Big Sisters

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Abstract

We model household investments in young children when parents and older siblings share caregiving responsibilities and investments by older siblings contribute to young children's human capital accumulation. To test the predictions of our model, we estimate the impact of having an older sister (as opposed to an older brother) on early childhood development in a sample of rural Kenyan households with otherwise similar family structures. Having an older sister rather than an older brother improves younger siblings' vocabulary and fine motor skills by more than 0.1 standard deviations.

JEL codes: O12, J13, J16, D13

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1 Introduction

Investments in early childhood are a critical determinant of later life outcomes, and stimulating activities — for example, shared reading and infant-directed speech — are an important way that older family members invest in young children (Knudsen, Heckman, Cameron, and Shonkoff 2006, Grantham-McGregor et al. 2007, Almond and Currie 2011, Walker et al. 2011, Aizer and Cunha 2012). Underinvestment in early childhood is an acute problem in low- and middle-income countries (LMICs), where an estimated 43 percent of children are at risk of failing to meet their developmental potential because of inadequate nutrition and cognitive stimulation (Black et al. 2017). A growing interdisciplinary literature examines parental investments in young children in LMICs, seeking to identify interventions that can change parenting practices to improve developmental outcomes in children and increase incomes in adulthood (cf. Gertler et al. 2014, Black et al. 2017, Andrew et al. 2018). However, parents are not the only caregivers in most societies — in many low-income contexts, much of that work is done by older siblings, particularly sisters (Weisner et al. 1977, Lancy 2015). Though this pattern is well-documented in the anthropology literature, older siblings' role in childrearing is often ignored in academic and policy discussions of investments in early childhood.[1]

[1]Though older siblings are known to play an important role in caring for young children in LMIC contexts, standard approaches to quantitative measurement frequently ignore both the investments older children make in their younger siblings and the impacts that early childhood interventions (including those that seek to change childrearing practices) might have on sibling caregivers. For example, the standard format of the Family Care Indicators, one of the most widely used measures of early childhood stimulation, does not record stimulating activities carried out by household members under 15 years old (Hamadani et al. 2010, Kariger et al. 2012). Researchers also tend to ignore the potential impacts of parenting interventions on sibling caregivers. For example, a recent systematic review of 466 impact evaluations of early childhood development interventions in LMICs found that only four measured indirect effects on older siblings in middle childhood or adolescence (Evans, Knauer, and Jakiela 2021). This tendency to ignore the caretaking role of older siblings is at least partially attributable to the perception that parental stimulation is more beneficial to young children than stimulation by older children (though it may also entail a higher opportunity cost). In a response to Weisner et al. (1977), Brian Sutton-Smith argued that "Maximal personal and social development of infants is produced by the mother (or caretaker) who interacts with them in a variety of stimulating and playful ways. Unfortunately the intelligence to do this with ever more exciting contingencies is simply not present in child caretakers," Weisner et al. (1977, p. 184). Thus,

We model older siblings' contributions to the human capital accumulation of young children. Our model extends existing work in economics by incorporating several insights from anthropology and psychology. First, older children do much of the childcare in many LMIC settings, and the quality of their caregiving practices impacts the human capital accumulation of their younger siblings (Weisner et al. 1977, Maynard 2002, Maynard and Tovote 2010, Lancy 2015). Second, households where older siblings are involved in caregiving make active tradeoffs, deciding how much older children should invest in their own human capital and how much they should invest in their younger siblings (Brody 2004, Bock 2010). Third, even when older children are less effective than parents at building younger children's human capital (Ellis and Rogoff 1982), it may be optimal to delegate some childrearing to older siblings when the opportunity cost of their time is low relative to that of adults (Chick 2010, Lancy and Grove 2010).

We extend a simple model of parental investments in children to consider the direct contributions of older siblings and the tradeoffs that arise when siblings and parents share caregiving responsibilities. Parental investments in both older and younger children entail opportunity costs in foregone domestic production, while older siblings' investments in their younger siblings come at the expense of their own human capital. At the optimum, these marginal costs are equated with the marginal benefit of greater human capital accumulation in young children. We show that parental investments in the youngest household members cannot be interpreted as measures of parental preferences in such settings. Because parents' and siblings' investments are substitutes, having an older child who is an effective caregiver allows parents to increase their labor supply and shift some caregiving responsibilities to older children without compromising young children's human capital.

In most societies where older children play a substantial caretaking role, older sisters

sibling caregiving, though widespread, is often considered a second-best alternative to greater maternal investment — particularly since childcare responsibilities might limit older siblings' ability to invest in their own human capital through formal schooling.

do more childcare than older brothers (Weisner et al. 1977, Hrdy 2009, Lancy 2015). Our model demonstrates that this can occur because older sisters are more effective caregivers than older brothers, or because households perceive a lower return to investing in the human capital of older girls than older boys. In either case, young children with an older sister (rather than an older brother) are likely to benefit, receiving more cognitive stimulation as a result. Having an older sister rather than an older brother can have a causal impact on young children's development even in settings where older children do not contribute to human capital accumulation in their younger siblings. However, if older siblings' investments in young children's human capital are not productive, any treatment effect of having an older sister must be driven by parental investments: parents who perceive a low return to investing in an older girl's human capital might invest *more* in younger children when they have an older girl rather than an older boy. In contrast, when older siblings contribute to the development of young children's human capital, parents with an older girl may actually invest *less* time in their young children — because they have an effective substitute. Our model illustrates that any treatment effect of older sisters (on child development) that is not explained by differential investments by parents can be attributed to — and provides evidence of — the contributions of older siblings.

To test the empirical predictions of our model, we estimate the impact of older sisters on early childhood development in a sample of rural Kenyan households that have at least one child aged three to six and exactly one older sibling aged seven to 14.[2] In this sample,

[2]Reviewing ethnographic evidence from 50 traditional societies, Rogoff et al. (1975) report that the typical age at which societies begin assigning older children childcare responsibilities is between five and seven years old. Ominde (1952) reports that in an area near Kisumu, Kenya, the "school-going age for the Luo girl" was the "age to which society has assigned the duty of nursing," with the girls' interest in this responsibility peaking at age "eight to nine years." Capen (1998) describes the Luo-language term *japidi* as a "girl who cares for a child," "nurse," or "nanny." Nearby, Weisner et al. (1977) report that (Kenyan) Luhya girls aged 6–8 years old spent 60 percent of their waking hours looking after younger children, though this caretaking was often under the explicit or implicit supervision of nearby adults. Similarly-aged boys (6–8 years old) and younger girls (aged 3–5) spent about half as much time caring for small children. Apoko (1967) and Lijembe (1967) also relate how in nearby Acholi communities (where the role is called the *lapidi*) as well as in Idakho communities, young girls are usually tasked with caring for infants; if there

we show that the gender of the older sibling is unrelated to household or community characteristics — and hence plausibly exogenous.[3] We find that young children with one older sister experience significantly more cognitive stimulation than those with one older brother. This pattern results from increased stimulation by older sisters, not by parents. Our model suggests that this empirical pattern will arise when both parents and older siblings perceive a gender gap in the return to investing in older children's human capital, and when parents know that stimulating activities with older siblings increase the youngest children's human capital.

Differential patterns of household investment translate into meaningful impacts on child development. An aggregate index of language and fine motor development is more than 0.1 standard deviations higher when a young child's older sibling is a sister and not a brother. In our sample, the magnitude of this difference is commensurate with that between children of mothers who completed primary school and children of those who did not. Impacts on fine motor skills are concentrated in the bottom half of the distribution, but impacts on language skills are not. Our results suggest that older siblings play an important role in shaping younger children's human capital in this context, and our model suggests that optimizing households behave as though they are aware of this fact.

Though economic models of investments in children typically focus on parents' investment decisions, several recent papers have indirectly highlighted the important caregiving

is no appropriately-aged older sister, the task may fall to an older brother. Tudge et al. (2006) document that young children in working-class families in urban Kisumu spend "most of their time at home with older siblings."

[3]An extensive literature treats the sex composition of children as a source of exogenous variation (cf. Angrist and Evans 1998, Washington 2008, Glynn and Sen 2015). However, the assumptions required for such estimates to identify causal impacts are unlikely to hold in general (Bisbee, Dehejia, Pop-Eleches and Samii 2017, Clarke 2018). In the United States, Dahl and Moretti (2008) show that having a firstborn daughter increases the likelihood of parental separation. In India, existing evidence suggests that son preference influences birth spacing and total fertility (Clark 2000, Jayachandran and Kuziemko 2011), so households with a firstborn son may not be comparable to households with a firstborn daughter. In the present context, we check that gender of the older sibling is uncorrelated with birth spacing and a variety of other characteristics both in our estimation sample and — as we discuss in Section 4.1 — in an additional Demographic and Health Survey sample from the same region of Kenya.

role played by older sisters in LMIC settings, by showing how interventions for one sibling may have spillovers on, or be mediated by, other siblings. In Turkey, Alsan (2017) shows that a nationwide vaccination campaign targeting young children improved literacy and educational attainment among adolescent girls — who are often forced to stay home tending sick younger siblings.[4] In Pakistan, Qureshi (2018) demonstrates that increasing older girls' educational attainment has positive impacts on the literacy and numeracy of younger brothers. In Kenya, Ozier (2018) shows that infants and toddlers whose older siblings were exposed to a school-based deworming program saw improvements in cognitive development, and that gains were larger among children with more older sisters.[5] These papers highlight the special alloparenting role played by older sisters in many LMIC contexts, showing that this role has empirical implications for both the girls themselves and their younger siblings. We extend this literature by estimating the overall developmental impact of having an older sister rather than an older brother, and by testing the theoretical mechanisms underlying the empirical relationship that we observe.

Our work is related to several broader strands of literature. First, we contribute to the growing body of work on early childhood development in low-income settings (Heckman 2007, Almond and Currie 2011, Black et al. 2017), specifically research analyzing the human capital production function (cf. Cunha, Heckman and Schennach 2010, Del Boca, Flinn and Wiswall 2014) and recent evaluations of interventions intended to change parenting practices (cf. Chang et al. 2015, Weisleder et al. 2017, Hamadani et al. 2019, Attanasio et al. 2020, Doyle 2020). Second, our work relates to the wider literature on gender norms affecting children in LMIC contexts (cf. Dhar, Jain and Jayachandran 2018, Vogl 2013), particularly work on factors constraining girls' education (cf. Kremer, Miguel and Thornton

[4] In Mozambique, Martinez, Naudeau, and Pereira (2017) find that the construction of new community-based preschools increased the likelihood that older children had ever attended school, decreased their childcare hours, and increased the amount of time spent on school work – though they do not disaggregate their analysis to show impacts on older sisters vs. older brothers.

[5] In addition, Attanasio et al. (2019) find that access to publicly-provided daycare in Brazil increased employment and income among *adult* older sisters (aged 15 and above).

2009, Baird, McIntosh and Özler 2011, Jensen 2012) and on the differential chore and carework responsibilities of male and female children (cf. Edmonds 2006, Montgomery 2010).[6] Finally, our work builds on literature in demography, economics, political science, and sociology using quasi-experimental variation in the sex composition of children to identify the impacts of daughters on parents' attitudes and behaviors (cf. Dahl and Moretti 2008, Washington 2008, Glynn and Sen 2015) as well as outcomes for other household members (cf. Parish and Willis 1993, Garg and Morduch 1998).

The rest of this paper is organized as follows. Section 2 presents our model of familial investments in young children and our empirical tests of the model. Section 3 describes our study setting and data. Section 4 presents our empirical results, and Section 5 concludes.

2 Conceptual Framework

2.1 A Simple Model of Parental Investment

We first consider a simple model in which stimulating activities performed by older siblings do not contribute to the human capital accumulation of the youngest family members. In this setting, only parents can intentionally invest in the human capital of young children, and any effect of older siblings is explained by changes in parental investment.

Consider a unitary household comprising a parent, an older (school-aged) child, and a younger (not yet school-aged) child. Parental investments increase child ability, leading to higher incomes (or greater overall welfare) in adulthood. The parent divides their time between household production and investing in their two children. The household utility

[6] Beyond the large literature on gender differences in schooling around the world (cf. Psaki, McCarthy and Mensch 2018, Evans, Akmal and Jakiela 2021a), there is of course a rich literature on gender differences in adult behavior (cf. Pitt, Rosenzweig and Hassan 2012, Alesina, Giuliano and Nunn 2013), but those topics are not the emphasis of the present paper.

function is given by

$$U = y\left(L_p\right) + \tilde{h}_o(p_o) + \tilde{h}_y\left(p_y\right) \tag{1}$$

subject to the constraint

$$L_p = 1 - p_o - p_y. \tag{2}$$

$L_p \geq 0$ is the amount of time allocated to home production, and $y\left(\cdot\right)$ is a strictly concave production function satisfying Inada conditions. Let $k \in \{o, y\}$ index children within the household, indicating whether a child is the older or younger sibling. p_k is the parent's investment of time in the human capital of child k, and $\tilde{h}_k\left(\cdot\right)$ is a strictly concave human capital production function satisfying Inada conditions.[7] To model gender gaps, we let

$$\tilde{h}_k(p_k) = \lambda_k^z h_k(p_k) \tag{3}$$

for $k \in \{o, y\}$ and $z \in \{G, B\}$, where z indicates whether child k is a girl or a boy.[8] Thus, age-specific human capital production functions are identical up to a parameter characterizing the relative returns by gender (as perceived by the parent).[9] Inada conditions guarantee an interior optimum characterized by the first-order condition:

$$y'(1 - p_o^* - p_y^*) = \lambda_o^z h_o'(p_o^*) = \lambda_y^z h_y'(p_y). \tag{4}$$

[7]Many models of human capital formation divide childhood into multiple periods (cf. Heckman 2007). We abstract from the intertemporal dynamics of investment in a particular child to focus on the intra-household process of building young children's human capital. An extension to our model would allow for consideration of dynamic effects in setting where older children contribute to the production of younger children's human capital.

[8]Because z always appears as a superscript on a parameter that is also indexed by a subscript k, we omit the subscript k (on z) to simplify notation.

[9]In this framework, lower objective returns — for example, gender differences in the return to schooling — are equivalent to lower subjective parental valuation of (objective) returns. For example, in a patrilocal society, parents' private return to educating a daughter may be low because the return is captured by the girl's husband's family. Alternatively, parents who simply prefer boys might place more weight on their sons' future income and wellbeing (relative to their daughters' future income and wellbeing). The utility weights λ_k^z reflect both objective and subjective factors influencing parents' perceptions of the return to investing in a child's human capital.

Three results are immediately apparent. First, a younger sibling's human capital only depends on the gender of the older sibling if there are gender differences in the human capital production function (as perceived by the parent): if $\lambda_o^G = \lambda_o^B$ and $\lambda_y^G = \lambda_y^B$, parental investments in human capital do not depend on the gender of either child. Second, if parents prefer boys — or, equivalently, if the returns to investments in human capital are systematically lower for girls than for boys at all ages — parents will invest less in girls and more in boys (conditional on child age). So, if $\lambda_o^G < \lambda_o^B$ and $\lambda_y^G < \lambda_y^B$, parents will invest less in older girls than in older boys, they will invest less in younger girls than in younger boys, and — conditional on the gender of the younger child — they will invest more in young children with an older sister than in young children with an older brother. Finally, if $\lambda_o^G < \lambda_o^B$ and $\lambda_y^G = \lambda_y^B$, parental investments in both children depend on the gender of the older sibling: if the older sibling is a girl, parents will invest less in her and more in her younger sibling — irrespective of the gender of the younger child. Such a situation might occur if, for example, parents perceive the return to higher levels of formal education as relatively low for girls because of their lower labor force attachment in adulthood; this would not necessarily imply a perceived disparity in the returns at younger ages, since fine motor skills, basic literacy, and the ability communicate might be sought after on the marriage market or valuable when running a household. Thus, we would expect to see a treatment effect of older sibling gender on the developmental outcomes of young children, and this effect would be driven by differences in parental investments in those children. If the marginal return to investing in older girls is relatively low (i.e. when one assumes that $\lambda_o^G < \lambda_o^B$ and $\lambda_y^G = \lambda_y^B$), parents with older girls have more time available to invest in their younger children. However, because $\lambda_y^G = \lambda_y^B$, parents would not invest more in young boys than in young girls (on average, holding the gender of the older sibling constant).

2.2 The Contributions of Older Siblings

We now extend the model to consider the contributions of older children in a framework that characterizes the active tradeoffs made by both parents and older siblings. Again, we consider a unitary household comprising a parent, an older child, and a younger child, but now we allow the actions of the older child to influence both their own human capital accumulation and the human capital of their younger sibling.[10] Familial (rather than parental) investments in children increase child ability, leading to higher adult welfare. The parent divides their time between household production and investing in their two children, and the older child divides their time between schoolwork (i.e. investing in their own human capital) and engaging in stimulating activities with the younger sibling.[11]

The younger child's human capital depends only on investments by older family members — since preschool-aged children do not make active choices (e.g. how hard to work in school) that increase human capital. The younger child's human capital production function is given by

$$\tilde{h}_y(I_y) = \lambda_y^z h_y(I_y) \tag{5}$$

where $h_y(\cdot)$ is assumed to be an increasing, concave function that satisfies Inada conditions. $I_y = p_y + \delta_o^z o_y$ where p_y is the parent's investment in the younger child, o_y is the older sibling's investment in her younger sibling, and $\delta_o^z < 1$ is a quality parameter indexing the productivity (with respect to human capital production) of investments made by an older sibling of gender z (relative to investments by adults in the household). Later, we will refer to I_y and its component $\delta_o^z o_y$ as *stimulation*, to distinguish them from the underlying time

[10]Because we consider a unitary household, there is no distinction between an older child who makes a tradeoff and a parent who dictates a tradeoff to an older child. In our model, parents and older children have the same preferences, so agency is irrelevant. In Section 2.3, we consider the consequences of relaxing this assumption by allowing parents and older children to have divergent preferences.

[11]Older children also carry out chores, and these tasks vary by sex in many cultural contexts, including the region we study. We discuss the ways that chores could be incorporated into the model in Section 2.3.3.

investment, o_y.[12] Thus, parents and older siblings are assumed to be perfect substitutes in the production of younger children's human capital — though parents may have an absolute advantage.[13]

Older children invest in their own human capital by exerting effort in school, and they also benefit from investments (in them) made by the adults in their household. The older sibling's human capital production function is given by

$$\begin{aligned}\tilde{h}_o\left(E_o, p_o\right) &= \lambda_o^z h_o\left(E_o, p_o\right) \\ &= \lambda_o^z\left[h_{o\to o}(E_o) + h_{p\to o}(p_o)\right]\end{aligned} \tag{6}$$

where E_o is the child's level of investment in their own human capital (e.g. in schoolwork) and p_o is the parent's investment in the older child. Thus, $h_o\left(E_o, p_o\right)$ is assumed to be additively separable in child and adult investments in human capital.[14] Both $h_{o\to o}(E_o)$ and $h_{p\to o}(p_o)$ are increasing and concave functions satisfying Inada conditions.

The parent divides one unit of time between household production and stimulating her children (as in Section 2.1). Household utility is given by:

$$U = y\left(L_p\right) + \lambda_o^z h_{o\to o}(E_o) + \lambda_o^z h_{p\to o}(p_o) + \lambda_y^z h_y\left(I_y\right) \tag{7}$$

where $L_p = 1 - p_o - p_y$, $E_o = 1 - o_y$, and $I_y = p_y + \delta_o^z o_y$. If an interior solution (p_o^*, p_y^*, o_y^*) exists, the following are true at the optimum: first, households equate the marginal product

[12] Within the model, the distinction between investment and stimulation is only relevant when considering the tradeoffs between investments by different household members. For each household member (e.g. the parent), the amount of time they invest and the amount of stimulation generated are linearly related. In practice, older household members invest both time and costly effort, and an appropriate measure of stimulation would capture both the quantity and the quality dimension to the extent possible.

[13] When δ_o^G and δ_o^B are sufficiently small, investments made by the older sibling do not improve the younger siblings' human capital, and the model reduces to the version considered in Section 2.1 — as we discuss further below.

[14] Cases where child effort and parental investment are complements have an intuitive appeal — for example, if parents assist school-aged children with their homework. However, such complementaries allow for the possibility of multiple equilibria. For this reason, we focus our analysis on the determinants of investments in younger children and simplify the rest of the environment as much as possible.

of parental labor with the marginal product of additional parental time invested in each child by setting

$$y'(1 - p_o^* - p_y^*) = \lambda_o^z h'_{p \to o}(p_o^*) = \lambda_y^z h'_y(p_y^* + \delta_o^z o_y^*), \tag{8}$$

and second, households equate the marginal product of older children's investments in their own human capital with the marginal product of their investments in younger siblings by setting

$$\lambda_o^z h'_{o \to o}(1 - o_y^*) = \delta_o^z \lambda_y^z h'_y(p_y^* + \delta_o^z o_y^*). \tag{9}$$

Two corner solutions are also possible: at the optimum, either o_y^* or p_y^* (but not both) might be equal to 0. If older children are sufficiently proficient at stimulating their younger siblings, parents may delegate this task to them by setting $p_y^* = 0$. On the other hand, when older children's investments in their younger siblings are sufficiently unproductive, (i.e. when δ_o^G and δ_o^B are sufficiently small), older siblings will devote all their time to building their own human capital by setting o_y^* to 0 and E_o to 1. For the rest of this exposition, we focus on the interior solution.[15]

When $\delta_o^G = \delta_o^B = 0$, the model reduces to simple case described in Section 2.1.[16] Reviewing those predictions: if human capital production functions do not differ by gender (i.e. if $\lambda_k^G = \lambda_k^B$ for $k \in \{o, y\}$), we would not expect gender gaps in parental investment or treatment effects of older sibling gender; when parents favor boys over girls (i.e. when $\lambda_y^G < \lambda_y^B$ and $\lambda_o^G < \lambda_o^B$), they invest more in boys than girls at all ages, and they also invest more in the younger siblings of older girls; finally, when $\lambda_y^G = \lambda_y^B$ and $\lambda_o^G < \lambda_o^B$, parents do not invest more in younger boys than in younger girls on average, but they invest more in the younger siblings of older girls — because they perceive a low return to spending time

[15]Beyond the the interior solution that is our emphasis here, one might note that a sufficient (but not necessary) condition under which this latter corner solution occurs is when $\delta_o^z = 0$. One way to guarantee that the corner solution is inapplicable is to assume that $h'_{o \to o}(E_o) \to 0$ as $E_o \to 1$. Relaxing this assumption does not change our analysis substantively, so we entertain the corner solutions no further here.

[16]Specifically, Equation 4 is the special case of Equation 8 that occurs when $\delta_o^G = \delta_o^B = 0$.

building the human capital of school-aged girls; thus, in summary, there is a treatment effect of older siblings that is mediated by parental investments.

2.2.1 Gender Differences in Productivity

We now characterize behavior when older children can improve their younger siblings' human capital by engaging in stimulating activities with them. In our framework, there are two reasons older girls might stimulate their younger siblings more than older boys. First, girls might be better at producing younger siblings' human capital with a given level of (time) investment ($\delta_o^G > \delta_o^B$). Alternatively, older boys and and girls might be equally good at caring for younger siblings, but the return to human capital might be lower for (older) girls than for (older) boys ($\lambda_k^G < \lambda_k^B$).[17] We have already considered the implications of the latter possibility, letting $\lambda_k^G < \lambda_k^B$, in the special case when δ_o^G and δ_o^B are both equal to 0. We now consider the first of these possibilities: the consequences of gender differences in δ_o^z, the relative productivity of older siblings' investments in young children's human capital (compared to the parents' investments), when human capital production functions do not differ by gender. Specifically, let $\delta_o^G > \delta_o^B$, $\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$, and $\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$. Let $p_o^*(\delta_o^z, \bar{\lambda}_o, \bar{\lambda}_y)$ denote the optimal level of parental investment in an older child of gender z (given our assumptions about δ_o^z and λ_k^z). Define $p_y^*(\delta_o^z, \bar{\lambda}_o, \bar{\lambda}_y), o_y^*(\delta_o^z, \bar{\lambda}_o, \bar{\lambda}_y), L_p^*(\delta_o^z, \bar{\lambda}_o, \bar{\lambda}_y), E_o^*(\delta_o^z, \bar{\lambda}_o, \bar{\lambda}_y)$, and $I_y^*(\delta_o^z, \bar{\lambda}_o, \bar{\lambda}_y)$ analogously

[17] It is apparent that one could extend the model to introduce other reasons that girls might spend more time stimulating younger siblings. In a model of occupational specialization, girls who expect to specialize in home production might see a high return to the development of home-specific human capital (such as child-rearing skills). Alternatively, one could introduce social norms that make it costly for boys or girls to engage in behaviors commonly associated with the opposite gender (see the model presented in Jakiela and Ozier (2019) for a simple example). Many of these theoretical extensions yield predictions that are identical to those derived here. Indeed, the δ_o^z parameter captures some of these social norm effects in a simplified way if we interpret as a measure of the amount of stimulation (for example, singing or storytelling) an older sibling engages in per unit of time spent caring for a younger sibling. If stimulating activities are perceived as feminine because they are often done by mothers, older brothers may be less likely to engage in such socially costly behaviors. Another interpretation is that sisters can achieve high levels of stimulation with modest time investments because their chores take place in the home, and they (like mothers) may be able to engage in stimulating activities with young children *while* carrying out other domestic tasks. We discuss this possibility in Section 2.3.2.

for $z \in \{G, B\}$.[18]

In Proposition 1, we show that when older sisters are more productive than older brothers (when it comes to improving younger siblings' human capital), children with older sisters receive more stimulation overall. However, parents with an older daughter substitute away from investing their time in early childhood stimulation because their older child is a good substitute, investing more in the older child's human capital and increasing their own their own labor supply in consequence. Impacts on older siblings' time allocation are ambiguous and depend on the functional forms of the production functions, but the overall quantity of stimulation by older siblings ($\delta_o^z o_y^*$) is higher when the older sibling is female.

Proposition 1. *Let* $\delta_o^G > \delta_o^B > 0$*, and further assume* δ_o^B *is sufficiently far above zero to guarantee that* $o_y^*(\delta_o^G, \lambda_o^G, \lambda_y^z) > 0$ *and* $o_y^*(\delta_o^B, \lambda_o^B, \lambda_y^z) > 0$*. Let* $\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$ $\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$*. The following are true:*

i. $I_y^*\left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > I_y^*\left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$,

ii. $p_o^*\left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > p_o^*\left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$,

iii. $p_y^*\left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) < p_y^*\left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$,

iv. $\delta_o^G o_y^*\left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > \delta_o^B o_y^*\left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$, *and*

v. $L_p^*\left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > L_p^*\left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$.

Proof. See Mathematical Appendix. □

When girls are more productive caregivers than boys, young children benefit from having an older sister: they receive more stimulation from their older sibling and more stimulation overall. Parents also benefit because older girls provide more effective support at home.

[18] An equilibrium is fully characterized by p_y^*, p_o^*, and o_y^*. The optimal L_p^*, E_o^*, and I_y^* are then defined by Equations 8 and 9.

As a result, gender differences in older children's effectiveness as caregivers translate into empirical predictions about both younger siblings' development and parents' responses.[19] Optimizing parents delegate more early childhood stimulation to more competent sibling caregivers, substituting toward other activities that cannot be done by their older children. Thus, if older girls are more effective caregivers than older boys, parents will appear to favor older girls by investing more in their human capital — but this appearance is deceptive because it results from gender differences in children's productivity rather than parents' preferences. This highlights the importance of explicitly modeling the human capital production function within the household, and accounting for the role that older children play in shaping younger children's human capital.

2.2.2 Gender Differences in the Returns to Human Capital

Thus far, we have seen that a treatment effect of having an older sister could be explained by two different mechanisms: either a gender gap in the return to human capital investment among older children when older siblings do not contribute to building younger children's human capital, or a gender gap in productivity where older sisters are better than older brothers at improving their younger siblings' human capital. We've considered each mechanism in isolation, and seen that the models make divergent predictions about parental investments in young children. Next, we characterize household behavior when the returns to human capital investments in school-aged children differ by gender *and* older siblings contribute to the development of human capital in young children by engaging in stimulating activities with them.

Proposition 2, which we state formally and prove in the Mathematical Appendix, shows that when returns to human capital are lower for girls than for boys and older boys and girls are equally efficient at improving younger children's human capital, children with older

[19] We consider the case of gender differences, but the proof is equally valid if other observable factors (e.g. older sibling age) generate systematic differences in δ_o^z.

sisters receive more stimulation overall. When returns to older siblings' human capital differ by gender, parents invest less in older sisters (relative to older brothers). However, when older children contribute to human capital accumulation in their younger siblings in this context, older sisters also invest less in their own human capital and more in the human capital of their younger siblings — breaking the link between the gender gap in the returns to investing in older children's human capital and parental investments in younger children.

Proposition 2 highlights the importance of older siblings' investments in young children — even when the treatment effect of older sisters is driven by gender differences in the return to education as opposed to productivity. As discussed in Section 2.1, when $\delta_o^G = \delta_o^B = 0$, parents respond to gender gaps in the return to parental investment in older children by investing more in their younger children. Incorporating the tradeoffs made by older siblings into the model changes this prediction because older girls also invest less in themselves — and more in their younger siblings — than older boys.

We have considered the $\delta_o^G = \delta_o^B > 0$ case, but results are similar when δ_o^G and δ_o^B are not exactly equal. If older girls are substantially more effective caregivers than older boys (i.e. if δ_o^G is substantially larger than δ_o^B), the gender gap in sibling productivity will be more important than the gender gap in the return to schooling, so parents of older girls will invest less in their young children than parents of older boys. The opposite is true if older boys are substantially more effective sibling caregivers than older girls. In both cases, any gender gap in the returns to investing in older children's human capital may offset the effect of the gender gap in productivity. The key insight is that when households trade off older siblings' investments in their own human capital with their investments in the human capital of their younger siblings, the effect of older sibling gender on parental investments in younger siblings is ambiguous because older sisters facing a lower return to investing in their own human capital invest more in the human capital of their siblings.

2.3 Extensions to the Model

2.3.1 Gender Bias

In much of our analysis, we have assumed that parents are not inherently prejudiced against girls. If gender differences were driven by parental bias, we would expect parents to invest less in older girls than in older boys, and we would also expect them to invest less in younger girls than in younger boys. In our framework, $\lambda_y^G < \lambda_y^B$ implies a lower optimal level of familial investment in young girls than in young boys — a prediction that is testable in our data.

2.3.2 Chores and Multitasking

In our model, older siblings divide their time between investing in their own human capital (i.e. studying) and investing in their younger sibling's human capital. To keep the model tractable and make the most important tradeoffs salient, we have omitted chores other than childcare. We have also structured both the parent's and the older sibling's budget constraints such that multitasking is impossible: older household members cannot exert greater effort that would allow them to stimulate a young child *while* engaging in other domestic activities. However, such multitasking is common in practice, and most children in LMICs do have household responsibilities, with the types of chores that children do varying by sex such that girls tend to help out at home while boys tend to handle chores such as herding that take place outside of the compound (Lancy 2015). This might suggest an alternative way of conceiving of girls' productivity in improving young children's human capital: they can achieve more with less time investment because they are able to combine stimulating activities like singing to a younger sibling with other domestic tasks.[20]

[20]Mothers, of course, also engage in such multitasking, and incorporating multitasking into a time budget constraint is complicated. If mothers were delegating their domestic tasks to older sisters but not older brothers, and if this led older sisters to engage in incidental stimulation of young children that had no developmental benefits, we would expect to see more parental stimulation of young children when the older

2.3.3 Beyond Unitary Households

We have also assumed a unitary household that can be represented by a single utility function. However, if parents perceive a low return to investing in the human capital of older girls (relative to older boys) but older girls do not, the unitary household assumption may be inappropriate. If older girls perceive a higher return to investing in their own human capital than their parents do, this will tend to shift older girls toward investing more in their own human capital relative to the parental optimum; parents will partially offset this by investing more in the younger siblings of an older girl than they would under the unitary model — though the overall treatment effect of older sibling gender on parental investments in young children remains ambiguous. Importantly, this channel can only matter when older siblings contribute to the human capital of the young children. If they did not, older siblings would invest all their time in building their own human capital irrespective of the gender gap in the returns to schooling.

2.4 Summary of Predictions

Table 1 summarizes the theoretical predictions that we will test empirically.[21] As discussed below, our data set includes information on the amount of early childhood stimulation done by parents, by older siblings, and by other individuals. The model summarizes predictions about three outcomes: p_y^*, the amount of parental stimulation of young children, $\delta_o^z o_y^*$; the amount of stimulation done by the older sibling; and I_y^*, the total amount of early childhood stimulation experienced by the youngest family members. When either $\delta_o^G > \delta_o^B$ or $\lambda_o^G < \lambda_o^B$, young children with an older sister will receive more stimulation than young children with an older brother. Where this increase in overall stimulation comes from provides information about the underlying parameter values. When $\delta_o^G = \delta_o^B = 0$, older

sibling is a girl (because the mother's time constraint is relaxed).

[21] The full set if theoretical predictions is presented in Table A9.

siblings' investments are not productive, so any overall impact of an older sister is mediated by parental investments. On the other hand, when $\delta_o^G > \delta_o^B > 0$ and $\lambda_o^G = \lambda_o^B$, the treatment effect of an older sister results from the fact that older sisters are more productive caregivers, and they do more stimulation of their younger siblings than older brothers. Parents respond to this by investing less in their younger children and more in their older children. Finally, when $\lambda_o^G < \lambda_o^B$ and $\delta_o^G \geq \delta_o^B > 0$, both mechansims are at play. Young children receive more stimulation from older sisters than older brothers. Because of this, parents may invest either more or less in their younger children. The fact that $\lambda_o^G < \lambda_o^B$ pushes them toward investing less in their older daughters and more in their younger children. However, older daughters also invest less in themselves and more in their younger siblings, lowering the marginal return to parental investments in young children. Thus, the overall impact on parental investments in young children cannot be signed when both mechanisms are at work.[22]

3 Data

Our sample includes data on 699 young children in 552 households from 73 rural communities in western Kenya. Data were collected during the baseline survey that preceded a pre-literacy intervention (Jakiela, Ozier, Fernald and Knauer 2020). Households living within 750 meters of the local government primary school were included in the sample if they had children between three and six years old. Here, we restrict attention to those households which also had exactly one older child between the ages of seven and 14. Our treatment of interest is an indicator for having an older child who is female. In this restricted sample of households, having an older child who is female is uncorrelated with a range of covariates, as we discuss further below.

[22]This is true for any values of λ_o^G and λ_o^B such that $\lambda_o^G \geq \lambda_o^B > 0$.

Our data set includes information on household and parental characteristics (e.g. household assets and mother's education) as well as multiple measures of child development and a measure of children's engagement in stimulating activities. We consider two main developmental outcomes that can be measured in preschool-aged children: vocabulary and fine motor skills. Both are measured through direct child assessment.

Our vocabulary index combines three sub-scales: expressive vocabulary and receptive vocabulary in English and Luo.[23] English is one of Kenya's national language and the primary language of instruction at upper levels of primary school, while Luo is a Nilotic language that is the mother tongue of all of the children in our sample. To measure receptive vocabulary in both languages, we adapted items from the British Picture Vocabulary Scale, a version of the Peabody Picture Vocabulary Test suitable for speakers of British or Commonwealth English (Dunn and Dunn 1997; Dunn, Dunn and Styles 2009; Knauer et al. 2019b). We assessed expressive vocabulary through a 37-item assessment developed and validated as part of an ongoing evaluation of an early literacy intervention (Knauer, Kariger, Jakiela, Ozier and Fernald 2019b). We measured children's fine motor skills using a subset of items from the Malawi Developmental Assessment Test (Gladstone et al. 2010). Specifically, the survey included six questions from the MDAT fine motor sub-scale that showed high predictive power (in terms of other development outcomes) in a pilot study (Knauer et al. 2019a). Both vocabulary and fine motor indices were converted into age-normalized z-scores. We then average the individual (z-score) components to construct an overall measure of child development.

To understand the mechanisms through which sibling gender impacts child development, we collected data on early childhood stimulation using an expanded version of the Family Care Indicators (FCI) questionnaire (Hamadani et al. 2010, Kariger et al. 2012). The

[23]Receptive vocabulary is the ability to understand words, while expressive vocabulary is the ability to produce words — for example, to identify familiar objects. Children begin developing receptive vocabulary before they begin to express themselves through speech (Fernald, Prado, Kariger and Raikes 2017).

FCI is the most widely used measure of parental stimulation practices in LMICs (Jeong et al. 2022). It has been validated in multiple LMIC contexts, and it is the measure of early childhood stimulation included by UNICEF in their Multiple Indicator Cluster Surveys (MICS), which have been implemented in more than 120 countries (Bornstein and Putnick 2012, Aboud and Yousafzai 2015, Jeong et al. 2016). The the FCI captures the number of stimulating activities families engage in rather than the number of hours spent, and it is the measure of household investments in young children's human capital used by economists studying early childhood in low-income settings: Attanasio et al. (2020) use the FCI to generate their measure of "quality time" that parents invest in young children, while Attanasio et al. (2022) use the FCI to calculate their measure of "parental investment." The key feature of the FCI is that, by measuring the variety of stimulating activities that older household members engage in with young children, it can to some extent capture both the quantity and the quality of these interactions.

UNICEF's version of the FCI asks about six types of stimulating activities: reading or looking at picture books, singing, telling stories, physical play, going places (i.e. taking the child outside the home or compound), and learning activities such as naming or counting objects. We expanded this set to include additional stimulating activities more appropriate for slightly older children: for instance, teaching a child letters or English words (Knauer et al. 2019a). Based on extensive piloting, we also expanded the questionnaire to better capture the full range of family members who engage in early childhood stimulation. While the original instrument asks about stimulation by a child's mother, father, and by other adults aged 15 and over, we also ask about stimulating activities by older sisters and brothers (who may not yet be 15), as well as grandparents. In Appendix Table A1, we show that this measure of early childhood stimulation is associated with higher levels of child development in our sample, consistent with the evidence summarized by Black et al. (2017), Bradley (1993), Elardo and Bradley (1981), Bradley and Caldwell (1976), and so on.

Summary statistics on who engages in early childhood stimulation are shown in Online Appendix Table A2. Older sisters engaged in more stimulating activities with young children than any other household members, including mothers. Sisters engaged in an average of 1.73 stimulating activities with young children in our sample over the three days prior to the survey; mothers engaged in 1.43 stimulating activities and brothers engaged in 1.22 activities. No other household members engaged in an average of more than one stimulating activity. A typical child engaged in 5.46 different stimulating activities, but this varies from zero to 12, with 99 percent of children engaged in at least one stimulating activity in the three days prior to the survey. Online Appendix Table A3 summarizes the types of stimulating activities that household members engage in. 85 percent of young children engaged in physical play with a household member or other adult, and more than half had someone read to them, sing them songs, take them outside of their compound, teach them letters or numbers, and build structures with them.

Figure 3 summarizes the correlations between the variables summarized in Online Appendix Tables A2 and A3. Most of the variables capturing who engages in stimulating activities are negatively correlated, suggesting that different family members substitute for one another in looking after and engaging with young children. Stimulating activities with older sisters, in particular, are negatively correlated with stimulation by all others. The only exceptions are married couples – stimulation by mothers is positively correlated with stimulation by fathers, and stimulation by grandmothers is positively correlated with stimulation by grandfathers – and "others" (for example, aunts and uncles) who engage in more stimulating activities when grandmothers do as well (possibly reflecting situations when children do not live with their own parents and siblings). In contrast, all the different types of stimulating activities are positively correlated, suggesting that children who receive more cognitive stimulation also receive a wider variety of forms of stimulation.

4 Analysis

4.1 Empirical Strategy

To estimate the impact of big sisters on child development, we assume that child gender is plausibly exogenous and estimate the regression equation:

$$Y_i = \alpha + \beta Sister_i + \varepsilon_i \tag{10}$$

where $Sister_i$ is an indicator equal to one if the older sibling in household i is female.[24] Parents cannot control the sex of any given child, and households in our study area have little access to sex-selection technologies — so gender is not explicitly endogenous. Nevertheless, our estimates of the treatment effect of older sisters will be biased if $Sister_i$ is correlated with any (observed or unobserved) covariates that also predict outcomes. For example, if adolescent girls were more likely to live at home in wealthier households, $\hat{\beta}$ would not capture the causal impact of having an older sister on child development. We test for this by comparing the observable characteristics of households with and without an older sister.

In our sample, households with an older sister are similar to households with an older brother in terms of family structure, parental characteristics, and living conditions; and younger children are similar in terms of gender, age, and school enrollment, as shown in Table 2.[25] Households where the older child is female are slightly smaller, but older sisters and older brothers are similar in age and the birth spacing between older and younger siblings is also similar, suggesting comparable patterns of fertility in the two types of households.[26]

[24] See Washington (2008) for a similar estimation approach.

[25] One out of 29 estimated coefficients is statistically significant at the five percent level, and another is significant at the ten percent level.

[26] If parents exhibited the form of son preference found in South Asia, we would expect household where

Our sample is also demographically similar to families sampled in the 2014 Kenya Demographic and Health Survey (DHS) (Kenya National Bureau of Statistics 2015). For example, in the DHS, among women age 15-49 in Kenya's former Nyanza province (the region where our study takes place) who had given birth at least once, the average number of years of schooling was 7.8, the average age was 31.7 years, and 82.6 percent had a latrine or toilet (author's calculations); this is similar to our sample, where, on average, mothers have 7.9 years of schooling, are 30.5 years old, and have a latrine or toilet 79.3 percent of the time.

In this DHS sample, families structured in the same way as those in our sample – with an older sibling as well as at least one younger child between the ages of 3 and 6 – also display balance on observables when comparing households with an older sister to those with an older brother, as shown in Appendix Table A4. There are small imbalances: among 29 tests in Table 2, one is significant at the ten percent level, and one is significant at the five percent level; among 23 tests in Table A4, again one is significant at the ten percent level, and one is significant at the five percent level. However, variables that are imbalanced in the DHS sample are different from those that are imbalanced in our sample, suggesting that these small imbalances are due to sampling variation. For example, the small household size imbalance has the opposite sign in our sample compared to the corresponding point estimate in the DHS sample. Since families with older sisters and older brothers look similar in terms of observable characteristics in our setting, we treat the gender of the older child as plausibly exogenous in our subsequent analysis.

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the older child is female to be larger rather than smaller, and we would expect meaningful differences in birth spacing (Jayachandran and Kuziemko 2011).

4.2 The Impact of Big Sisters on Child Development

Kernel density estimates of our early childhood development index are presented in Figure 1. Negative z-scores are more common among young children with older brothers, and z-scores are more concentrated about zero among children with older sisters. The density functions are quite similar for z-scores above one. Thus, the graphical evidence suggests that poor early childhood development outcomes are less common in families with an older child who is female.

Regression estimates of the impact of older sisters on younger siblings' development are reported in Table 3. Having an older sister rather than an older brother has a statistically significant effect on younger siblings. Estimates of Equation 10 suggest that young children with an older sister score 0.129 standard deviations higher on our aggregate measure of early childhood development (p-value 0.035). In specifications that include controls for child gender, age (fixed effects for child age in months), mother's education, the number of young children, household size, and an index of household assets, the estimated impact of big sisters rises to 0.138 (p-value 0.027). The magnitude of the coefficients suggests that the treatment effect of having a big sister is developmentally meaningful. For comparison, the estimated effect is roughly equivalent to the difference in development between children whose mothers completed primary school and those whose mothers had less than eight years of education.[27]

Quantile regressions of the early childhood development index on the indicator for having an older sister rather than an older brother are summarized in Panel A of Figure 2. We estimate one regression for every quantile between the 10^{th} and 90^{th}, inclusive. Using the functional inference techniques proposed by Chernozhukov, Fernández-Val, and Melly (2020, 2022), we test two hypotheses: first, that big sisters have no impact on the

[27]In OLS specifications including controls for child gender, age (fixed effects for child age in months), and an index of household wealth, the coefficient on the indicator for completing primary school is 0.135 (p-value 0.030).

distribution of the child development index, and second, that the impact of big sisters is constant across the distribution. Quantile regressions again confirm the existence of a treatment effect of big sisters on early childhood development, rejecting the hypothesis of no treatment effect across the range of quantiles we consider (p-value from a hypothesis test based on a Cramer-von Mises statistic 0.040). Though estimated treatment effects are slightly larger for the lower quantiles, we cannot reject the hypothesis that the treatment effect of having an older sister is constant across the distribution (p-value 0.230).

In Panel B of Table 3, we decompose the underlying elements of the early childhood development index, estimating the treatment effect of big sisters on young children's vocabulary and fine motor skills. Results show that having an older sister leads to improvements in both outcomes. In specifications including controls (child gender, child age, mother's education, and an index of household assets), having an older sister as opposed to an older brother is associated with a 0.126 standard deviation increase in vocabulary (p-value 0.052) and a 0.151 standard deviation increase in fine motor skills (p-value 0.066).

In Panels B and C of Figure 2, we present quantile regressions of the impact of older sisters on vocabulary and fine motor skills. Estimated impacts on vocabulary are relatively constant across the distribution, and using the functional inference approach, we cannot reject the hypothesis that having an older sister does not have a statistically significant impact on the distribution of vocabulary skills (p-value 0.182). We also fail to reject the hypothesis that the treatment effect of older sisters on vocabulary skills is constant across the distribution. For fine motor skills, we find clear evidence that the impacts of big sisters are concentrated in the bottom half of the distribution. We can reject the hypothesis of no treatment effect of big sisters on fine motor skills (p-value 0.056), and we can also reject the hypothesis that the treatment effect is constant across the distribution (p-value 0.008). Thus, having a big sister appears to be particularly important for young children with relatively weak fine motor skills.[28]

4.3 The Impact of Big Sisters on Investments in Young Children

As discussed in Section 2, there are several different reasons that younger siblings might benefit from having an older sister. One possibility is that older sisters are more effective than older brothers at improving younger siblings' human capital. Alternatively, older girls and their parents might believe that the returns to investing in their human capital are relatively low (as compared with similarly aged boys). If older siblings' investments in young children are not productive, parents who invest less in their older girls will invest more in their youngest children. On the other hand, if older children contribute to the human capital accumulation of their younger siblings, older girls will invest less in themselves and more in their younger siblings — and the impact of older sibling gender on parental investment will be ambiguous.

We test the predictions of the model using data on early childhood stimulation — both the overall amount of stimulation received by each young child, and the amount of stimulation done by different family members (e.g. the mother, the father, the older siblings, etc.). Estimates of the impact of having an older daughter on the overall level of early childhood stimulation are reported in Panel C of Table 3. We find large and statistically significant impacts of older sisters on the level of early childhood stimulation a child experiences. Having an older sister increases the number of different stimulating activities (out of 12) over the three days prior to the survey by between 0.637 (without controls, p-value 0.006) and 0.744 (with controls, p-value 0.001). Among households where the older child is male, the mean number of stimulating activities is 5.147; hence, the estimated treatment effect of having an older sister represents more than a ten percentage

[28] In Online Appendix Table A8, we test for treatment effect heterogeneity across a small set of key covariates. We do not find evidence of statistically significant variation in treatment effects.

point increase in early childhood stimulation. Seen through our model, this suggests that we can rule out the possibility that both $\delta_o^G = \delta_o^B$ and $\lambda_o^G = \lambda_o^B$ (that is, we can rule out the possibility that *neither* mechanism is at work) — since we observe a clear treatment effect of older sibling gender on early childhood stimulation.

Next, we test whether parents or siblings are the main channel of impact. In Figure 4, we summarize the estimated treatment effect of having an older sister on 10 different outcome variables related to early childhood stimulation. First, we present the treatment effect on the overall level of early childhood stimulation (replicating the specification in Panel C of Table 3 that was discussed above). Then, we present treatment effects on the amount of early childhood stimulation done by parents and the amount done by siblings. Finally, we present treatment effects on the amount of early childhood stimulation done mothers, by fathers, by sisters, by brothers, by grandmothers, by grandfathers, and by other individuals. Having an older sister does not impact the amount of stimulation young children receive from their parents, nor does it impact the amount received from the mother or father specifically, from either grandparent, or from others. All estimated coefficients are relatively precise zeros. Instead, having an older sister leads to a significant increase in the amount of stimulation received from siblings. Having an older sister increases the amount of stimulation done by sisters and decreases the amount done by brothers, but the positive impact on stimulation by sisters is larger – leading to a positive impact on the overall level of sibling stimulation.[29] In Online Appendix Table A5, we report the estimated treatment effect of having an older sister on the types of stimulation young children receive (i.e. on the individual activities captured by the FCI). Having an older sister has a weakly positive impact on all twelve activities considered (though this drops to eleven of twelve in the covariate-adjusted specification), suggesting that having an older sister mainly changes the amount of stimulation young children receive rather than the type of stimulation. Children

[29]Since our measure also captures stimulation by adult siblings, the level of stimulation by older sisters is not zero in households where the older child is male.

with older sisters are significantly more likely to have been told stories, engaged in physical play with someone, been taught letters and numbers, had someone draw with them, and to have had someone teach them the names of objects. Hence, older sisters engage in activities that might be expected to improve both motor skills and vocabulary – consistent with the pattern of results that we find.[30]

4.4 Gender Bias

As a final test of the empirical predictions of our model of household investments in young children, we test whether parents engage in more stimulating activities with young boys than with young girls. Our model predicts that parents who are gender biased or perceive lower across-the-board returns to investing in young girls' human capital, relative to boys, would spend less time engaging in stimulating activities with a young daughter than they would with a young son. We test this prediction by regressing our measure of parental stimulation, the number of stimulating activities parents engage in with their young child, on dummies for male children, having an older sister rather than an older brother, and an interaction between the two. Results are reported in Online Appendix Table A7. We find no evidence that parents invest more in young male children than in young female children, nor do we find any evidence of an interaction between older sibling gender and having a big sister.

[30]Table A6 shows that the patterns shown in Figure 4, which capture the treatment effects of big sisters on both the intensive and the extensive margin of early childhood stimulation, are also present when we look only at the extensive margin: young children with an older sister rather than an older brother are more likely to engage in stimulating activities with a sibling, more likely to engage in stimulating activities with a sister, and less likely to engage in stimulating activities with a brother. They are also slightly less likely to engage in stimulating activities with their grandfather, though the impacts are small in magnitude (as grandfathers do very little early childhood stimulation).

4.5 Connecting the Model to the Empirical Results

To summarize, we find that young children who have an older sister rather than an older brother engage in more stimulating activities with older family members. This difference is driven by sibling behavior: older sisters do more stimulating activities with younger siblings than older brothers, but the amount that parents do with young children does not depend on the gender of the older sibling. Our model predicts that parents who perceive equal returns to investing in girls' and boys' human capital but who view older girls as more effective caregivers than older boys will invest *less* in young children when their older child is a daughter, because they have an effective substitute – but we do not see this in the data. Since we do not observe a negative treatment effect of older sisters on stimulation of young children by parents, our model suggests that we can rule out the case where the treatment effect of older sisters is driven entirely by gender differences in the productivity of human capital investments by sisters vs. brothers. On the other hand, our model also predicts that that if parents' perceive a low return to investing in older girls' human capital and they do not believe that older siblings can improve young children's human capital, then we will observe a *positive* treatment effect of having an older sister on parental investments in young children – and we do not see this either. Our model therefore suggests that both mechanisms must be at play: parents must perceive a relatively low return to investing in older girls' human capital and they must believe that older girls can improve younger siblings' human capital by engaging in stimulating activities with them. The pattern of empirical results can be explained by our model if older siblings contribute to the human capital accumulation of their young siblings and households know it, so parents substitute the older sister's time with the young child for their own.

5 Conclusion

Older sisters have a positive and significant impact on their younger siblings' development. Our results are not consistent with a model in which parents of older sisters invest more in young children only because of a relaxed budget constraint associated with lower perceived labor market returns to investment in the older sister. Instead, our results suggest that older siblings and parents *both* contribute to the development of young children's human capital. Importantly, the empirical patterns we observe can only arise in our model if households perceive a lower return to human capital investments in older girls, relative to older boys, and they believe that stimulating activities with older siblings improve younger siblings human capital. Our model suggests that this pattern can arise because older sisters invest less in their own human capital than older brothers, and they invest more in their younger siblings. This changes the marginal utility of parental investments, so parents of older girls may or may not invest more in their youngest progeny than parents of older boys.

Our results highlight the critical importance of older children (both sisters and brothers) in child rearing in developing country contexts. In our sample, siblings do more cognitive stimulation than any other household member — but their role is typically ignored in models of household investments in children and policy discussions about early childhood. Our results suggest that evaluations of early childhood interventions are unlikely to fully capture effects on households if they do not take account of older siblings, and the critical role that they play in childrearing in many LMIC contexts. In addition, evaluations targeting older children should explicitly consider impacts on younger siblings in critical stages of child development. Our findings are consistent with recent evidence from Pakistan showing that educating girls has positive spillover effects on younger siblings (Qureshi 2018), and with evidence from Mozambique and Turkey demonstrating that early childhood interventions that improve child health or increase preschool availability can have positive spillover effects on older children's educational outcomes (Alsan 2017, Martinez, Naudeau and Pereira 2017). Siblings, particularly sisters, play an important role in shaping the developmental trajectories of young children in many developing country contexts, and researchers seeking to understand households' investments in young children or the constraints on older girls' educational attainment cannot fully capture these dynamics while ignoring the special role that older children play in caring for their younger siblings.

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Figure 1: Kernel Density Estimates of Early Childhood Development Indices

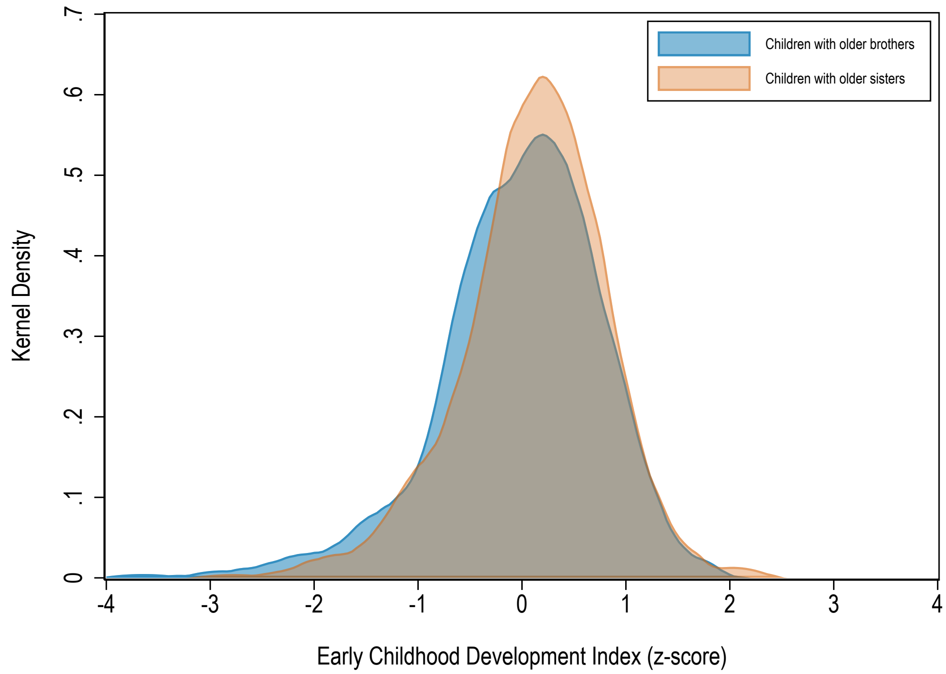
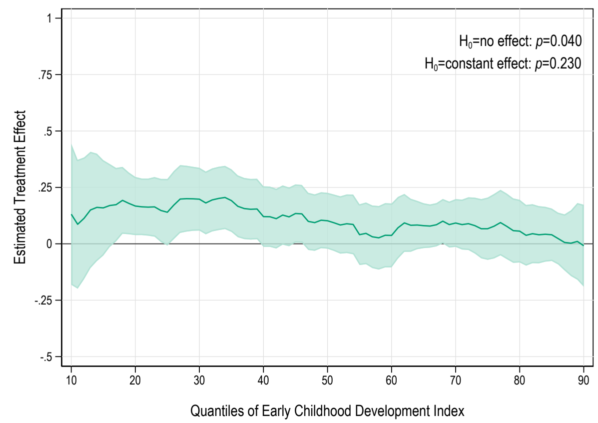


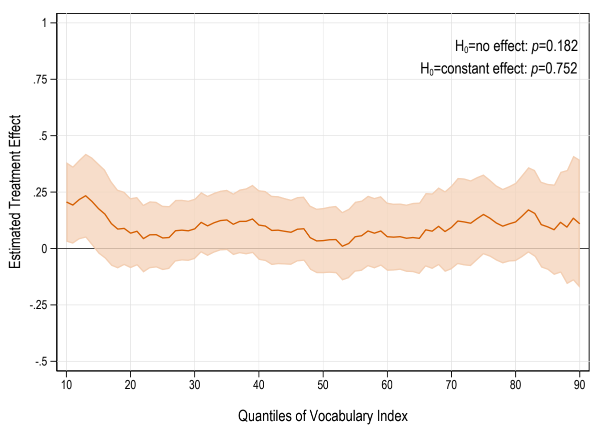
Figure shows kernal density estimates of a summary index of early childhood development among Kenyan children aged 3 to 6 years who have one older sister aged seven to 14 ($N = 352$, in orange) or one older brother in that age range($N = 347$, in blue). The child development index is a composite of three vocabulary sub-scales (expressive vocabulary, receptive vocabulary in Luo, and receptive vocabulary in English) and a fine motor skills index based on items adapted from the Malawi Development Assessment Tool (MDAT).

Figure 2: Quantile Regressions of the Impact of Big Sisters

Panel A: Impacts on Index of Early Childhood Development



Panel B: Impacts on Vocabulary



Panel C: Impacts on Fine Motor Skills

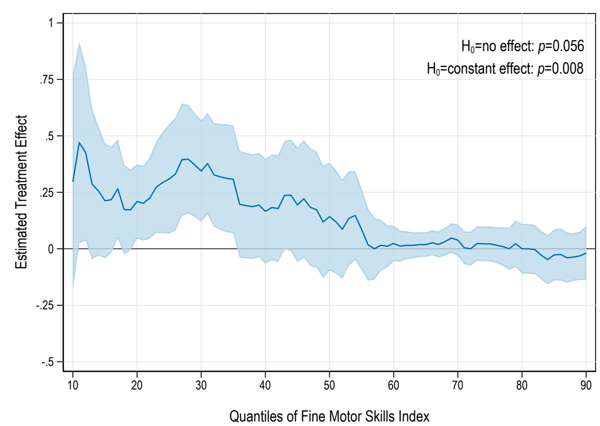
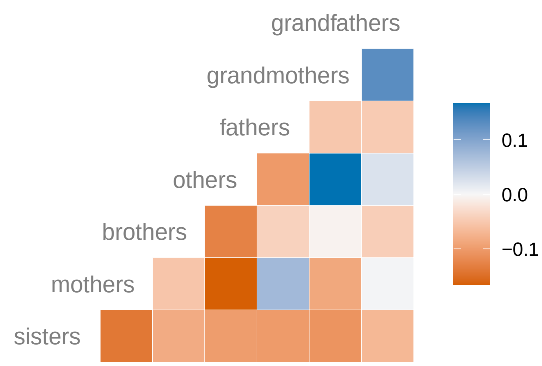


Figure shows estimated coefficients and 95 percent confidence intervals from quantile regressions estimating the impact of having one older sister aged seven to 14 as opposed to one older brother in that age range. Confidence intervals estimated following Chernozhukov, Fernández-Val and Melly (2022). The child development index is a composite of the vocabulary and motor skills indices. The vocabulary index includes three sub-scales: expressive vocabulary, receptive vocabulary in Luo, and receptive vocabulary in English. The fine motor skills index includes items adapted from the Malawi Development Assessment Tool (MDAT).

Figure 3: Correlations Between Components of the FCI

Panel A. Correlogram of Stimulation by Household Members



Panel B. Correlogram of Types of Stimulation

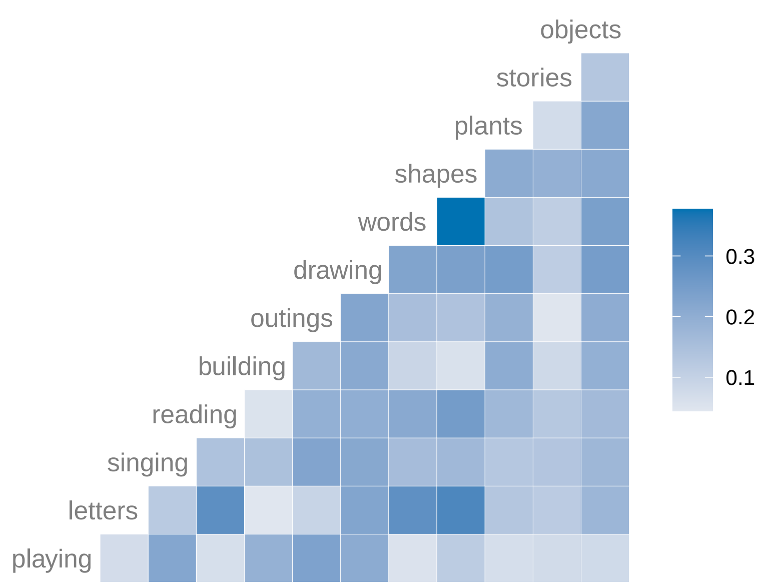


Figure shows correlograms summarizing the correlations between the variables presented in Table A2 (in Panel A) and Table A3 (in Panel B). Variables in Panel A reflect the number of stimulating activities a child engaged in with each of the household members listed. Variables in Panel B are indicators for engaging in a particular type of stimulating activity with any older household member.

Figure 4: Decomposing the Impact of Having a Sister on Early Childhood Stimulation

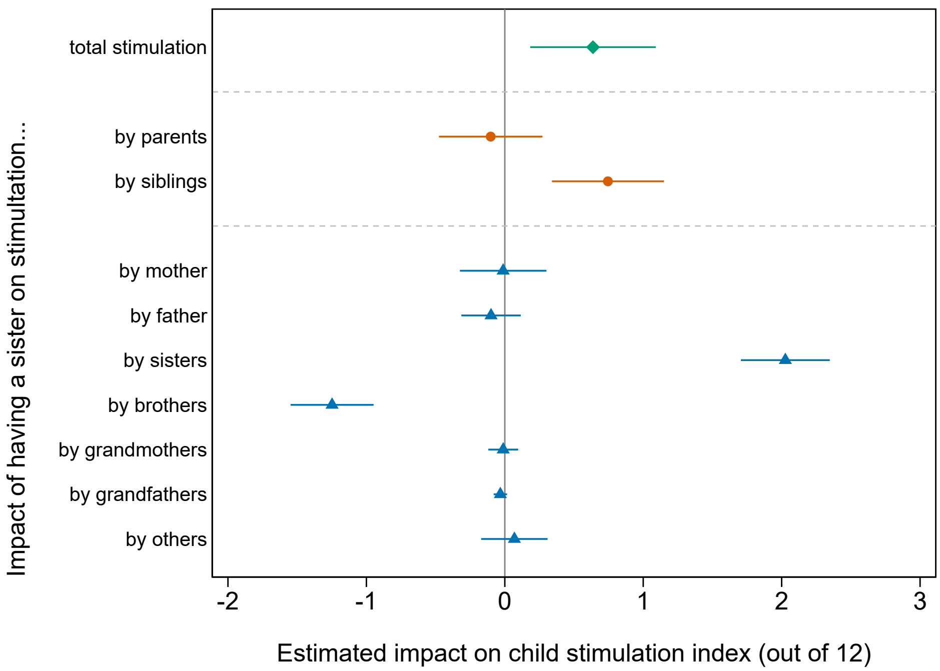


Figure shows OLS regression coefficients and 95 percent confidence intervals (robust standard errors clustered at the household level in all specifications) from regressions estimating the impact of having one older sister aged seven to 14 as opposed to one older brother in that age range. Early Childhood Stimulation is measured using an adapted version of the Family Care Indicators questionnaire.

Table 1: Testable Predictions of the Theoretical Model when $\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$

Assumptions:	p_y^*	$\delta_o^z o_y^*$	I_y^*
No gender differences			
$\delta_o^G = \delta_o^B \geq 0$			
$\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$	$p_y^G = p_y^B$	$\delta_o^G o_y^G = \delta_o^B o_y^B$	$I_y^G I_y^B$
$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$			
Differential returns, zero sibling productivity			
$\delta_o^G = \delta_o^B = 0$			
$\lambda_o^G < \lambda_o^B$	$p_y^G > p_y^B$	$\delta_o^G o_y^G = \delta_o^B o_y^B = 0$	$I_y^G > I_y^B$
$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$			
Equal returns, differential sibling productivity			
$\delta_o^G > \delta_o^B > 0$			
$\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$	$p_y^G < p_y^B$	$\delta_o^G o_y^G > \delta_o^B o_y^B$	$I_y^G > I_y^B$
$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$			
Differential returns, equal (positive) sibling productivity			
$\delta_o^G = \delta_o^B > 0$			
$\lambda_o^G < \lambda_o^B$	–	$\delta_o^G o_y^G > \delta_o^B o_y^B$	$I_y^G > I_y^B$
$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$			
Differential returns, differential (positive) sibling productivity			
$\delta_o^G > \delta_o^B > 0$			
$\lambda_o^G < \lambda_o^B$	–	$\delta_o^G o_y^G > \delta_o^B o_y^B$	$I_y^G > I_y^B$
$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$			

Table 2: Summary Statistics by Older Sibling Gender

Older sibling is a...	Sister		Brother		Difference	
	Mean	S.D.	Mean	S.D.	Diff.	S.E.
Child is male	0.48	0.50	0.53	0.50	-0.05	0.04
Child age (in months)	59.70	13.72	60.46	14.14	-0.76	0.90
Child is enrolled in school	0.90	0.30	0.87	0.33	0.03	0.02
Older sibling age	9.53	2.16	9.51	2.19	0.02	0.20
Caregiver is child's mother	0.84	0.37	0.84	0.37	0.00	0.03
Caregiver is child's father	0.01	0.08	0.00	0.05	0.00	0.00
Caregiver is child's grandmother	0.12	0.33	0.13	0.34	-0.01	0.03
Caregiver illiterate	0.48	0.50	0.54	0.50	-0.06	0.05
Child's mother is alive	0.96	0.19	0.97	0.17	-0.01	0.01
Mother's age	30.50	7.03	30.44	6.90	0.06	0.60
Mother is Luo	0.95	0.21	0.95	0.22	0.01	0.02
Mother's education in years	7.88	2.39	8.02	2.42	-0.15	0.21
Father unknown or deceased	0.24	0.43	0.19	0.39	0.05	0.04
Mother currently married	0.82	0.38	0.82	0.39	0.01	0.04
Father's age	39.41	9.43	38.37	9.22	1.04	0.87
Father is Luo	0.99	0.10	0.98	0.14	0.01	0.01
Father's education in years	8.67	2.76	8.89	2.59	-0.23	0.25
Number of children aged 3–6	1.38	0.48	1.47	0.50	-0.09*	0.05
Number of children aged 0–2	0.43	0.62	0.46	0.71	-0.03	0.06
Number of adults in household	2.38	1.30	2.55	1.29	-0.17	0.12
Household size	5.18	1.43	5.47	1.60	-0.29**	0.14
Young child age spacing	1.99	0.85	2.01	0.91	-0.03	0.15
Old-young child age spacing	5.06	2.43	4.97	2.60	0.08	0.21
Has cement floor	0.15	0.36	0.16	0.37	-0.01	0.03
Has iron roof	0.98	0.13	0.99	0.12	-0.00	0.01
Has latrine or toilet	0.81	0.40	0.78	0.42	0.03	0.04
Has solar power	0.39	0.49	0.44	0.50	-0.04	0.04
Distance to primary school (in meters)	438.64	185.28	428.14	156.11	10.50	15.35
Observations	352		347			

Sample includes data on 699 children aged 3 to 6 years in 552 unique households. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table 3: Impacts of Big Sisters on Early Childhood Development

		Coefficient on Big Sister	
Outcome variable	Mean	No Controls	W/ Controls
Panel A. Summary Measures of Younger Siblings' Development			
Child development index (z-score)	-0.022	0.129**	0.138**
		(0.061)	(0.062)
Panel B. Components of Child Development Index			
Child vocabulary (z-score)	-0.015	0.108*	0.126*
		(0.064)	(0.064)
Fine motor skills (z-score)	-0.028	0.149*	0.151*
		(0.078)	(0.082)
Panel C. Early Childhood Stimulation			
Early childhood stimulation index (out of 12)	5.147	0.637***	0.744***
		(0.231)	(0.226)

OLS coefficients reported. Robust standard errors clustered at the household level are reported in parentheses. The child development index is a composite of the vocabulary and motor skills indices. The vocabulary index includes three sub-scales: expressive vocabulary, receptive vocabulary in Luo, and receptive vocabulary in English. The fine motor skills index includes items adapted from the Malawi Development Assessment Tool (MDAT). The stimulation index records the number of different stimulating activities (out of 12) experienced by the child over the three days prior to the survey. The mean indicates the average value of each outcome variable among households with a single male child between the ages of seven and 14; the OLS coefficient estimates denote the treatment effect of having one older sister aged seven to 14 rather than one older brother in that age range. The specification with controls includes child age (fixed effects for age in months), child gender, mother's education, the number of young children in the household, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Mathematical Appendix

Proof of Proposition 1

Statement of Proposition 1. Let $\delta_o^G > \delta_o^B > 0$, and further assume δ_o^B is sufficiently far above zero to guarantee that $o_y^*(\delta_o^G, \lambda_o^G, \lambda_y^z) > 0$ and $o_y^*(\delta_o^B, \lambda_o^B, \lambda_y^z) > 0$ (so, older brothers allocate a strictly positive amount of time to engaging in stimulating activities with their younger siblings). Let $\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$ $\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$. Then, the following are true:

i. $I_y^* \left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > I_y^* \left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$,

ii. $p_o^* \left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > p_o^* \left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$,

iii. $p_y^* \left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) < p_y^* \left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$,

iv. $\delta_o^G o_y^* \left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > \delta_o^B o_y^* \left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$, and

v. $L_p^* \left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right) > L_p^* \left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$.

Notation. To simplify notation within the proof, we omit the arguments of the quantities agents are maximizing over. We use I_y^G to denote $I_y^* \left(\delta_o^G, \bar{\lambda}_o, \bar{\lambda}_y\right)$ and I_y^B to denote $I_y^* \left(\delta_o^B, \bar{\lambda}_o, \bar{\lambda}_y\right)$. For $z \in \{G, B\}$, p_o^z, p_y^z, o_y^z, L_p^z, and E_o^z are defined analogously. The arguments are unnecessary within the proof because we have explicitly stated our assumptions regarding the values of δ_o^z, λ_o^z, and λ_y^z above. Within the proof, we use * (e.g. in I_y^*) in comparative statics analysis to indicate the optimal value defined as a function of δ, not the optimum at a specific value of δ such as δ_o^G or δ_o^B.

Step 1. An increase in δ_o^z leads to an increase in I_y^*, so $I_y^G > I_y^B$. Assume not: assume an increase in δ_o^z leads to either a decrease or no change in $I_y^* = p_y^* + \delta_o^z o_y^*$.

First, consider the possibility that an increase in δ_o^z leads to a decrease in I_y^* and thus an increase in $\bar{\lambda}_y h_y'(p_y^* + \delta_o^z o_y^*)$. By Equation 8, this implies an increase in both $y'(1 - p_o^* - p_y^*)$ and $\bar{\lambda}_o h_{p\to o}'(p_o^*)$. The latter implies a decrease in p_o^* since $h_{p\to o}(\cdot)$ is strictly concave. By a similar argument, the former implies an increase in $p_o^* + p_y^*$; since we've already shown that p_o^* must decrease, p_y^* must increase. So, if an increase in δ_o^z leads to a decrease in $\delta_o^z o_y^* + p_y^*$, it implies an increase in p_y^*; thus, the decrease in $\delta_o^z o_y^* + p_y^*$ must come from an increase in o_y^*.

An increase in δ_o^z must also lead to either an increase in $h_{o\to o}'(1 - o_y^*)$ or a decrease in $h_y'(\delta_o^z o_y^* + p_y^*)$ (or both) if Equation 9 is to hold. Since we started from the assumption that $\delta_o^z o_y^* + p_y^*$ decreases, $h_y'(\delta_o^z o_y^* + p_y^*)$ must increase. Hence, Equation 9 can only hold if $h_{o\to o}'(1-o_y^*)$ increases. However, we have already shown that o_y^* must decrease, so $1-o_y^*$ and

$h_{o\to o}(1-o_y^*)$ must increase — leading to a decrease in $h'_{o\to o}(1-o_y^*)$. Thus, the assumption that an increase in δ_o^z leads to an decrease in I_y^* leads to a contradiction.

Next, consider the possibility that an increase in δ_o^z leads to no change in I_y^*. This means that there is no change in $h'_y(\delta_o^z o_y^* + p_y^*)$. There is consequently no change in either p_o^* or p_y^* (by Equation 8). Since there is no change in p_y^*, o_y^* must decrease to offset the increase in δ_o^z (keeping I_y^* constant). This implies an decrease in $h'_{o\to o}(1-o_y^*)$. However, Equation 9 requires an *increase* in $h'_{o\to o}(1-o_y^*)$ to offset the increase in δ_o^z — since $h'_y(\delta o_y^* + p_y^*)$ and $\bar{\lambda}_y$ do not change. So $h'_{o\to o}(1-o_y^*)$ must increase and decrease simultaneously — a contradiction.

Step 2. $I_y^G > I_y^B$ implies $p_o^G > p_o^B$. This follows directly from Equation 8 since $h_{p\to o}(\cdot)$ and $h_y(\cdot)$ are concave.

Step 3. $I_y^G > I_y^B$ and $p_o^G > p_o^B$ together imply $L_p^G > L_p^B$ and $p_y^G < p_y^B$. Since $h_y(\cdot)$ and $y(\cdot)$ are both strictly concave, the increase in I_y^* means that $y'(1-p_o^*-p_y^*)$ must decrease if Equation 8 is to hold. Hence, $L_p^G > L_p^B$ must increase. We have already shown that $p_o^G > p_o^B$. Since $L_p^z = 1 - p_o^z - p_y^z$, $L_p^G > L_p^B$ and $p_o^G > p_o^B$ together imply $p_y^G < p_y^B$.

□

Proposition 2

Statement of Proposition 2. Let $\lambda_o^G < \lambda_o^B$, $\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$, and $\delta_o^G = \delta_o^B = \bar{\delta}_o > 0$. Then, the following are true:

i. $I^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right) > I^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$,

ii. $L_p^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right) > L_p^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$,

iii. $p_o^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right) < p_o^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$,

iv. $o_y^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right) > o_y^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$,

v. $\delta_o^G o_y^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right) > \delta_o^B o_y^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$, and

vi. $E_o^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right) < E_o^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$.

Notation. To simplify notation within the proof, we omit the arguments of the quantities agents are maximizing over. We use I_y^G to denote $I_y^*\left(\bar{\delta}_o, \lambda_o^G, \bar{\lambda}_y\right)$ and I_y^B to denote $I_y^*\left(\bar{\delta}_o, \lambda_o^B, \bar{\lambda}_y\right)$. For $z \in \{G, B\}$, p_o^z, p_y^z, o_y^z, L_p^z, and E_o^z are defined analogously. The arguments are unnecessary within the proof because we have explicitly stated our assumptions regarding the values of δ_o^z, λ_o^z, and λ_y^z. Within the proof, we use * (e.g. in I_y^*) to indicate the optimal value defined as a function of δ, not the optimum at a specific value of λ_o such as λ_o^G or λ_o^B.

Step 1. A decrease in λ_o leads to a decrease in p_o^*.

Assume not: assume a decrease in λ_o leads to either a increase or no change in p_o^*.

By Equation 8, $\lambda_o = y'(1 - p_o^* - p_y^*)/h'_{p\to o}(p_o^*)$ (Equation 8). Hence, a decrease in λ_o means that either $y'(1-p_o^*-p_y^*)$ must decrease or $h'_{p\to o}(p_o^*)$ must increase. Because $h_{p\to o}(\cdot)$ is concave, $h'_{p\to o}(p_o^*)$ can only increase if p_o^* decreases. So, for λ_o to decrease without a decrease in p_o^*, $y'(1 - p_o^* - p_y^*)$ must decrease — and for this to happen without a decrease in p_o^*, p_y^* must decrease. So, if λ_o decreases, p_y^* must decrease.

By Equation 8, $\lambda_o = \bar{\lambda}_y h'_y(\bar{\delta}_o o_y^* + p_y^*)/h'_{p\to o}(p_o^*)$. So, if λ_o decreases and p_o^* does not, $h'_y(\bar{\delta}_o o_y^* + p_y^*)$ must decrease (since $\bar{\lambda}_y$ does not change). Since $h'_y(\cdot)$ is concave, this implies an increase in either o_y^* or p_y^*. Above, we demonstrated that p_y^* must decrease (if λ_o decreases and p_o^* does not), so o_y^* must increase.

Combining Equation 8 and Equation 9, we see that

$$\frac{h'_{p\to o}(p_o^*)}{h'_{o\to o}(1 - o_y^*)} = \frac{1}{\delta}. \tag{11}$$

Since o_y^* must increase and $\bar{\delta}_o$ does not change, we see that p_o^* must decrease — though we have assumed that it does not. Thus, starting from the assumption that p_o^* does not decline leads to a contradiction. Hence, a decrease in λ_o implies a decrease in p_o^*.

Step 2. The decrease in p_o^* implies a decrease in E_o^* and an increase in o_y^*.

This follows directly from Equation 11 and the definition of E_o^*.

Step 3. The decrease in p_o^* implies an increase in I_y^* and L_p^*.

We proceed by contradiction. We have already shown that o_y^* must increase. As a consequence, if we assume that I_y^* does not increase, then p_y^* must decrease. Since we have already shown that p_o^* must decrease, this means that $1 - (p_o^* + p_y^*)$ must increase, and (by concavity) $y'(1 - p_o^* - p_y^*)$ must decrease. Note, however, that if I_y^* does not increase, then $h'_y(\bar{\delta}_o o_y^* + p_y^*)$ cannot decrease and (as a result) Equation 8 cannot hold. This is a contradiction. So, I_y^* must increase, and (by Equation 8) L_p^* must increase as well.

A Online Appendix: not for print publication

Table A1: Early Childhood Stimulation Is Associated with Child Development

	Coefficient on Stimulation Index	
Outcome variable	No Controls	W/ Controls
Child development index (z-score)	0.030***	0.024**
	(0.011)	(0.012)

OLS coefficients reported. Robust standard errors clustered at the household level are reported in parentheses. The child development index—the outcome in these regressions—is a composite of the vocabulary and motor skills indices, as described in notes to Table 3. The independent variable is an early childhood stimulation index, recording the number of different stimulating activities (out of 12) experienced by the child over the three days prior to the survey. The OLS coefficient estimates denote the (unconditional or conditional) predicted child development level given a level of stimulation. The specification with controls includes child age (fixed effects for age in months), child gender, mother's education, the number of young children in the household, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table A2: Summary Statistics on Stimulation by Individual Household Members

Outcome variable	Mean	S.D	Median	Min.	Max.	N
Any early childhood stimulation	0.99	0.12	1	0	1	699
Early childhood stimulation index (out of 12)	5.46	2.68	5	0	12	699
Stimulating activities with parents	1.92	2.17	1	0	11	699
Stimulating activities with siblings	2.72	2.46	2	0	12	699
Stimulating activities with mother	1.43	1.84	1	0	9	699
Stimulating activities with father	0.55	1.22	0	0	8	699
Stimulating activities with sister	1.73	2.22	1	0	12	699
Stimulating activities with brother	1.22	1.84	0	0	9	699
Stimulating activities with grandmother	0.20	0.68	0	0	8	699
Stimulating activities with grandfathers	0.04	0.32	0	0	5	699
Stimulating activities with others	0.95	1.49	0	0	10	699

Sample includes data on 699 children aged 3 to 6 years in 552 unique households.

Table A3: Summary Statistics on Types of Stimulating Activities

Outcome variable	Mean	S.D	Median	Min.	Max.	N
Someone read to child	0.53	0.50	1	0	1	699
Someone told child stories	0.24	0.43	0	0	1	699
Someone sang child songs	0.56	0.50	1	0	1	699
Someone took child out of compound	0.50	0.50	0	0	1	699
Someone engaged in physical play with child	0.85	0.36	1	0	1	699
Someone taught child letters or numbers	0.62	0.49	1	0	1	699
Someone taught child shapes or colors	0.30	0.46	0	0	1	699
Someone drew with the child	0.47	0.50	0	0	1	699
Someone constructed objects with the child	0.53	0.50	1	0	1	699
Someone taught child plant, animal names	0.27	0.45	0	0	1	699
Someone taught child English words	0.38	0.49	0	0	1	699
Someone taught child names of objects	0.22	0.41	0	0	1	699

Sample includes data on 699 children aged 3 to 6 years in 552 unique households.

Table A4: DHS 2014 Nyanza Summary Statistics by Older Sibling Gender

Older sibling is a...	Sister		Brother		Difference	
	Mean	S.D.	Mean	S.D.	Diff.	S.E.
Child is male	0.49	0.50	0.49	0.50	-0.00	0.04
Child age (in months)	60.62	14.60	59.74	14.32	0.88	0.89
Child is enrolled in school	0.83	0.38	0.77	0.42	0.06**	0.03
Older sibling age	9.53	2.18	9.65	2.16	-0.12	0.19
Child's mother is alive	0.98	0.14	0.95	0.21	0.03*	0.02
Mother's age	29.88	6.11	29.65	6.13	0.24	0.57
Intervew language is Luo	0.57	0.50	0.55	0.50	0.02	0.04
Respondent's language is Luo	0.60	0.49	0.61	0.49	-0.01	0.04
Mother's education in years	8.30	3.23	8.58	3.03	-0.28	0.31
Child's father is alive	0.90	0.30	0.92	0.27	-0.02	0.03
Child's father is in household	0.54	0.50	0.61	0.49	-0.06	0.04
Father's age	37.22	9.03	36.52	8.04	0.69	0.98
Father's education in years	9.16	3.39	9.33	3.24	-0.18	0.39
Number of children aged 3–6	1.55	0.63	1.54	0.69	0.02	0.07
Number of children aged 0–2	0.56	0.60	0.48	0.62	0.08	0.05
Number of adults in household	2.29	1.20	2.38	1.13	-0.08	0.11
Household size	5.41	1.56	5.39	1.49	0.01	0.15
Young child age spacing	1.99	0.89	1.90	0.88	0.09	0.14
Old-young child age spacing	4.98	2.51	5.17	2.45	-0.19	0.21
Has cement floor	0.27	0.45	0.33	0.47	-0.06	0.04
Has iron roof	0.90	0.30	0.89	0.31	0.01	0.03
Has latrine or toilet	0.81	0.39	0.87	0.34	-0.05	0.03
Has solar power	0.10	0.30	0.11	0.31	-0.01	0.03
Observations	375		395			

Sample includes data on 770 children aged 3 to 6 years in 582 unique households. Standard errors are clustered at the household level. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table A5: Impacts of Big Sisters on Components of Family Care Indicators

		Coefficient on Big Sister	
Outcome variable	Mean	No Controls	W/ Controls
Someone read to child	0.524	0.018	0.038
		(0.041)	(0.042)
Someone told child stories	0.210	0.057	0.076**
		(0.036)	(0.038)
Someone sang child songs	0.524	0.066	0.061
		(0.042)	(0.043)
Someone took child out of compound	0.496	0.001	0.004
		(0.042)	(0.043)
Someone engaged in physical play with child	0.816	0.068**	0.071**
		(0.030)	(0.031)
Someone taught child letters or numbers	0.553	0.126***	0.148***
		(0.039)	(0.040)
Someone taught child shapes or colors	0.265	0.064*	0.060
		(0.038)	(0.039)
Someone drew with the child	0.427	0.096**	0.119***
		(0.041)	(0.042)
Someone constructed objects with the child	0.507	0.050	0.052
		(0.041)	(0.043)
Someone taught child plant, animal names	0.268	0.008	-0.004
		(0.037)	(0.038)
Someone taught child English words	0.354	0.046	0.056
		(0.040)	(0.041)
Someone taught child names of objects	0.202	0.037	0.063*
		(0.034)	(0.035)

OLS coefficients reported. Robust standard errors clustered at the household level are reported in parentheses. The mean indicates the average value of each outcome variable among households with a single male child between the ages of seven and 14; the OLS coefficient estimates denote the treatment effect of having one older sister aged seven to 14 rather than one older brother in that age range. The specification with controls includes child age (fixed effects for age in months), child gender, mother's education, the number of young children in the household, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table A6: Impacts of Big Sisters on Stimulation by Individual Household Members

Outcome variable	Mean	Coefficient on Big Sister: No Controls	Coefficient on Big Sister: W/ Controls
Any early childhood stimulation by parents	0.651	-0.026	-0.014
		(0.040)	(0.042)
Any early childhood stimulation by siblings	0.723	0.078**	0.069**
		(0.035)	(0.035)
Any early childhood stimulation by mother	0.585	-0.034	-0.016
		(0.041)	(0.042)
Any early childhood stimulation by father	0.256	-0.015	-0.006
		(0.037)	(0.038)
Any early childhood stimulation by sister	0.297	0.467***	0.485***
		(0.037)	(0.036)
Any early childhood stimulation by brother	0.634	-0.381***	-0.400***
		(0.039)	(0.040)
Any early childhood stimulation by grandmother	0.118	-0.007	-0.009
		(0.026)	(0.026)
Any early childhood stimulation by grandfather	0.037	-0.026**	-0.019*
		(0.013)	(0.011)
Any early childhood stimulation by others	0.452	-0.018	-0.009
		(0.041)	(0.042)

OLS coefficients reported. Robust standard errors clustered at the household level are reported in parentheses. The mean indicates the average value of each outcome variable among households with a single male child between the ages of seven and 14; the OLS coefficient estimates denote the treatment effect of having one older sister aged seven to 14 rather than one older brother in that age range. The specification with controls includes child age (fixed effects for age in months), child gender, mother's education, the number of young children in the household, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table A7: Sex Differences in Parental Stimulation

Independent variable	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Child is male	-0.033	-0.210	0.034	-0.146
	(0.158)	(0.234)	(0.164)	(0.248)
Child has big sister		-0.275		-0.222
		(0.262)		(0.280)
Male × big sister		0.340		0.353
		(0.318)		(0.337)
Additional controls	No	No	Yes	Yes

OLS coefficients reported. Robust standard errors clustered at the household level are reported in parentheses. The outcome is parental stimulation—the number of stimulating activities parents engage in with their young child. The specification with controls includes child age (fixed effects for age in months), child gender, mother's education, the number of young children in the household, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table A8: Heterogeneity in the Impacts of Big Sisters

Interacted Trait	Main Effect of Big Sister	Interaction Sister × Trait
Younger child under 5	0.219***	-0.179
	(0.076)	(0.110)
Older sibling under 10	0.219**	-0.137
	(0.097)	(0.126)
Below median mother's education	0.075	0.145
	(0.076)	(0.125)
Primary caregiver illiterate	0.064	0.135
	(0.082)	(0.122)
Below median household assets	0.108	0.063
	(0.082)	(0.126)
Father absent	0.165**	-0.137
	(0.070)	(0.148)

OLS coefficients reported. Robust standard errors clustered at the household level are reported in parentheses. The outcome is the same child development index that is the outcome in Panel A of Table 3. All specifications include controls for child age (fixed effects for age in months), child gender, mother's education, the number of young children in the household, household size, and an index of household assets. Statistical significance: ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

Table A9: Summary of All Theoretical Predictions when $\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$

	Assumptions:	p_o^*	p_y^*	L_p^*	o_y^*	$\delta_o^z o_y^*$	E_o^*	$I_y^* = p_y^* + \delta_o^z o_y^*$
(I)	$\delta_o^G = \delta_o^B = 0$							$I_y^G = I_y^B$
	$\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$	$p_o^G = p_o^B$	$p_y^G = p_y^B$	$L_p^G = L_p^B$	$o_y^G = o_y^B = 0$	$\delta_o^G o_y^G = \delta_o^B o_y^B$	$E_o^G = E_o^B = 1$	$I_y^G = p_y^G$
(II)	$\delta_o^G = \delta_o^B = 0$							$I_y^G > I_y^B$
	$\lambda_o^G < \lambda_o^B$	$p_o^G < p_o^B$	$p_y^G > p_y^B$	$L_p^G > L_p^B$	$o_y^G = o_y^B = 0$	$\delta_o^G o_y^G = \delta_o^B o_y^B = 0$	$E_o^G = E_o^B = 1$	$I_y^G = p_y^G$
	$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$							$I_y^B = p_y^B$
(III)	$\delta_o^G > \delta_o^B > 0$							
	$\lambda_o^G = \lambda_o^B = \bar{\lambda}_o$	$p_o^G > p_o^B$	$p_y^G < p_y^B$	$L_p^G > L_p^B$	–	$\delta_o^G o_y^G > \delta_o^B o_y^B$	–	$I_y^G > I_y^B$
	$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$							
(IV)	$1 \geq \delta_o^G = \delta_o^B > 0$							
	$\lambda_o^G < \lambda_o^B$	$p_o^G < p_o^B$	–	$L_p^G > L_p^B$	$o_y^G > o_y^B$	$\delta_o^G o_y^G > \delta_o^B o_y^B$	$E_o^G < E_o^B$	$I_y^G > I_y^B$
	$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$							
(V)	$\delta_o^G > \delta_o^B > 0$							
	$\lambda_o^G < \lambda_o^B$	–	–	$L_p^G > L_p^B$	–	$\delta_o^G o_y^G > \delta_o^B o_y^B$	–	$I_y^G > I_y^B$
	$\lambda_y^G = \lambda_y^B = \bar{\lambda}_y$							

The table above shows predictions in five scenarios. In terms of their assumptions, the scenarios may be described as: (I) No gender differences; (II) Differential returns, zero sibling productivity; (III) Equal returns, differential sibling productivity; (IV) Differential returns, equal (positive) sibling productivity; (V) Differential returns; differential (positive) sibling productivity.