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The effect of siblings' sex ratio on physical capital, human capital, and gendered time use among adolescents in Ethiopia

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ABSTRACT

We examine the role of siblings' sex ratio on adolescents' physical and human capital development, as well as gendered time allocation using data from the Young Lives project in Ethiopia. We use BMI-for-age and Weight-for-age to measure physical capital and grade attainment and scores in Mathematics and English tests as human capital indicators. Gendered time use is proxied by the hours per day the adolescent spends doing traditionally female-specific chores. Our identification strategy relies on the absence of sex-selective reproduction in our study area which implies that for a given number of siblings, their sex ratio should be exogenous. Our results show that having relatively more brothers than sisters increases both physical and human capital for adolescents, typically with a stronger effect for boys. Yet it also increases girls' time spent on traditionally female-specific tasks, especially in the rural areas. This points to a complex relationship between siblings' sex composition and long-term life outcomes for women.

1. Introduction

The family is an important institution where individuals acquire and develop their physical, human, and cultural capital (Bau and Fernández, 2021; Bubolz, 2001). Within this burgeoning economics literature there are relatively few studies that focus on the role of siblings despite its obvious importance as demonstrated by research in other disciplines including psychology, sociology and biology (Downey, 2001; Steelman et al., 2002; Sulloway, 2001). Siblings for example reinforce delinquent behavior among each other (Breining et al., 2020; Slomkowski et al., 2001; Snyder, Bank, and Burraston, 2005; M.Q. Wang et al., 1995) and similarly, parents' and siblings' smoking behavior influences smoking in children, with a stronger effect on same-sex and same-age children (Vink, Willemsen, and Boomsma, 2003) while middle-and last-born children are more likely to engage in risky behavior compared to first-born children.

We study a specific aspect of siblings - the effects of siblings' sex composition on physical and human capital outcomes and gendered time-use for adolescents in a resource-constrained environment. Economic household models studying the role of siblings commonly follow Becker and Tomes (1986)'s investment model with imperfect markets where the idea is that in the presence of binding constraints, children will be better off when competing with less-abled siblings for the same household's resources (Garg and Morduch, 1998). Given the pro-male bias that is ubiquitous across societies around the world, children would then benefit most from growing up with relatively more sisters than brothers. This effect may, however, be reduced or even reversed if parents care about the well-being of all their children and get utility from fairness in outcomes (Behrman, Pollak, and Taubman, 1982). Moreover, there may be spill-overs if parents invest more in perceived high-return (boys) versus low-return (girls) children through sharing e.g., better food or educational materials or if boys bring in more resources. Yet girls may be more likely to take care of their younger siblings or do additional household chores, which may free up parental time and resources to be spent on the girl's male siblings. Another form of spillovers is what Garg and Morduch (1998) consider to be 'reference group effects' where having at least one brother or sister changes the way parents treat their children. For most, if not all of these hypothesized effects, there is some empirical evidence suggesting that the net impact of a sibling's sex composition is ultimately an empirical question that is likely to be context-specific. We discuss the relevant literature below.

Early work on the topic focused on gender discrimination and excess mortality among girls due to son preference, especially in East and South Asia (Gupta, 1987; Muhuri and Preston, 1991). Pande (2003) provides a

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complementary perspective by focusing on surviving children and finds evidence of gender discrimination in health outcomes, but the level of discrimination co-varying with surviving older sibling's sex composition. Others also examine the role of surviving sibling's sex composition in relation to health and associated development outcomes. Garg and Morduch (1998), in Ghana, shows that children have 25–40% better anthropometric outcomes if they are born to an all sisters household rather than an all brothers household, regardless of the child being male or female. Huang and Elo (2009) look at sibling sex composition in relation to risk of mortality for Chinese people aged 80 and above and find that mortality hazards are higher for men and women that are only children relative to those growing up with opposite-sex siblings. They also report that men are better off in mixed-sex sibling households relative to having only brothers, possibly due to reduced competition for resources. Women growing up with only sisters, in contrast, had the lowest mortality risk, which may suggest reduced competition or survivor bias channels at work.

Next to impacts on physical health, sibship composition may affect certain preferences associated with distinct human development trajectories (Anderson and Mellor, 2008; Bonin et al., 2007; Hsieh, Parker, and van Praag, 2017; Jaeger et al., 2010, see examples) for evidence of risk preferences determining aspects of health, investment, labor and migration outcomes). Okudaira et al. (2015) study the role of siblings' sex on the development of competitive preferences among Japanese adolescents and find male children with older sisters to be less competitive than male children without siblings. They also find a higher taste for competition among female children with younger brothers than female children without younger brothers and conclude that siblings' structure affects the development of such a critical preference. Also, Detlefsen et al. (2018) report high-school children with same-sex older siblings tend to be more risk-takers than children with opposite-sex siblings and that mixed-sex sibship has stronger effects on trust and trustworthiness than same-sex sibship.

A natural extension to the above is examining sibling's composition in relation to educational outcomes for which the intrahousehold resource allocation, the preference for inequality argument as well as the spillover hypothesis may be relevant. In addition, Butcher and Case (1994) suggests reference group effects through peer siblings that may affect motivation and learning. The empirical evidence, however, does not provide strong support for any of these theoretical predictions. Kaestner (1996) extends the Butcher and Case (1994) study using children and teenagers samples in addition to an adult sample, uses multiple indicators of sibling's sex composition, and examines various moderating variables including race, parental marital status, wealth, and finds no robust unidirectional relation between sibling's sex composition and educational outcomes. Morduch (2000) also reports mixed results where having all sisters instead of all brothers increases grade attainment in Tanzania - suggestive of the sibling rivalry argument - but no effect in South Africa. Lastly, there may be impacts later in life as, for example, shown in Cools and Patacchini (2019) that finds that having a younger brother reduces female earnings by 7% for a sample of U.S. women because of parent's lower academic expectations, decreased monitoring of girl's schoolwork and girls engaging more in traditional female (household) tasks. The latter result is consistent with recent work by Brenøe (2021) which documents that first-born Danish women who grow up with brothers are more likely to conform to traditional gender norms (as reflected by their choice of occupations and life partners) and earn less from their labor than those who grow up with sisters. She also reports that households with mixed-sex children tend to have a gender-specific parenting style (i.e., parents tend to have a parenting style that conforms to the traditional gender norms when they have mixed-sex children).

In sum, siblings' sex composition affects matters sometimes, depending on the context and subpopulation. We contribute to this evidence base by investigating its impact on resource-constrained rural households in Ethiopia for which family size, structures, and needs differ from those in the West (Bau and Fernández, 2021).[1] Also, our study extends the existing scholarship by examining impacts on both physical and human capital, gendered time use, impact heterogeneity and exploring potential underlying mechanisms.

Our data come from the latest two rounds of the Young Lives study (YL) for Ethiopia. YL is a collaborative joint research project from the University of Oxford, the former UK government Department of International Development the former Ethiopian Development Research Institute (EDRI), Ethiopia.[2] YL has been collecting longitudinal data on poverty and inequality among children in Ethiopia, India, Peru and Vietnam since 2001.[3] For identification we rely on the idea that in the absence of sex-selective reproduction, for a given number of siblings, the share of brothers is determined by nature and is orthogonal to our outcomes of interest. We have both data and some anecdotal evidence that supports the idea that sex-selective reproduction is unlikely in our study setting thereby lending credibility to our identification strategy.

We use anthropometric measurements (BMI-for-age and Weight-for-age) as outcomes for physical capital; highest school grade achieved, math test scores, and English language test scores as measures of human capital; and an indicator for gendered times use (female-specific chores) by subtracting the time spent on female-specific tasks from that on male-specific tasks. Overall, our results show that having more brothers than sisters leads to higher physical as well as human capital outcomes. The results are stronger and more robustly significant for boys except for highest grade attained, which is significantly positive only for girls. At the same time, having more brothers than sisters increases girls' time spent on traditionally female chores. We also find that results are different for rural versus urban areas and some support for the idea that results may be driven by positive spillovers from brothers.

2. Conceptual framework

To understand the role of siblings' sex composition on adolescents' physical and human capital, we base our analyses on the family model of Becker and Tomes (1986). In the absence of credit constraints, and assuming every child has the same rate of return, the family model states that parents would invest equally in every child until the point where the additional investment equals the expected marginal rate of return. However, if households are credit-constrained, and if sex is correlated with the marginal rate of returns, they would have to allocate their limited resources in a way that maximizes the return on their investments. Consequently, households would invest more in "high--ability" children as they expect a higher return for their investment. Recent empirical evidence from Jakiela et al. (2020) show that households perceive lower returns to investments in girls than in boys. Regardless of whether this true or is a perception bias, if parents assume that boys have a higher expected marginal return than girls based on the current labor market conditions – and if indeed they invest strictly based on expected returns – they would systematically invest

[1] Families in developing countries are typically larger than their counterparts in developed countries. For example, in 2018, the total fertility rates in the USA and Europe were 1.54 and 1.73, respectively, compared to 4.7 in Sub-Saharan Africa.Sources (all visited on June 7, 2021): https://data.worldbank.org/ indicator/SP.DYN.TFRT.IN?locations=US; https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ ddn-20210323–2; https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?locations=ZG. Family relations are also likely to differ as male family members in developing countries are vital for household security and livelihoods, especially in weak institutional environments. Sons and brothers may, for example, serve as insurance mechanisms or are responsible for relaxing household liquidity constraints (Guo and Zhang, 2020; Hoddinott, 1992; Lambert and Rossi, 2016; Zhou, 2014).

[2] Following the change in the government, the EDRI has been restructured in November 2018 and is currently known as the Policy Studies Institute (PSI) (PSI, 2018).

[3] https://www.younglives.org.uk.

more in boys than in girls (Becker and Tomes, 1986; Butcher and Case, 1994).

In the absence of spillovers, if parents invest strictly to maximize returns – given a certain budget and keeping the number of siblings constant – a higher share of high-ability (i.e., male) siblings would then necessarily imply a lower share of investments going to the female child, regardless of it being of high- or low-ability. In this case we should expect the relationship between the brothers-to-siblings ratio and physical and human capital to be negative. At the same time we may believe that this relationship has the opposite sign. For some investments it is harder to assume the absence of spillovers. If parents invest in nutritious food or supplementary books to help increase their returns from boys, girls would also be able to consume the food and use the books. Also, siblings could benefit from household investments in the "more-able" children if parents have some sort of inequality-averse utility. In this case, rather than the result of a spill-over, increased resources would be directed to (perceived) low-ability children because of equality motives, or a sense of guilt towards less advantaged children. Panel (a) of Fig. 1 depicts the expected relationship for both spillover and no spillover scenarios).

Another aspect of children's life that could be affected by their siblings' sex composition is their time use. Given gender-biased norms in most low-income countries, boys are more likely to participate in income-generating work to complement household income than girls. Girls, instead, tend to work more on domestic chores than boys. Assuming a fixed amount of household chores to be taken care of, and again keeping the number of siblings constant, having more brothers could increase girls' domestic workload because they have less female siblings to share it with (Alvi and Dendir, 2011; Dammert, 2010) (see panel (a), Fig. 1). At the same time, if inequality motives dominate, we should expect the opposite to happen, with either no effect of sibling sex on time use, or even a leveling of tasks across genders (if parents with more boys find it unfair to assign most chores to girls) (see panel (b), figure 1). The analysis on gendered time allocation in this paper therefore serves two purposes. First, it is a self-standing research question of interest. In fact, regardless of the effect on physical and human capital, if sibling sex affects time allocation towards more or less gendered tasks, this could have long-term consequences on the capacity to enter a job market or develop productive skills. Second, it helps us explore the mechanism underlying changes in physical and human capital of adolescents, as it provides some scope to discriminate between egalitarian motives and spill-overs.

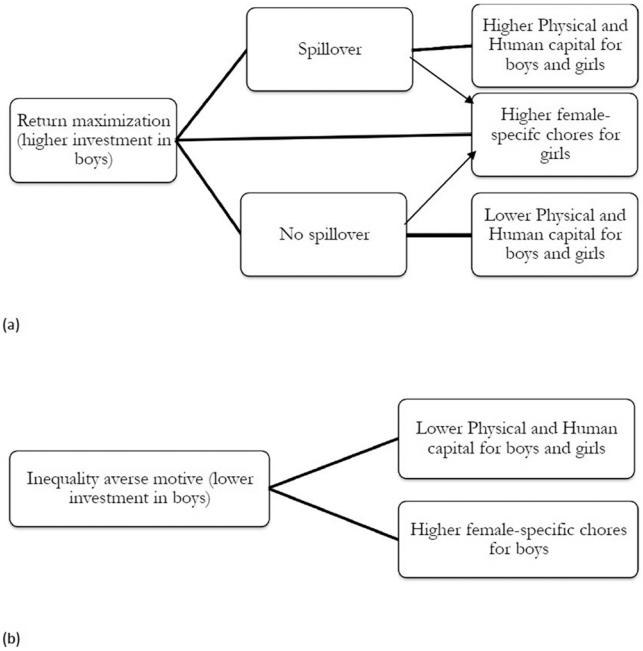

Fig. 1. Graphical representation of the expected siblings' sex composition effects; return maximization motives (a) and inequality averse motives (b).

3. Methodology

3.1. Context

Our study is set in Ethiopia where physical development problems prevail due to poor nutrition. For example, 38% of children under five are stunted, about 24% are underweight, and 28% of child deaths are due to under-nutrition (UNICEF, 2016). Existing evidence show that childhood under-nutrition has negative repercussions on later life educational attainment and economic wellbeing (Alderman, Hoddinott, and Kinsey, 2006; Galler et al., 2012; Weldeegzie, 2017).

Ethiopia has a mandatory (and free) eight years of primary education policy. According to 2015 statistics, the Ethiopian government spends about 4.74% of its GDP on education (WorldBank, 2020).[4] The country has achieved higher accessibility of primary education and has expanded universities and technical and vocational schools (for example, net enrollment rate grew from 29% in 1989 to 86% in 2015).[5] However, the quality of education remains very low and arguably deteriorating (Goshu and Woldeamanuel, 2019). According to a study that uses the Young Lives (YL) data and compares learning outcomes in four countries, Ethiopia, India, Peru, and Vietnam, "At the age of 12, about half of the children in Ethiopia fail to reach the low achievement benchmark for children aged ten years." For the remaining three countries, only about a quarter of the students aged 12 fell below the achievement benchmark for children aged ten (Singh et al., 2014). Ethiopia also has a lower adult literacy rate. According to 2017 statistics, is about 52% (59% for male and 44% for female), which is much lower than, for example, its neighboring Kenya, where adult literacy is about 82% (85% for male and 78% for female) (CIA, 2020).

According to Ethiopian law, everyone who has reached the age of 18 and above has the right to form a family through the institution of marriage.[6,7] The average child per woman in Ethiopia in 2018 is about

[4] Until 1900, education in Ethiopia has been primarily provided by the Ethiopian Orthodox Church to produce its clergy. The first "Western" style school was opened in 1908 following the permission granted by Emperor Menelik II to the European missionary schools. The main aim then was to produce bureaucrats that can serve the Ethiopian modernization process envisioned by the Emperor and strengthen the country's sovereignty and the power of the monarchy (the education at that time focused on teaching foreign languages). Rulers that followed, from Empress Zewditu (1916–1930); to Emperor Haile Selassie I (1930–1974), to Mengistu Hailemariam (1977–1991), to Meles Zenawi (1995–2012)) have all placed their marks in expanding "modern" education in Ethiopia (Bishaw and Lasser, 2012).

[5] Source https://wenr.wes.org/2018/11/education-in-ethiopia, visited on 30 June 2021.

[6] Ethiopia is the second-most populous landlocked country located in the horn of Africa, with an estimated population of about 110 million. As is the case in most African countries, most of Ethiopia's population is very young; almost 60% of the population is below the age of 24 while nearly 92% is under the age of 54 (CIA, 2019a). According to the law, marriage is a voluntary union between a man and a woman. Because of Ethiopia's long-standing Christian traditions, the majority of its communities prohibit polygamous marriages.

[7] The pre-modern law of Ethiopia, which was in place until 1934, known as the *Fetha Nagast*, (translates into "the law of the kings") prohibited polygamy (Heron, 2018). Similarly, Ethiopia's current law bans polygamy but grants regions the autonomy to set up their own marriage laws based on their people's religion, customs, and traditions. As a result, in some regions and communities, polygamous marriages are practiced. According to the Demographic Health Survey (DHS), polygamy is practiced by 11% of the Ethiopian population, with most of it coming from the Somali (29%), Benshangul-Gumuz (21%), Gambella (21%), Afar (19%), Southern Nations and Nationalities Region (16%), Oromia (14%) regions, and least practiced by the Amhara (1%), Addis Ababa (2%), and Tigray (3%) regions (CSA, 2016).

4.2 children. In the late 1990 and early 2000 (during the time the adolescents in this study were born), it was about seven children per woman (WorldBank, 2018). Most Ethiopian families have distinct roles to female and male household members where females are on average more likely to be in charge of domestic chores while males are in charge of earning livelihoods (Dinku, Fielding, and Gen¸c, 2019; Pankhurst, Crivello, and Tiumelissan, 2016).

3.2. Data and descriptive statistics

For this study, we use data from the last two rounds of the Young Lives (YL) data set collected in 2013 and 2016 as these rounds contain information on most of our outcome variables for both the younger and older cohorts. The YL data for Ethiopia tracks the lives of 3000 children from two age-cohorts since 2002. The older cohort consists of 1000 children born in 1994/95 (aged about eight years at the beginning of the survey), and the younger cohort consists of 2000 children born in 2001/02 (aged about 6–18 months during the first survey round).[8] The data covers 20 (relatively poorer) sentinel sites from rural and urban areas across five regions–Addis Ababa, Amhara, Oromia, Southern Nations and Nationalities Region (SNNPR), and Tigray regions (see YoungLives, 2017 for detailed sampling strategy).

In our analyses, we use the rich information that the YL provides and account for various factors that could potentially affect adolescents' human and physical capital development. These include demographic factors, such as, sex and age (Buser, Peter, and Wolter, 2017; Fyfe et al., 2017)); parents' demographic characteristics and children's human capital development (examples, (Alves et al., 2017; Becker and Tomes, 1986; Daouli et al., 2010); various shocks and human capital development (Haile, Tirivayi, Nillesen et al., 2019; Maccini and Yang, 2009). We thus account for adolescents' and parents' demographic characteristics (adolescents and parents age, sex, and religion); and households' economic status and self-reported exposure to various shocks (such as economic and family shocks) in all of our regressions.

Table 1 presents the descriptive statistics of our outcome variables in panel A and other covariates in panel B.

Table 1
Descriptive Statistics.

Variable	Mean	Std. Dev.	Min.	Max.	N
Panel A: Outcome variables					
Weight-for-age z-score	-1.914	1.134	-4.995	2.067	4227
BMI-for-age z-score	-1.659	1.099	-6.100	2.29	3882
Math skills	36.162	20.076	0	96.429	3908
English skills	43.539	22.978	0	96.296	3855
Highest grade	5.187	2.91	0	14	4302
Highest grade: females	5.372	2.927	0	14	2006
Highest grade: males	5.024	2.884	0	14	2296
Hours/day spent in chores: females	2.738	1.57	0	16	2151
Hours/day spent in chores: males	1.399	1.200	0	12	2426
Hours in productive tasks: females	0.815	1.525	0	12	2150
Hours in productive tasks: males	2.292	2.630	0	15	2426
Female-specific chores	0.379	3.096	-15	16	4286
Panel B: Treatment and covariates					
Number of brothers	1.843	1.471	0	8	4302
Number of siblings	4.125	2.073	1	14	4302
Brothers-to-siblings ratio	0.438	0.307	0	1	4302
Male child = 1	0.534	0.499	0	1	4302
Child's age in years	14.671	2.577	11.333	20	4289
Caregiver's SWB	4.998	1.569	1	9	3442
Younger mom = 1	0.481	0.5	0	1	4302
Father literate = 1	0.63	0.483	0	1	4302
Mother literate = 1	0.797	0.403	0	1	4302
Wealth index	0.401	0.176	0.006	0.924	4290
Land ownership	0.775	0.418	0	1	4280
Year = 2016	0.396	0.489	0	1	4302
Christian	0.821	0.383	0	1	4302
Muslim = 1	0.167	0.373	0	1	4302
Shock economic = 1	0.49	0.5	0	1	4302
Shock family = 1	0.302	0.459	0	1	4302
Tigray	0.211	0.408	0	1	4302
Amhara	0.198	0.398	0	1	4302
Oromia	0.216	0.412	0	1	4302
SNNP	0.249	0.433	0	1	4302
Addis	0.123	0.329	0	1	4302

3.3. Variables

Here, we describe how the outcome and control variables are constructed/measured and provide respective descriptive statistics.

3.3.1. Outcome variables

We investigate siblings' sex composition effects on physical capital, using BMI-for-age z-scores and Weight-for-age z-scores.[9] According to a YL report by Benny, Boyden, and Penny (2018), "A child's body mass index z-score (BMIZ) indicates the child's relative position in the distribution of body mass index for a population of the same age and sex. This is expressed in terms of standard deviations from the median BMI of the reference population."[10] Based on the descriptive statistics presented in panel B of Table 1, the average BMI-for-age among adolescents in our sample is − 1.65 standard deviations. To put this number in perspective, according to the World Health Organization's classifications developed by de Onis et al. (2007), individuals are categorized as follows; Obesity, when Z-scores $> +2\,SD$; Overweight, when Z-scores $> +1\,SD$; and, Thinness, when Z-scores $< -2sd >$. Similarly, Weight-for-age z-scores (WAZ) also shows "the number of standard deviations of the actual weight of a child from the median weight of the children of his/her age as determined from the standard sample." Panel B of Table 1 shows that, on average, the WAZ in our sample is − 1.9— meaning that the average person is slightly underweight.[11].

Next we measure human capital development, proxied by adolescents' scores on mathematics and English language tests and highest school grade attained. The YL project administers mathematics and English language tests to measure the learning quality across the four countries involved in YL. Both tests contain 40-item multiple-choice questions, solved independently by the adolescents. The mathematics test intends to gauge adolescents ability in three mathematical cognitive domains–"Knowing: the facts, concepts, and procedures students need to know"; "Applying: the ability of students to apply knowledge and the conceptual understanding to solve problems or answer questions"; and, "Reasoning: going beyond the solution of routine problems to

[8] Note that these children would be between the ages of 13.6 and 14.6 for the younger cohort and 20–21 for the older cohort in 2013 and between 17.6 and 18.6 for younger cohort and 23–24 in the older cohort in 2016.

[9] We also construct a PCI by simply adding the three z-scores (BMI-for-age z-scores, Height-for-age z-score, and Weight-for-age z-scores) and standardize the PCI such that it has mean zero and standard deviation of one.

[10] The reference population according to the World Health Organization is, "8440 healthy breastfed infants and young children from diverse ethnic backgrounds and cultural settings" sampled from six countries, Brazil, Ghana, India, Norway, Oman, and USA (World Health Organization, 2006).

[11] One may question whether gaining weight is a positive outcome especially for the Ethiopian urban population where risk of overweight and obesity are increasing (Kassie, Abate, and Kassaw, 2020). We investigate to what extent this may be the case for our sample and while BMI-for-age and weight-for-age scores are significantly lower for rural participants, the average urban respondent is also still classified under the "thin category" (see appendix A2). We thus argue that for our sample of adolescents an increase in weight should be considered a positive outcome.

encompass unfamiliar situations, complex contexts, and multi-step problems" (Azubuike et al., 2017, P. 5). Similarly, the English language test aims to gauge the adolescents' "functional English" skills, defined as "the application of skills in purposeful contexts and scenarios that reflect real-life situations" (Azubuike et al., 2017, P. 6). Note that, since the English language test involves multiple choice questions, it only measures reading skills.[12].

Scores are converted into percentage correct answers such that, if an adolescent answers all 40 questions, he/she has a score of 100%; or, if one answers 30 questions correctly, he/she has a score of 75%, etc. This means that our dependent variable is the percentage of correct answers in the two 40-item tests. We also use highest grade completed which is the number of years of schooling the adolescent completed during the survey period. Based on the statistics reported in panel A of Table 1, on average, the adolescents in our sample have about 5.2 years of schooling. Moreover, even though math scores range between zero and about 96, the average is about 37%—meaning that the adolescents in our sample are, on average, able to solve less than half of the questions correctly. Similarly, the average score in the English language test is about 44%; again, less than half of the questions are correctly solved.[13] Appendix B1 shows the distribution of the outcome indicators.

Our third outcome is time-use that we turn into a relative measure of gender time use.

We first measure the absolute time spent on household chores as a proxy for traditionally 'female specific tasks' and absolute time spent on household "productive" tasks as a proxy for traditionally 'male specific task'. Time spent on household chores is measured by the self-reported number of hours the adolescent spends working on unpaid domestic work per day. Time spent on household "productive" tasks is measured by the self-reported number of hours the adolescent spends working on family farms and businesses per day. We then proceed by generating a relative measure of gendered time use by subtracting time spent on male-specific productive tasks from female-specific household chores. The outcome that thus we use in our regressions will thus take a positive value for respondents spending more time on traditionally female tasks than male tasks, negative otherwise. Panel A of Table 1, shows gender-disaggregated figures for the absolute measures where we see that female adolescents in our sample spend on average about twice as much time (2.7 h) in household chores (i.e., female specific tasks) than males (1.4 h). Females spend about 0.8 h on productive chores (i.e., male specific tasks) while males spend about 2.3 h per day (also see appendix A3). Our relative measure is not split by gender and shows that overall respondents spend about 0.4 h more on traditionally female household chores per day than on male (productive) tasks.

3.3.2. Treatment and covariates

Here, we present the descriptive statistics for the main explanatory variable–the share of brothers–along with the other covariates we account for in our regression analyses. We express the share of brothers as the ratio of brothers-to-siblings. This transformation does not affect our identification assumption as the ratio of brothers to a given number of siblings would still be exogenous.

Based on the statistics presented in panel B of Table 1, adolescents in our sample, on average, have about 1.8 brothers, 4 siblings, and the brothers-to-siblings ratio is about0.44–less than half. We also check for the sex distribution of households in our sample by dividing the total number of boys in a household (including the YL child) to the total sibling size and find a ratio of 0.46 (also less than half).[14] About 63% of fathers and 80% of mothers are literate. The average age of our respondents is about 15 years. Information on the subjective wellbeing (SWB) in the YL data is generated by asking caregivers the following question: "There are nine steps on this ladder. Suppose we say that the ninth step, at the very top, represents the best possible life for you, and the bottom represents the worst possible life for you. Where on the ladder do you feel you personally stand at the present time?" The average SWB of caregivers is about 5. About 48% of mothers are younger than the median age for mothers. We account for the economic status of families by using households' land ownership and their wealth index as a proxy for their economic status.[15] The average wealth index is 0.4 and about 78% of respondents own land. The majority of adolescents in our sample are Christians (82%), followed by Muslims (17%). In terms of region of residence, about 20% of adolescents are from Amhara, 22% from Oromia, 21% from Tigray, 25% from Southern Nations and Nationalities, and 12% from Addis Ababa. The most common shocks experienced by households are economic shocks encountered by 49% of households and family shocks, reported by about 30% of households. Lastly, we present the summary of the birth order of adolescents under investigation in appendix A4. Based on the descriptive statistics reported in appendix A4, our sample consists of adolescents with birth orders ranging from first to ninth. However, given the small proportion of adolescents after the sixth order we code birth orders sixth and above as 1; 0 otherwise.

3.4. Empirical strategy

Our identification strategy for the brothers' effect on adolescents' human capital development relies on the assumption that for a given number of siblings, the gender assignment of siblings is determined by nature and is exogenous to the outcomes of adolescents under investigation.[16] A similar identification strategy has been used by Zhou (2014) in his study of the effect of brothers on households' saving in China and S. Wang and Zhou (2018) in their study of the effect of brothers on happiness, also in China.[17].

[12] While providing richer data implementing writing, speaking, and listening skills tests in a large scale survey are very difficult. YL therefore only conducts the reading skills test.

[13] Unfortunately, the math and English tests are not administered for the older cohort in 2016–the last round of the survey.

[14] To check whether there is a systematic difference in the brothers-to-siblings ratio for any given number of siblings, we look at the summary statistics at each level of sibling size. The results show that, for example, the average brothers-to-siblings ratio at sibling size = 1 is 0.36; from 2 to 5 it is between 0.42 and 0.44; at sibling size 6, the ratio is 0.47; at 7 it becomes 0.43; at 9 it is almost 0.5; but at 10 it becomes 0.3.

[15] The wealth index takes into account the following three broad dimensions: 1) Housing quality including the main material of walls, the main material of the roof, the main material of the floor, and household density–the re-scaled value of rooms-to-household-size ratio; 2) access to services including access to electricity, access to safe drinking water; access to a safely managed sanitation service; and access to adequate fuel for cooking and 3) consumer durables which is a sub-index comprising household's ownership of common household items, such as TV and other country-specific household items (Briones, 2017).

[16] Our measure of sibship consists of those who share either both parents or at least one parent.

[17] Other previous studies have used twins' sex composition or the sex of the second born to study outcomes on the first child. For example, Guo and Zhang (2020) uses the sex-composition of twins born to the one-child policy of China as their identification strategy to study parents' old-age care expectations from their female and male children and find that parents have higher old-age care expectations from their male children. A study by Brenøe (2021) uses the sex of the second-born sibling on the gender norms of the first-born and finds those first-born females with a second-born brother rather than sister hold more traditional gender norms. Yet given the nature of our data (twins are not the target population in the YL study and our sample of respondents comprises a randomly selected mix of first and higher birth order children, with detailed information only available for the sample respondent and not for its siblings) we cannot use twins or sex of the second-born sibling for our identification.

We specify the following relationship to generate the main results.

$$\text{Outcomeh} = \gamma \text{Bro}_i + \delta(\text{Sib}_i) + \alpha \text{Order}_i + \beta X_i + \gamma L_i + \epsilon_i \quad (1)$$

where, *Outcome*h stands for outcome *h* of adolescent *i*, where *h* represents human capital, physical capital, and gendered time allocation indicators; Bro_i is the brothers-to-siblings ratio for adolescent *i*; Sib_i is the number of siblings of adolescent *i*; $Order_i$ is a dummy indicator for adolescent *i*'s birth order; X_i denotes adolescent and household characteristics presented in panel B of Table 1; L_i represents sentinel-site fixed effects; ϵ_i is the stochastic error term; and, γ is our parameter of interest.

Our identification assumption relies on the idea that parents do not select the sex of their children either by sex-selective pregnancy termination or by following the fertility-stopping rule where parents stop fertility once the household reaches a desirable number of the "preferred" sex. In this case, the number of brothers is no longer determined by nature but endogenously by the parents. We believe that these assumptions hold in our study context and in the next paragraphs we explain why.

Sex-selective pregnancy termination is unlikely among Ethiopian households because legal abortions, from 2004 on, are only allowed under specific conditions (such as if the pregnancy is considered risky for the mother's life; if the pregnancy resulted from rape or incest, and if there is fetal impairment). The law before 2004 was much stricter and allowed abortion only if the pregnancy was dangerous to the mother's health (Wada, 2008). Although there are illegal abortions undertaken by "traditional" methods, given that they have no access to ultrasound technology, they are unlikely to perform sex-selective abortions.

Also, the fertility-stopping rule is unlikely to apply to our households. Based on the variations in rituals that follow a child's birth, there is a good reason to suspect that parents in most Ethiopian communities may have a preference for sons.[18] To test whether the rituals have translated into a tangible son-targeting reproduction behavior among households in our sample, we adopt the following definition of the characteristics of son-targeting fertility behavior from the demography literature: "if a population practices son targeting fertility behavior, girls will be born into relatively larger families" (Basu and De Jong, 2010, P. 521). This is something we can test with our data, and we find no difference in sibship size (appendix A1 presents these results). Evidence from previous studies also confirms that, in sub-Saharan Africa, son-preference has not been an issue. For example, Rossi and Rouanet (2015), using data from 37 African countries, find that in sub-Saharan Africa, parents have a preference for child sex balance but find no evidence that shows preference to any particular sex. Additionally, the sex-ratio statistics also confirm that there is no reason to suspect a sex-selective reproduction in Ethiopia. The sex ratio at birth in Ethiopia is 1.03 male(s)/female while it is 1.11 males/females in China and India, the two countries with the "missing" women problem. Moreover, the population average sex ratio is 0.99 male(s)/female (CIA, 2019b).

We further check for the validity of our identification strategy by conducting a balance check where we examine whether there is a systematic correlation between household characteristics and the brothers-to-siblings ratio and present these results in Table 2, where column 1 shows the balance test for the full sample and columns 2 and 3 show the results for girls and boys, respectively. In support to our identification strategy, neither the number of siblings nor birth order significantly correlate with the brothers-to-siblings ratio of boys and girls. We test eighteen covariates and find three to be unbalanced in the full sample: caregivers SWB; Father's literacy and land ownership. Among these three variables we only have some plausible explanation for caregivers' SWB and its correlation with our key independent. Caregivers (often women/mothers) with more boys could feel more fulfilled and therefore report a higher life satisfaction given the societal and practical values/benefits of boys in societies like Ethiopia (for example, Mizell and Steelman, 2000 find higher marital satisfaction among women with a greater share of sons, which in fact would argue for the effect to run from the brothers-to-siblings-ratio to SWB). When we split the balance test by the adolescent's sex, we find that both Christian and Muslim religions marginally and positively correlate with brothers-to-siblings ratio of boys. Throughout the analysis we include the variables presented in Table 2 to net out potentially confounding effects arising from these correlations.

[18] Based on anecdotal evidence (and, the first author's own experience), in some Ethiopian communities, the number of "*elilta*"–a celebratory sound made by family and neighbors, to express their happiness for the birth of a child, varies for boys and girls–where it is higher when the child is a boy.

Table 2
Balance test.

	(1)	(2)	(3)
VARIABLES	Full sample	Girls	Boys
Number of siblings	0.00386	0.00533	0.00426
	(0.00336)	(0.00466)	(0.00485)
First born	0.0227	-0.0132	0.0740
	(0.0372)	(0.0505)	(0.0547)
Second born	0.0409	0.0281	0.0646
	(0.0355)	(0.0482)	(0.0521)
Third born	0.0489	0.0412	0.0679
	(0.0345)	(0.0475)	(0.0502)
Fourth born	0.0205	0.00603	0.0463
	(0.0346)	(0.0474)	(0.0505)
Fifth born	0.00737	-0.0170	0.0377
	(0.0365)	(0.0496)	(0.0536)
Caregiver's SWB	0.0118 * **	0.0176 * **	0.00757
	(0.00364)	(0.00537)	(0.00496)
Younger mom = 1	0.00228	0.0242	-0.0109
	(0.0137)	(0.0199)	(0.0189)
Mother literate = 1	0.00693	0.00906	0.00260
	(0.0142)	(0.0205)	(0.0195)
Father literate = 1	0.0754 * **	0.0750 * **	0.0764 * **
	(0.0116)	(0.0168)	(0.0160)
Wealth index	0.0455	0.0400	0.0435
	(0.0342)	(0.0505)	(0.0465)
Land ownership	0.0455 * **	0.0292	0.0546 * **
	(0.0146)	(0.0209)	(0.0204)
Child's age in years	-0.00282	0.00263	-0.00809
	(0.00375)	(0.00537)	(0.00521)
Christian	0.0291	-0.0719	0.132 *
	(0.0467)	(0.0625)	(0.0696)
Muslim = 1	0.0687	0.0110	0.133 *
	(0.0483)	(0.0649)	(0.0717)
Shock economic = 1	-0.00483	0.0164	-0.0232
Brothers-to-siblings ratio			

Standard errors in parentheses. Sixth and above birth order is the base category. Significance: * ** p< 0.01, * * p< 0.05, * p< 0.1.

4. Results

We start by presenting the main results and later some heterogeneous effects.

4.1. Main results

In Table 3, we present the main results that show the effects of brothers-to-siblings ratio on adolescents' physical capital indicators, (columns 1–4), human capital indicators (columns 5–10), and household gendered time allocation (columns 11 and 12). For each of the outcome variables, in the first columns, we present the main effects and in the second columns, we include an interaction term between adolescent's sex and brothers-to-siblings ratio to see whether the effects are heterogeneous by sex. The results show that having a greater share of brothers rather than sisters increases physical and human capital outcomes of both boys and girls. Moreover, it increases females' time allocation on female-specific tasks.

Table 3
Brothers effects on physical capital, Human capital, and gendered time allocation.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
	BMI-for-age z-score		Weight-for-age z-score		Math skills		English skills		Highest grade		Female-specific chores	
VARIABLES												
Brothers-to-siblings ratio	0.168***	0.248***	0.120**	0.161**	2.754***	3.386***	2.194**	2.452*	0.292***	0.190	0.123	-0.143
	(0.0560)	(0.0758)	(0.0544)	(0.0729)	(0.907)	(1.235)	(0.892)	(1.253)	(0.0907)	(0.130)	(0.124)	(0.179)
Number of siblings	0.000718	0.00124	-0.00283	-0.00255	-0.311*	-0.307*	-0.472***	-0.471***	-0.0587***	-0.0594***	-0.0963***	-0.0981***
	(0.0113)	(0.0113)	(0.0115)	(0.0115)	(0.181)	(0.180)	(0.181)	(0.181)	(0.0181)	(0.0182)	(0.0259)	(0.0259)
Father literate = 1	-0.0378	-0.0375	0.0364	0.0365	-0.0489	-0.0456	0.828	0.829	0.0831	0.0826	-0.00953	-0.0109
	(0.0402)	(0.0402)	(0.0401)	(0.0401)	(0.632)	(0.633)	(0.649)	(0.649)	(0.0681)	(0.0680)	(0.0949)	(0.0948)
Mother literate = 1	-0.0498	-0.0498	-0.00221	-0.00222	1.806**	1.805**	1.438*	1.437*	0.00245	0.00253	-0.126	-0.126
	(0.0464)	(0.0464)	(0.0491)	(0.0491)	(0.756)	(0.757)	(0.788)	(0.789)	(0.0819)	(0.0818)	(0.108)	(0.108)
Female = 1	0.311***	0.387***	0.411***	0.450***	0.0146	0.616	1.765***	2.008**	0.369***	0.274***	2.682***	2.431***
	(0.0352)	(0.0608)	(0.0353)	(0.0594)	(0.558)	(0.982)	(0.552)	(0.977)	(0.0572)	(0.101)	(0.0775)	(0.136)
Female X Brothers ratio		-0.172		-0.0882		-1.373		-0.557		0.217		0.572**
		(0.112)		(0.107)		(1.811)		(1.782)		(0.180)		(0.246)
FWER P-values	0.003		0.038		0.003		0.024		0.002		0.346	
Observations	3396	3396	3362	3362	3063	3063	2977	2977	3406	3406	3399	3399
R-squared	0.176	0.177	0.218	0.218	0.339	0.340	0.548	0.548	0.538	0.538	0.391	0.392
Birth order	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed in Table 1 as well as region and sentinel-site fixed effects. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

When we look at the effects of brothers-to-siblings ratio on BMI-for-age (column 1) of Table 3 we find that a unit increase in the brothers-to-siblings ratio leads to a BMI-for-age that is higher by about 0.17 standard deviations, significant at 1%. Similarly, our results from the Weight-for-age indicator shows that a greater share of brothers increases adolescents' weight-for-age by 0.12 standard deviations, significant at 5%. In columns 2 and 4, we find that the effects are driven by increases in boys: although the interaction terms are insignificant, the effects on girls are less than half as strong and insignificant too. We report similar results from an analysis using a physical capital index in appendix A5. In our main analysis we also report the Family Wise Error Rates (FWER) corrected p-values at the bottom of the table to account for multiple hypothesis testing List, Shaikh, and Xu (2019). We also test for a potential non-linearity effect of brothers by including a second-order polynomial for Brothers-to-siblings ratio and find it matters for weight-for-age (at 5% significance) but not for the rest of our outcomes (see appendix A6). Overall we show that having more brothers positively affects physical capital which is consistent with a theory of spillovers of parental investments or an income effect through brothers' (boys') contribution to household resources. The results are not consistent with the siblings rivalry argument. We however acknowledge that the anthropometric indicators for this age group may not be straightforward to interpret as the period of adolescence is characterised by rapid growth spurts and which onset co-varies with sex and potentially nutritional shocks during early childhood, possibly leading to considerable noise in the data.[19].

We then proceed to our human capital indicators (column 5–10) and find that a unit increase in the brothers-to-siblings ratio leads to a mathematics score that is higher by about 2.8 percentage points (significant at 1%) and an English language score that is higher by about 2.2 percentage points (significant at 5%). Once again these results are driven by boys, with outcomes for girls muted, especially for maths (columns 6 and 8). Instead, for our measure of highest grade attained (column 9) the significant effect appears to be driven by girls, with a coefficient more than twice as large as that of boys (column 10). We also aggregate these individual components into a human capital index and find similar effects (see appendix A5.) These results are in line with some of the existing evidence that shows positive effects of brothers on educational outcomes. Our results conform to those in Butcher and Case (1994) where they find women who grew up with only brothers receive a higher level of education than women raised with any sisters. Our results are also, to an extent, similar to those in Joensen and Nielsen (2018) where they show that having an older brother who is enrolled in advanced math courses increases the younger brother's likelihood to choose an advanced math course. On the other hand, our null results on grade attainment contradict those in Morduch (2000) where they find that sisters rather than brothers increase grade achievement and those in Lei et al. (2017) that also report a greater share of sisters increasing educational attainment. While evidence on the effect of brothers on linguistic skills is limited, our results that show a positive brothers' effect on English language skills contradict those in a recent study by Jakiela et al. (2020) where they find that older sisters, rather than older brothers increase their younger siblings' vocabulary. The positive results of brothers on human capital are again supportive of the idea that spillovers or increased contributions may be the underlying channels and not supportive of an increased-competition-for-resources argument.

Our final set of results investigates the effect of brothers on time use. Column 12 of Table 3 shows that a unit increase in the brothers-to-siblings ratio, on average, increases girls' time spent on traditionally female-specific chores by about 0.4 h per day.[20] We also present the

[19] we thank the associate editor for emphasizing this caveat.

[20] We test whether the sum of the coefficients of brothers-to-siblings ratio and the interaction between female and brothers-to-siblings ratio is zero and reject this null hypothesis at 1% (p-value = 0.009).

results on the individual components, i.e., hours per day spent on household chores (traditionally female tasks) and productive chores (traditionally male tasks) in appendix A7, which show similar results: having more brothers increases time spent on traditionally female tasks for girls but not for boys. These findings correspond to the idea of reference group effects where parents with offspring of opposite sex tend to tend to practice a gender-specialized parenting style than parents with same-sex children. Our results also partly confirm those in Dahl, Rooth, and Stenberg (2020) where they find that in Sweden, traditional gender norms spill over across same-sex siblings but not across mixed-sex siblings.[21].

4.2. Heterogeneous effects

Since impacts may differ by subgroups we now turn a heterogeneity analysis where we examine whether we observe differences between urban and rural areas. This part has a more of an exploratory character as we have no strong priors as to whether having more brothers than sisters affects rural households differently from those living in urban areas. Also, urban and rural households may differ in various dimensions including wealth, preferences, social norms, opportunity costs etc. So our interpretations will be speculative and we are aware that there might be alternative explanations. The results of the subgroup analysis are presented in 4 and 5 respectively. We find BMI-for-age to be positively affected by a greater share of brothers in both the rural and urban sub-samples, yet coefficients on human capital are mostly significant for rural households (see columns 5–10 in Table 4). In rural areas we find that a unit increase in brothers-to-siblings ratio increases math skills by about 3% points (significant at 1%) and English language skills by about 2.8% points (significant at 5%) although this effect is much smaller for girls, with only about about 0.6% points increase in their English skills and is not statistically significant (the joint test of significance fails to reject the null hypothesis that the sum of the main coefficient and the interaction equals zero, with a p-value of 0.707).

We also find that the increase in female adolescents' time spent on household chores seems to be driven by the rural sub-sample (see the interaction between adolescent's sex and brothers-to-siblings ratio in column 12 of Table 4). In column 12, we find that the interaction between adolescent's sex and brothers-to-siblings ratio is positive and significant where we find a unit increase in brothers-to-siblings ratio increases girls' time spent on traditionally female chores by about 0.7 h per day in rural areas (significant at 5%) whereas we find no significant effects for urban households.[22] This be may related to stronger traditional gender norms in the rural areas.

Looking at (column 1–4 in Table 5) we see some interesting patterns emerging for the urban sample. First and foremost, physical capital gains seem to be driven mostly by the urban households where a unit increase in brothers-to-siblings ratio, on average, increases adolescents' BMI-for-age in urban areas by about 0.25 standard deviations (significant at 1%) and their weight-for-age by about 0.17 standard deviations (significant at 5%). Perhaps urban households have a larger degree of re-allocating income to food consumption if needed, compared to rural households that may experience higher levels of food scarcity that allow for more spillovers. Alternatively, brothers in urban areas are more likely to have a job and contribute more to households' resources. With respect to human capital outcomes, we find that girls in the urban sample appear to gain more in their English language skills (about 3% points increase in

Table 4
Rural sub-sample: Brothers' effects on Physical capital, Human capital, and gendered time allocation.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	BMI-for-age z-score	Weight-for-age z-score	Math skills	English skills	Highest grade	Female-specific chores					
VARIABLES											
Brothers-to-siblings ratio	0.107	0.213 * *	0.0852	0.0803	2.996 * **	3.642 * *	2.786 * *	4.653 * **	0.300 * *	0.0661	0.373 * *	0.0271
	(0.0705)	(0.0956)	(0.0746)	(0.100)	(1.140)	(1.528)	(1.229)	(1.714)	(0.138)	(0.196)	(0.178)	(0.260)
Number of siblings	0.000548	0.00121	0.00189	0.00186	0.0683	0.0720	-0.207	-0.197	-0.0291	-0.0306	-0.143 * **	-0.145 * **
	(0.0130)	(0.0130)	(0.0137)	(0.0137)	(0.211)	(0.211)	(0.221)	(0.221)	(0.0222)	(0.0222)	(0.0327)	(0.0328)
Father literate = 1	-0.0173	-0.0168	0.107 * *	0.107 * *	-0.948	-0.945	0.169	0.175	0.0878	0.0865	0.0101	0.00776
	(0.0476)	(0.0475)	(0.0499)	(0.0499)	(0.751)	(0.751)	(0.827)	(0.828)	(0.0923)	(0.0922)	(0.121)	(0.121)
Mother literate = 1	-0.0587	-0.0570	-0.0103	-0.0104	2.057 * *	2.069 * *	2.007 * *	2.045 * *	-0.0484	-0.0522	-0.136	-0.142
	(0.0551)	(0.0548)	(0.0601)	(0.0600)	(0.902)	(0.903)	(0.987)	(0.990)	(0.107)	(0.106)	(0.134)	(0.134)
Female = 1	0.379 * **	0.480 * **	0.441 * **	0.436 * **	-0.903	-0.273	0.621	2.427 *	0.347 * **	0.123	3.407 * **	3.074 * **
	(0.0411)	(0.0765)	(0.0431)	(0.0799)	(0.660)	(1.212)	(0.699)	(1.317)	(0.0749)	(0.150)	(0.0989)	(0.197)
Female X Brothers ratio		-0.225		0.0104		-1.394		-4.003 *		0.496 *		0.737 * *
		(0.141)		(0.146)		(2.264)		(2.425)		(0.270)		(0.360)
FWER P-values	0.126		0.258		0.009		0.021		0.028		0.039	
Observations	2263	2263	2232	2232	1953	1953	1879	1879	2271	2271	2264	2264
R-squared	0.163	0.164	0.168	0.168	0.118	0.118	0.427	0.428	0.446	0.447	0.452	0.453
Birth order	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed in Table 1 as well as region and sentinel-site fixed effects. Significance: * ** p< 0.01, * * p< 0.05, * p< 0.1.

[21] To further probe the robustness of our results to changing sample size, we repeat our analyses (using the indices to save space) in a sample that includes adolescents with no (zero) siblings and find largely similar results (see appendix A8).

[22] Similarly, we test for the significance of the sum between the brothers-to-siblings ratio and the interaction with female and find it to be significant with p-vale = 0.001.

Table 5
Urban sub-sample: Brothers' effects on Physical capital, Human capital, and gendered time allocation.

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
BMI-for-age z-scoreWeight-for-age z-scoreMath skillsEnglish skillsHighest gradeFemale-specific chores												
VARIABLES												
Brothers-to-siblings ratio	0.246 * **	0.321 * *	0.174 * *	0.279 * *	1.051	0.949	0.698	-1.348	0.218 * *	0.280 *	-0.162	-0.147
	(0.0938)	(0.127)	(0.0811)	(0.109)	(1.444)	(2.015)	(1.309)	(1.841)	(0.108)	(0.158)	(0.147)	(0.221)
Number of siblings	0.0110	0.0115	-0.000761	1.88e-05	-1.064 * **	-1.065 * **	-0.756 * *	-0.774 * *	-0.125 * **	-0.125 * **	-0.00129	-0.00118
	(0.0222)	(0.0223)	(0.0208)	(0.0209)	(0.336)	(0.335)	(0.307)	(0.307)	(0.0330)	(0.0329)	(0.0395)	(0.0396)
Father literate = 1	-0.0900	-0.0900	-0.104	-0.104	1.940 *	1.939 *	2.273 * *	2.266 * *	0.141	0.141	0.0633	0.0633
	(0.0757)	(0.0758)	(0.0682)	(0.0683)	(1.119)	(1.120)	(1.048)	(1.044)	(0.0903)	(0.0905)	(0.140)	(0.140)
Mother literate = 1	-0.0339	-0.0372	0.0445	0.0399	1.476	1.481	0.642	0.753	0.117	0.114	-0.248	-0.249
	(0.0855)	(0.0860)	(0.0833)	(0.0836)	(1.401)	(1.400)	(1.335)	(1.336)	(0.123)	(0.123)	(0.164)	(0.164)
Female = 1	0.211 * **	0.277 * **	0.382 * **	0.475 * **	1.391	1.302	3.578 * **	1.770	0.383 * **	0.438 * **	1.214 * **	1.227 * **
	(0.0662)	(0.101)	(0.0613)	(0.0908)	(0.989)	(1.577)	(0.896)	(1.445)	(0.0852)	(0.129)	(0.105)	(0.162)
Female X Brothers ratio		-0.159		-0.224		0.218		4.396 *		-0.133		-0.0317
		(0.182)		(0.158)		(2.840)		(2.585)		(0.222)		(0.280)
FWER P-values	0.007		0.031		0.479		0.591		0.049		0.272	
Observations	1138	1138	1135	1135	1115	1115	1103	1103	1140	1140	1140	1140
R-squared	0.129	0.130	0.197	0.198	0.277	0.277	0.567	0.568	0.571	0.571	0.175	0.175
Birth order	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed in Table 1 as well as region and sentinel-site fixed effects. Significance: * ** $p < 0.01$, * * $p < 0.05$, * $p < 0.1$.

their English scores and marginally significant with a p-value for the sum of the main and interacted coefficient equaling 0.095) but not in their Math skills. We also find that for adolescents' in urban areas having more brothers increases grade attainment by some 0.2 years (significant at 5%).

5. Conclusion

The family environment is where children spend most of their critical growth period and develop much of their physical and human capabilities. Understanding the role of family environments in their development is therefore important to explain later life outcomes. In this paper, we focus on examining the role of siblings' sex ratio on physical capital, human capital, and household gendered time allocation.

Our study contributes to academic scholarship on gendered intra-household resource distribution in resource-constrained environments. Overall, our results show that having more brothers rather than sisters increases both physical and human capital, with the effect often stronger for boys than for girls. In a country like Ethiopia, with endemically high undernutrition rates and low average educational attainment, our findings shed new light on the positive role of male siblings on physical and human capital formation. At the same time, having relatively more brothers increases girls' time spent on traditionally female specific household tasks. This indicates the complex effect that siblings' sex has on the opportunities and constraints faced by children and adolescents, especially in a context where strong traditional gender norms prevail such as rural areas. On the one hand, girls seem to benefit from a greater share of male siblings as much as their male peers, in terms of higher educational attainments and performance. We find not support for the idea that having more brothers leads to increased competition. If anything, brothers may even contribute to increased household resources and (or) facilitate spillovers which may be mediating channels through which the observed effect comes about. Yet girls also face increased pressure to engage in gendered time use, a result that seems to be driven by the rural sub-sample and possibly explained by stronger traditional gender norms in these areas. Next to direct positive effects on human capital through possible spillovers and increased resources there may be indirect effects as older brothers may function as role models or tutors to their younger male siblings as in Joensen and Nielsen (2018). Role model effects however are more difficult to explain with our results if we expect role models to be gender-specific - that is older brothers (sisters) only serving as role models to younger brothers (sisters), whereas we find that having brothers serves girls equally well as boys. Also, role model effects are unlikely to explain the findings on physical capital.

Our study may also be of relevance to policymakers, albeit we cannot pinpoint the exact mechanisms thereby complicating straightforward policy recommendations. We however highlight the following take-away message: the Ethiopian and presumably many other developing (and even developed) country contexts indicate persistent gender norms where perceived returns on investments are higher for boys than girls. While girls born into families with more brothers may even benefit from having a larger share of brothers than sisters these are indirect and relative benefits at best. Moreover, such effects may eventually be dominated by later-life outcomes as girls with more brothers need to perform more female chores and are less involved in productive tasks - indicative of persistent gender-biased norms - which may ultimately affect girls' socio-economic as well as psychological outcomes. Understanding the extent of such bias and the role of brothers therein requires more fine-grained data on both parents, brothers, and their siblings. Well-targeted interventions that facilitate direct parental investments in girls through for example information treatments on potential female productivity, returns on investment and releasing resource constraints may be a first step in creating a level playing field for girls and women.

CRediT authorship contribution statement

Hiwot Mesfin: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. **Francesco Cecchi:** Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Eleonora Nillesen:** Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Nyasha Tirivayi:** Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Appendix A

See appendix Tables A1-A8.

Table A1
Testing for son-preference.

	Mean	Std. Err.	N
Female	3.828	0.050	2111
Male	3.877	0.045	2360
Diff	-0.048	0.067	

Significance: * ** p < 0.01, * * p < 0.05, * p < 0.1.

Table A2
Testing for Weight differences in rural and urban.

Diff	Rural	Urban
BMI-for-age	-1.817	-1.360
-0.456 * **		
	(0.020)	(0.030)
(0.036)		
Observations	1350	2531
3881		
	Weight-for-age	-2.097
-1.582	-0.515 * **	
	(0.021)	(0.028)
(0.035)		
Observations	1502	2724
4226		

Significance: * ** p < 0.01, * * p < 0.05, * p < 0.1.

Table A3
Time allocation by adolescents' sex.

	Girls	Boys	Diff
Female specific tasks	2.776	1.395	-1.381 * **
	(1.552)	(1.200)	(0.042)
Male specific tasks	0.844	2.376	1.532 * **
	(1.552)	(2.640)	(0.067)
Observations	2006	2296	4302

Significance: * ** p < 0.01, * * p < 0.05, * p < 0.1.

Table A4
Birth order.

Birth order	Number	Per cent
First born	1174	26
Second born	1185	26
Third born	1022	22
Fourth born	678	15
Fifth born	351	8
Sixth born	138	3
Seventh born	35	1
Eighth born	8	0
Ninth born	1	0
Total	4592	100

Table A5
Brothers' effects on Physical and Human Capital Index.

		PCIHCI		
VARIABLES	(1)	(2)	(3)	(4)
Brothers-to-siblings ratio	0.135 * **	0.205 * **	0.127 * **	0.118 * *
	(0.0491)	(0.0659)	(0.0370)	(0.0526)
Number of siblings	-0.00109	-0.000616	-0.0247 * **	-0.0247 * **
	(0.0100)	(0.0101)	(0.00729)	(0.00729)
Father literate = 1	-0.00128	-0.00105	0.0233	0.0233
	(0.0360)	(0.0359)	(0.0265)	(0.0265)
Mother literate = 1	-0.0183	-0.0181	0.0703 * *	0.0703 * *
	(0.0428)	(0.0428)	(0.0317)	(0.0317)
Female = 1	0.341 * **	0.407 * **	0.0659 * **	0.0572
	(0.0314)	(0.0534)	(0.0227)	(0.0406)
Female X Brothers ratio		-0.150		0.0200
		(0.0972)		(0.0739)
Observations	3367	3367	2978	2978
R-squared	0.209	0.209	0.491	0.491
Birth order	YES	YES	YES	YES
Controls	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed site fixed effects. Significance: * ** $p < 0.01$, * * $p < 0.05$, * $p < 0.1$.

Table A6
Non-linear effects: Brothers effects on physical capital, Human capital, and gendered time allocation:.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	BMI-for-age z-score	Weight-for-age z-score	Math skills	English skills	Highest grade	Female-specific chores
Brothers-to-siblings ratio	-0.142	-0.258	3.998	1.172	0.323	0.113
	(0.196)	(0.201)	(3.167)	(3.055)	(0.322)	(0.443)
Brothers-to-siblings Squared	0.320	0.392 * *	-1.289	0.909	-0.0489	0.00592
	(0.197)	(0.199)	(3.192)	(3.045)	(0.320)	(0.448)
Number of siblings	0.00630	0.00482	-0.342 *	-0.486 * *	-0.0640 * **	-0.0972 * **
	(0.0121)	(0.0124)	(0.194)	(0.190)	(0.0197)	(0.0282)
Father literate = 1	-0.0329	0.0417	-0.0488	0.859	0.0773	-0.00593
	(0.0405)	(0.0405)	(0.634)	(0.657)	(0.0687)	(0.0952)
Mother literate = 1	-0.0480	-0.000604	1.950 * **	1.609 * *	0.0243	-0.114
	(0.0466)	(0.0493)	(0.754)	(0.791)	(0.0822)	(0.107)
Female = 1	0.306 * **	0.404 * **	0.0154	1.606 * **	0.355 * **	2.675 * **
	(0.0352)	(0.0353)	(0.558)	(0.554)	(0.0575)	(0.0775)
Observations	3401	3367	3068	2982	3411	3404
R-squared	0.175	0.215	0.337	0.543	0.531	0.391
Birth order	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed in Table 1 as well as region and sentinel-site fixed effects. Significance: * ** $p < 0.01$, * * $p < 0.05$, * $p < 0.1$.

Table A7
Brothers' effects on gendered time allocation.

	Girls		Boys	
	(1)	(2)	(3)	(4)
VARIABLES	Female specific tasks	Male specific tasks	Female specific tasks	Male specific tasks
Brothers-to-siblings ratio	0.207 * *	-0.143	-0.0242	-0.0306
	(0.101)	(0.0986)	(0.0764)	(0.147)
Number of siblings	-0.0105	0.0261	-0.0151	0.116 * **
	(0.0193)	(0.0209)	(0.0169)	(0.0330)
Father literate = 1	0.0123	-0.00239	0.00532	0.0594
	(0.0721)	(0.0830)	(0.0545)	(0.113)
Mother literate = 1	-0.160 *	0.0165	0.0507	0.160
	(0.0872)	(0.0914)	(0.0644)	(0.130)
Observations	1600	1599	1805	1805
R-squared	0.233	0.245	0.248	0.374
Birth order	YES	YES	YES	YES
Controls	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed in Table 1 as well as region and sentinel-site fixed effects. Significance: * ** $p < 0.01$, * * $p < 0.05$, * $p < 0.1$.

Table A8
Brothers effects on physical capital, Human capital, and gendered time allocation: including no sibling sample.

	PCI		HCI	
VARIABLES	(1)	(2)	(3)	(4)
Brothers-to-siblings ratio				
0.163 * **				
0.231 * **				
0.119 * **				
0.0975 * *				
	(0.0472)	(0.0624)	(0.0354)	(0.0493)
Number of siblings	0.00466	0.00509	-0.0238 * **	-0.0240 * **
	(0.00954)	(0.00954)	(0.00677)	(0.00676)
Father literate = 1	0.0195	0.0196	0.0245	0.0245
	(0.0345)	(0.0345)	(0.0251)	(0.0251)
Mother literate = 1	-0.00886	-0.00903	0.0715 * *	0.0716 * *
	(0.0411)	(0.0410)	(0.0301)	(0.0300)
Female = 1	0.344 * **	0.403 * **	0.0578 * **	0.0387
	(0.0303)	(0.0486)	(0.0218)	(0.0361)
Female X Brothers ratio		-0.146		0.0473
		(0.0914)		(0.0682)
Observations	3605	3605	3207	3207
R-squared	0.203	0.203	0.500	0.501
Birth order	YES	YES	YES	YES
Controls	YES	YES	YES	YES

Robust standard errors in parentheses. Controls include all the adolescent and household covariates listed in Table 1 as well as region and sentinel-site fixed effects. Significance: * ** $p < 0.01$, * * $p < 0.05$, * $p < 0.1$.

Appendix B

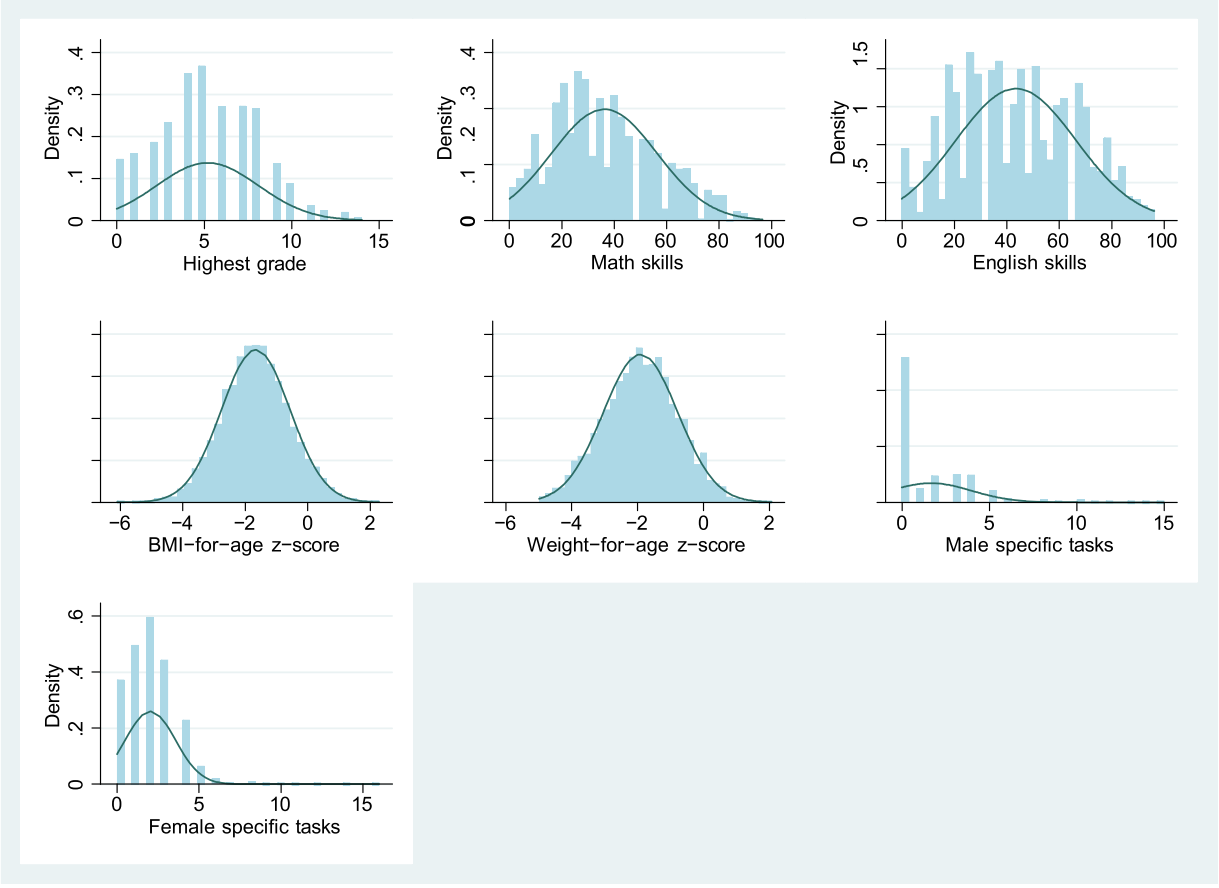

Fig. B1. The distribution of individual components of the outcome variables.

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