this equal Z.
$\frac{\partial y_s}{\partial d_s} = YU' - y_s(p_s + d_s) YU'' + (p_b + d_b)^2 U'U''$ which is negative. An increase in the distance

cost of girl's school decreases sister's schooling and for the non-corner solution for y_s, there is also a negative income effect. $\frac{\partial y_b}{\partial d_s} = -(p_b + d_b)(p_s + d_s)U'U'' - y_s(p_b + d_b)ZU''$, where the first term is positive and the second is negative. The first term is a positive substitution effect while the second term is a negative income effect.

In a model with spillovers, the SOCs are as follows:
MB of y_b with respect to $y_b = a_b V''(W_b)r_b^2 g_{y_b}^2 + a_b V'(W_b)r_b g_{y_b y_b}$ Let this equal A.
MB of y_b with respect to $y_s = a_b V''(W_b)r_b^2 g_{y_b} g_{y_s} + a_b V'(W_b)r_b g_{y_b y_s}$. Let this equal B.
MB of y_s with respect to $y_s = a_s V''(W_s)r_s^2 f_{y_s}^2 + a_s V'(W_s)r_s f_{y_s y_s} + a_b V''(W_b)r_b g_{y_s}^2 + a_b V'(W_b)r_b g_{y_s y_s}$.
Let this equal C. Notice that C = Z + K where K $= a_b V''(W_b)r_b g_{y_s}^2 + a_b V'(W_b)r_b g_{y_s y_s}$.

Assuming that the net spillover of oldest sister's schooling is positive, $g_{y_s y_s} = g_{H_s} f_{y_s y_s} + g_{H_s H_s} f_{y_s} - g_{H_s x_s} f_{y_s} + g_{x_s x_s} - g_{x_s H_s} f_{y_s}$ which is negative because $g_{H_s} > 0, f_{y_s} > 0, f_{y_s y_s} < 0, g_{H_s H_s} < 0, g_{x_s x_s} < 0$ due to the assumption of positive and diminishing marginal returns of the inputs, and $g_{H_s x_s} > 0$ due to the assumed complementarity between sister's human capital and time spent with brother. I assume that the term B i.e. the differential of the MB of y_b with respect to y_s is negligible.

$\frac{\partial y_s}{\partial d_s} = AU' + y_s(p_b + d_b)BU'' - y_s(p_s + d_s)AU' + (p_b + d_b)^2 U'U$" which is negative as in the model without spillovers.[A.1] $\frac{\partial y_b}{\partial d_s} = -(p_b + d_b)(p_s + d_s)U'U'' - y_s(p_b + d_b)ZU'' - y_s(p_b + d_b)KU'' + [y_s(p_s + d_s)U'' - U']B$ which is ambiguous as in the model without spillovers. While the positive substitution effect exists in both models, even if we assume B=0, the model with spillovers picks up an additional negative term due to the spillover.[A.2]

In a model without any spillovers, an increase in the distance cost of girl's schooling has an ambiguous effect on brother's schooling. There is a positive substitution effect (brothers' schooling is now relatively cheaper), and a negative income effect (if parents still invest in girls' schooling and incur the higher cost, it squeezes household resources). In the model with spillovers, an increase in the distance cost of girl's schooling has three effects: the positive substitution effect, the negative income effect as well as an ambiguous spillover effect.

B Earnings returns to additional year of schooling

Back-of-the-envelope calculations show that increasing a girl's schooling by one year increases her average lifetime earnings by about $300 and the average lifetime earnings of her younger brother by an average of $375. The average annual earnings for men and women are $1225 and $642 while labor force participation rates are 70 and 20 percent, respectively (Labour Force Survey of Pakistan, 2013). I assume the return to an additional year of schooling is 8 percent following the estimates in Card (1999) and Duflo (2001) and accumulate the yearly earnings gains over a lifetime using 40 years of expected earnings and a 3% discount rate.

[A.1] This expression is negative if B is negligible or if $B > 0$.

[A.2] If $B > 0$, then the expression is even more negative because there is a strong complementarity between sister and brother schooling such that there is pressure for brother schooling to fall in response to the distance-induced decrease in sister schooling.

Table B.1: Mother's years of schooling and reported child literacy and numeracy

	Read	**Read**	**Read**	**Read**	**Write**	**Write**	**Write**	**Write**
Panel A: Mother's report for reading and writing								
Mother's years of schooling	0.002	0.003	0.004	0.004*	0.001	0.001	0.003	0.003
	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
English test score	0.073***	0.077***			0.100***	0.098***		
	(0.007)	(0.008)			(0.009)	(0.010)		
Urdu test score			0.076***	0.081***			0.118***	0.117***
			(0.007)	(0.008)			(0.009)	(0.010)
Mother's years of schooling X English test score		-0.003				0.001		
		(0.003)				(0.003)		
Mother's years of schooling X Urdu test score				-0.003				0.001
				(0.003)				(0.003)
Observations	2,360	2,360	2,360	2,360	2,341	2,341	2,341	2,341

	Count	**Count**	**Add**	**Add**
Panel B: Mother's report for adding and counting				
Mother's years of schooling	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Math test score	0.013***	0.013***	0.021***	0.022***
	(0.002)	(0.003)	(0.004)	(0.004)
Mother's years of schooling X Math test score		-0.001		-0.001
Observations	2,369	2,369	2,348	2,348

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses.
This table relates the reading, writing, adding and counting capability reports provided for each child by their mother with the mother's years of schooling and child test score in English, Urdu (the vernacular in Pakistan), and Math. Some regression specifications additionally control for an interaction term between the mother's years of schooling and child's test score.

Table B.2: OLS Estimates Showing the Heterogeneity in Oldest Sister's Schooling Effects by Maternal Education

	Read	Write	Add	Count	Schooling
Panel A: Households with uneducated mothers					
Oldest sister's years of schooling	0.027***	0.020***	0.022***	0.016***	0.149***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.017)
Mean of dependent variable	0.388	0.306	0.623	0.764	2.849
Observations	2,688	2,680	2,663	2,696	4,088
Panel B: Households with educated mothers					
Oldest sister's years of schooling	0.018***	0.021***	0.010	0.001	0.142***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.028)
Mean of dependent variable	0.485	0.396	0.706	0.838	3.309
Observations	745	743	742	745	1,054

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
This table shows the OLS estimtes for the effect of oldest sister's schooling estimated separately for households with uneducated mothers and households with educated mothers. Uneducated mothers are mothers who have no schooling while educated mothers are those who have any schooling. The dependent variables read, write, add, and count are indicator variables for whether the younger brother is reported as capable of reading, writing, adding/subtracting, and counting, respectively. The dependent variable schooling is years of schooling completed. All regressions control for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, and district-by-year fixed effects. Robust standard errors are clustered at the household level.

Table B.3: Comparing Effects of Mother's Schooling and Oldest Sister's Schooling on Younger Brothers

	Younger brother's years of schooling			
	OLS coefficients		IV coefficients	
Panel A	(1)	(2)	(3)	(4)
Mother's years of schooling	0.057***	0.103***		
	(0.015)	(0.015)		
Observations	5,112	5,112		
R^2	0.593	0.578		
Panel B				
Oldest Sister's years of schooling	0.154***	0.173***	0.228**	0.226*
	(0.015)	(0.015)	(0.103)	(0.118)
Observations	5,162	5,162	5,162	5,162
R^2	0.616	0.612	0.660	0.659

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Panel A includes estimates relating mother's years of schooling to younger brother's years of schooling while Panel B contains estimates relating oldest sister's years of schooling to younger brother's years of schooling. Specification 1 controls for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, and district-by-year fixed effects. Specification 2 includes the controls from specification 1 except for the variables of father's schooling, and wealth/asset controls. The IV regression in specification 3 uses distance to the closest government girls' school as the instrument for oldest sister's schooling, and controls for age of the oldest sister, age of the younger brother, household characteristics, parents' education, wealth/asset controls, household location controls, district-by-year fixed effects, and village fixed effects.. Specification 4 includes the controls in specification 3 except for the variables of father's schooling, and wealth/asset controls. Robust standard errors are clustered at the household level.