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Birth Order, Sibling Sex Composition, and Quantity–Quality Trade-offs – Evidence from India

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Abstract: *We use two waves of data from the India Human Development Survey to investigate the effect of family size on (i) parental expenditures on children's education; and (ii) test scores of proficiency in reading, writing, and maths for 8–11-year-old children. We investigate whether these effects vary by gender, birth order of children, and sibling sex composition. We address the endogeneity of family size, using an instrumental variable approach. Our ordinary least squares estimates provide evidence of quantity–quality trade-offs in children's educational expenditures, the existence of birth-order effects, and a sizeable pro-son bias. For test scores as well, ordinary least squares estimates indicate negative spillovers from additional children. The instrumental variable estimates, in contrast, find no evidence of quantity–quality trade-offs, birth order, or sibling sex composition effects in either expenditures or test scores. However, instrumental variable estimates of the male premium are bigger than ordinary least squares estimates. They also suggest that children enrolled in private schools do no better than those in government schools. Moreover, the advantage that boys appear to have over girls in maths is largely reversed in private schools.*

Keywords: quantity–quality trade-offs; birth order; sibling sex composition; son preference; intra-household resource allocation; learning outcomes; India

JEL Classification: I24, J13, J16, O53

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1. Motivation

The motivation for this paper comes from the extensive literature on the trade-off facing parents between child quantity and quality. The quantity–quality (Q-Q) trade-off was modelled by Becker and Lewis (1973) in the context of investments made by households in the human capital development of their children. Important policy implications arise from this hypothesis. For developing countries, the existence of a Q-Q trade-off implies that significant gains in human capital development are possible with a reduction in fertility levels. Such calculations have driven several countries – for example, China and India – to adopt aggressive population control policies.

Empirically, a negative relationship between family size and academic achievement, found by several early studies, provided evidence to support the existence of such a substitution.[1] Over time, other papers emphasised the methodological challenge in testing this hypothesis, given that fertility decisions and human capital investments in children are jointly determined.[2] These papers used some exogenous variation in family size to address the endogeneity issue and found conflicting evidence.[3]

Parental preference for sons in several countries, particularly in Asia, further complicates the methodological challenge. Amongst high-fertility communities, couples wanting sons are likely to keep having children until they have as many sons as they desire, a behaviour termed 'son-preferring, differential stopping behaviour' (SP-DSB) in the literature. This behaviour implies that, on average, girls will have more siblings than boys. Thus, a seemingly negative effect for girls might arise even when parents do not discriminate against girls; it might simply be a consequence of family size effects (Jensen, 2003). Thus, in the context of these countries, it is important not only to address the endogeneity of family size but also to separate the family size effect from the birth order effect and the sibling sex composition effect.

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[1] See Hanushek (1992) and the review by Schultz (2005), for example.
[2] See Browning (1992), Haveman and Wolfe (1995), and Angrist et al. (2010), for instance.
[3] Rosenzweig and Wolpin (1980) and Black et al. (2005) are influential papers that used twin births as a natural experiment to instrument for family size.

In this paper, we look for evidence of discrimination, if any, amongst surviving children with respect to human capital investments. We use parental expenditures on children's education as a direct measure of child quality. This is a preferred measure over the standard proxies used in the literature, such as schooling or earnings, which are more appropriately viewed as the outcomes of parental investments than the inputs (Lee, 2008; Azam and Saing, 2018). Moreover, with the exception of very few countries, mandatory schooling laws are the norm across the world. Thus, the decision of whether to send a child to school is largely out of the parents' ambit. However, many decisions that impact children's learning remain under the parents' discretion, such as whether to send a child to a public or private school, how much to spend on supplementary learning resources such as engaging a private tutor. We then study the impact of these investments on test scores for proficiency in reading, writing, and maths.

We investigate the effect of family size on parental expenditures on children's education, and on children's learning outcomes in India – proxied by scores on standardised, age-appropriate tests in reading, writing, and maths – using two waves of the India Human Development Survey (IHDS) – IHDS I (2004–2005) and IHDS II (2011–2012). We control for a number of confounding variables, such as parental education, children's nutritional status, and cultural norms and expectations, that are likely to be highly correlated with the household's views regarding the importance of human capital attainment. We also control for birth order and sibling sex composition to understand how much of the family size effect is due to these factors. We use ordinary least squares (OLS) models, as well as instrumental-variable (IV) models to control for unobserved heterogeneity amongst households.

Our OLS estimates indicate sizeable and significant Q-Q trade-offs in educational expenditures. Birth order effects are negative, sizeable, and significant, and sibling sex composition effects are broadly consistent with birth order effects. However, estimates from our two-stage least squares (2SLS) models using IV indicate no Q-Q trade-offs, no birth order effects, and no impact of sibling sex composition on households' education expenditures, implying that all the estimates from the OLS models are due to unobserved heterogeneity amongst households. However, the IV estimates of the male premium are bigger than the corresponding OLS estimates and significant, implying a strong pro-son bias in educational investments.

OLS estimates of test scores of 8–11-year-old children in reading, writing, and maths proficiency indicate negative spillovers from additional children. Children enrolled in private schools do better on all tests than their government school counterparts. There is a robust household wealth gradient, with children from wealthier households doing better on all tests. The IV estimates, however, suggest no effect of additional children on test scores. Neither the OLS nor the IV estimates indicate any birth order effects on proficiencies. There is also strong evidence of a secular decline in learning outcomes between the two waves. The IV estimates do not support a private school premium in learning. Moreover, the advantage that boys appear to have over girls in maths is eroded in private schools, with girls outperforming boys in reading and maths in these schools. Thus, our results indicate sizeable and significant son-biased investments in educational expenditures that do not translate into better learning outcomes.

The period between the two waves of the survey saw the passage, in 2009, of the landmark Right to Education Act in India. The act guarantees access to free schooling for all children aged 6–14, requiring government schools to provide free schooling for this age group. The act also mandates that students cannot be retained in grade due to poor performance or expelled from school. A set of minimum quality standards are defined for schools in terms of physical facilities, teacher background, and maximum class size. Moreover, private schools are required to accept poor students up to one-quarter of their student body at first grade. Chatterjee et al. (2020) show that the act has increased competitive pressure amongst students and caused richer families to seek increased academic resources for their children, thus increasing inequity in education. Whilst our data do not allow us to test the impact of this policy on parental investments in children's education or children's academic achievement (we have a two-wave panel of households but not of children), we speculate on how it might explain changes in the pattern of results we obtain using samples from the two waves.

Our paper has important policy implications for India, which is seeking to leverage the demographic dividend brought about by decreasing fertility levels and mortality rates. There is evidence of large gender gaps in the country along several dimensions, particularly educational attainment (Jensen, 2003). Recent evidence highlights a male advantage in science, technology, engineering, and mathematics, and finds that performance disparities in these subjects between girls and boys grow as students progress from primary to secondary level (Bhagat and Vijayaraghavan, 2019). Jayachandran (2015) noted that male labour force participation rate is three times that of women in India and that women have little autonomy over decisions affecting their life.

Developing countries face formidable challenges in achieving sustained and balanced economic growth against the backdrop of rapid technological advancements and changing global patterns of trade. Institutions such as the World Bank have stressed the primacy of human capital, especially in developing countries, to harness the benefits of technology and to blunt its worst disruptions (World Bank, 2019). This depends critically on private intergenerational investments in human capital of all citizens – male and female – and on social forces that channel such investments into productivity-enhancing growth. Efforts to increase educational attainment amongst women and their labour force participation will be crucial to meet current and future challenges to sustained growth.

The rest of the paper is organised as follows. Section 2 reviews the literature that is closely related to our paper. Section 3 describes the data used in this paper and presents detailed summary statistics. Section 4 lays out our empirical strategy. Section 5 presents the discussion of our resulting estimates. Section 6 draws conclusions.

2. Related Literature

Testing the Q-Q trade-off hypothesis has largely employed data from developed countries.[4] There is a nascent but burgeoning literature on this topic that uses data from developing countries.

[4] See Hanushek (1992), Schultz (2005), Black et al. (2005), Angrist et al. (2010), for example, and references therein.

Rosenzweig and Wolpin (1980) are amongst the early authors examining the Q-Q trade-off in India. Using Additional Rural Income Survey data for 1969–1971, they used twin births as a natural experiment to instrument for family size and find evidence of a trade-off in terms of lower levels of completed schooling.

Kugler and Kumar (2017), using the Indian District Level Household Survey data for 2007–2008, examined the impact of family size on three educational outcomes for children in the 5–21 age group: ever attended school, current attendance, and completed schooling. Using the gender of the first child to instrument for family size, the authors found that an additional child in the family reduces schooling by 0.08 years, and lowers the probability of being enrolled or ever attending school by about 1 and 2 percentage points, respectively. These effects are quantitatively bigger in rural areas, amongst poorer and low-caste families and amongst families with illiterate mothers.

A key channel through which households exercise their pro-son bias is by enrolling their sons in more expensive private schools whilst sending their daughters to government schools. Azam and Kingdon (2013) used the 1993 and 2004 waves of the IHDS to investigate whether girls are disadvantaged in India. They found that despite progress on gender equality in education during this period, families spend less on girls' education, primarily by enrolling them in public schools. This bias is more pronounced in rural areas. Maitra et al. (2016) used two waves of the IHDS data to examine the intra-household gender gap in private school enrolment, and found evidence that girls are less likely to be enrolled in private schools.

Muralidharan and Kremer (2006) documented the characteristics of rural private primary schools in India, based on a nationally representative survey conducted in 2003. A pertinent finding from their analysis is that children enrolled in private schools have higher attendance rates and higher test scores than children in public schools, even after controlling for observable family and school characteristics. Together, these findings suggest that families' decision to send their sons to private schools and daughters to public schools might be a primary reason for the observed gender achievement gap. We address this issue in our paper.

Makino (2018) is closely related to our work. She used the first wave of the IHDS survey data to examine whether sibling sex composition and birth order affect human capital outcomes, specifically, test scores – reading, writing, and maths – of school-age children. She estimated OLS models separately for different sibship (number of children) samples and controls for household fixed effects. She found some evidence of a positive birth order effect amongst girls; higher birth-order girls fare better on tests than lower birth-order girls. However, there is a negative birth-order effect amongst boys, in that later-born boys perform worse than their older brothers. Amongst two-child households, however, a second-born girl with an older brother fares worse. Makino also found a gender gap in achievement amongst rural households with more than three children. Another recent paper that used two waves of the IHDS data and methods similar to ours is by Congdon Fors and Lindskog (2017). They examined families' pecuniary as well as time investments into children's human capital accumulation, controlling for gender of children and birth order effects. They used sibship fixed effects models to control for the endogeneity of family size. They found negative birth order effects on children's test scores and parental pecuniary investments, but positive birth order effects for time investments. They also found evidence that girl children are disadvantaged within families.

Our approach varies from that of Makino (2018) and Congdon Fors and Lindskog (2017). Instead of using sibship fixed effects or estimating separate regressions for various sibship sizes, we follow Mogstad and Wiswall (2016) in allowing for a linear as well as an unrestricted relationship between family size and our chosen child outcomes. Our decision is driven by the fact that the mothers of the children in our sample are predominantly young, making it very likely that fertility is incomplete in these families. This makes it challenging to interpret estimates based on sibship fixed effects.

3. Data and Descriptives

The IHDS is a nationally representative survey that covered 41,554 households in 1,503 villages and 971 urban neighbourhoods in the first wave in 2004–2005 (Desai et al., 2005). The second wave re-interviewed 83% of the original households as well as split households residing within the same locality in 2011–2012. The sample is spread across 33 (now 34) states and covers rural and urban locations. The IHDS collects extensive data on education, health, livelihoods, marriage, fertility, social capital, gender relations, and cultural practices.

The IHDS employs two principal survey instruments. The household questionnaires are administered to the individual most knowledgeable about income and expenditure, frequently the male head of the household; the questionnaire for health and education is administered to a woman in the household, usually the spouse of the household head. We can thus observe changes in the household's financial situation as well as decisions regarding investments in education and health of household members. In the second wave, questions on fertility, marriage, and gender relations in the households are addressed to an ever-married woman in the household who was 15–49 years of age during the first wave. If no household member fit these criteria, that portion of the questionnaire was skipped (about 19% of all households); if the household had more than one ever-married woman of 15–49 years, one woman was selected randomly to answer those questions.

For multiple-family households, each resident's father's and mother's roster number is used to match parents with children. The survey records parental expenditures on components of children's education: tuition fees, uniforms, textbooks, transport, and private tuition. Table 1 presents summary statistics for the sample of test-taking children for each wave. A bigger fraction of girls attend government schools than boys, and the reverse is true for private schools. Girls are also more likely to be recipients of government benefits, a consequence of public policies to increase their enrolment and educational attainment. We see the opposite pattern in parental investments, with families spending more on boys' education. All these differences are statistically significant. We see the same pattern in the second wave, although the gaps are bigger and enrolment in private schools has increased for both genders. These gender disparities in expenditures could be due to an effort by families to redress the imbalance in government benefits, or reflect perceived differences in returns to investment in girls versus boys. The gender difference in private tuition suggests that the latter explanation is more likely since these tuitions tend to be largely an optional investment.

Table 1: Characteristics of Test-Taking Children

Variables	Mean (all)	Mean (girls)	Mean (boys)	T-test (girls-boys)
Wave I				
Type of school attending (shares):				
Government	0.693	0.721	0.669	6.15***
	[0.004]	[0.006]	[0.006]	
Private	0.284	0.257	0.307	-6.02***
	[0.004]	[0.006]	[0.006]	
Students receives from government(shares):				
Free books	0.582	0.628	0.541	3.36***
	[0.005]	[0.006]	[0.006]	
Free uniform	0.164	0.209	0.124	12.47***
	[0.003]	[0.005]	[0.004]	
School fees	0.169	0.181	0.158	3.34***
	[0.003]	[0.005]	[0.005]	
Scholarship	0.126	0.15	0.105	7.25***
	[0.003]	[0.005]	[0.004]	
Parental investments, previous year: ln (Rupees/year)				
School fees	4.012	3.827	4.174	-7.34***
	(2.583)	(2.584)	(2.57)	
Other school expenses	5.839	5.769	5.9	-5.09***
	(1.407)	(1.448)	(1.367)	
Private tuition	1.269	1.138	1.383	-4.71***
	(2.599)	(2.476)	(2.696)	
Total expenditure on education	6.387	6.284	6.477	-6.38***
	(1.506)	(1.531)	(1.478)	
# Observations	12,407	5,816	6,591	
Wave II				
Type of school attending (shares):				
Government	0.627	0.671	0.587	10.3***
	[0.005]	[0.006]	[0.006]	
Private	0.359	0.313	0.401	-10.75***
	[0.005]	[0.006]	[0.006]	
Students receives from government (shares):				
Free books	0.609	0.654	0.567	10.04***
	[0.005]	[0.006]	[0.006]	

Free uniform	0.358	0.427	0.293	14.67***
	[0.005]	[0.007]	[0.006]	
School fees	0.422	0.461	0.386	8.46***
	[0.005]	[0.007]	[0.006]	
Scholarship	0.226	0.257	0.198	6.93***
	[0.004]	[0.006]	[0.005]	
Parental investments, previous year: ln (Rupees/year)				
School fees	3.976	3.764	4.415	-9.91***
	(3.408)	(3.428)	(3.506)	
Other school expenses	6.099	6.009	6.359	-9.35***
	(1.949)	(2.02)	1.91)	
Private tuition	1.723	1.408	1.721	-5.5***
	(3.052)	(2.851)	(3.088)	
Total expenditure on education	6.831	6.702	7.089	-10.13***
	(1.945)	(2.015)	(1.959)	

Note: Standard errors are in [] and standard deviations in () parentheses; *** - significant at the 99% level;** - significant at the 95% level; * - significant at the 90% level.
Source: Authors.

The IHDS also reports reading, writing, and maths proficiency test scores for children aged 8–11 in the household.[5] The tests were developed in collaboration with researchers and were pre-tested to ensure comparability across languages. The scores are our proxy for human capital. Since the tests were administered by the survey enumerators, the data on test scores are not subject to recall error or exaggeration. This also means that we do not have to take account of cohort effects, an important consideration when studying birth order effects (Makino, 2018).

The grades for the reading test are on a 0–4 assessment scale: 0 – cannot read, 1 – can read letters, 2 – can read words, 3 – can read a paragraph, 4 – can read a story. The maths test is graded to measure four discrete proficiency levels: 0 – cannot count, 1 – familiar with numbers, 2 – can do subtraction, and 3 – can do division. The writing test measures two levels of proficiency: 0 – cannot write and 1 – can write with two or fewer mistakes. As is standard practice, we normalise the reading and maths scores to lie between 0 and 1 such that they measure standard deviations from the mean. We report summary statistics of normalised test scores for both waves in Table 2.

[5] Note that our two waves of data give us a panel of households but not of the test-taking children.

Table 2: Test Scores of Children

Wave I	Mean (all)	Mean (girls)	Mean (boys)	T-test (girls-boys)
Test scores:				
Reading	0.655	0.641	0.667	-4.346***
	(0.332)	(0.338)	(0.326)	
# Observations	12,387	5,809	6,578	
Writing	0.693	0.678	0.705	-3.277***
	(0.461)	(0.467)	(0.456)	
# Observations	12,280	5,777	6,503	
Maths	0.526	0.501	0.548	-7.484***
	(0.342)	(0.346)	(0.338)	
# Observations	12,337	5,788	6,549	
Wave II	**Mean (all)**	**Mean (girls)**	**Mean (boys)**	**T-test (girls-boys)**
Reading	0.613	0.604	0.621	-3.02***
	(0.35)	(0.354)	(0.345)	
# Observations	11,392	5,470	5,922	
Writing	0.547	0.536	0.557	-1.778*
	(0.399)	(0.4)	(0.398)	
# Observations	11,275	5,409	5,866	
Maths	0.482	0.46	0.502	-6.311***
	(0.322)	(0.321)	(0.321)	
# Observations	11,344	5,448	5,896	

Note: Standard deviations are in parentheses; Test scores are normalized to the [0,1] range; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level.
Source: Authors.

On average, young schoolchildren in our sample are more proficient in reading and writing than in maths; in both waves, the average child was able to read words but not a full paragraph, able to write, and was familiar with numbers but not yet able to do mathsematical operations. Boys outperformed girls on all three tests, and these differences are all statistically significant. Whilst the gender gap narrowed over time, this is a consequence of worsening learning outcomes across all three domains for both sexes, with boys doing worse. Many researchers have documented the low learning levels in India and the negative trends in learning outcomes over time.[6]

[6] See ASER (2012), Muralidharan (2013), and Shah and Steinberg (2019), for example.

In Table 3, we report summary statistics of children's test scores by government versus private school enrolment. In wave I, the gender gaps in proficiency are bigger amongst children in government schools. Over time, this gap has narrowed although girls are still at a disadvantage in maths. Girls in private school, however, are more proficient in writing than boys and are equally proficient in reading and maths. Once again, we note the drop in scores over the two waves.

Table 3: Test Scores of Children, by Government vs Private School

Wave I				
Government School	**Mean (all)**	**Mean (girls)**	**Mean (boys)**	**T-test (girls-boys)**
Reading	0.626	0.615	0.636	-2.969***
	(0.331)	(0.334)	(0.328)	
# Observations	8,360	4,052	4,308	
Writing	0.658	0.65	0.664	-1.367
	(0.475)	(0.477)	(0.472)	
# Observations	8,290	4,034	4,256	
Maths	0.486	0.464	0.505	-5.567***
	(0.336)	(0.337)	(0.334)	
# Observations	8,338	4,041	4,297	
Private School	**Mean (all)**	**Mean (girls)**	**Mean (boys)**	**T-test (girls-boys)**
Reading	0.771	0.776	0.767	0.956
	(0.283)	(0.285)	(0.281)	
# Observations	3,425	1,448	1,977	
Writing	0.819	0.81	0.826	-1.137
	(0.385)	(0.392)	(0.379)	
# Observations	3,391	1,435	1,956	
Maths	0.661	0.653	0.667	-1.301
	(0.313)	(0.318)	(0.309)	
# Observations	3,400	1,439	1,961	
Wave II				
Government School	**Mean (all)**	**Mean (girls)**	**Mean (boys)**	**T-test (girls-boys)**
Reading	0.561	0.557	0.564	-1.593
	(0.351)	(0.353)	(0.349)	
# Observations	6,905	3,571	3,334	
Writing	0.493	0.483	0.502	-1.057
	(0.401)	(0.402)	(0.4)	
# Observations	6,842	3,542	3,300	
Maths	0.435	0.419	0.453	-3.957***
	(0.315)	(0.312)	(0.318)	
# Observations	6,875	3,561	3,314	

Private School	Mean (all)	Mean (girls)	Mean (boys)	T-test (girls-boys)
Reading	0.722	0.722	0.721	1.513
	(0.314)	(0.319)	(0.31)	
# Observations	4,100	1,691	2,409	
Writing	0.657	0.662	0.654	2.34**
	(0.37)	(0.366)	(0.373)	
# Observations	4,052	1,664	2,388	
Maths	0.578	0.563	0.588	-1.071
	(0.31)	(0.316)	(0.305)	
# Observations	4,085	1,681	2,404	

Note: Standard deviations are in parentheses; Test scores are normalized to the [0,1] range; *** - significant at the 99% level ** - significant at the 95% level; * - significant at the 90% level.
Source: Authors.

Table 4 describes some characteristics of test-taking children. Given son preference and the SP-DSB rule, girls tend to have more siblings; girls come from bigger families on average, and the difference is significant. Boys constitute about 53% of the sample. The average number of children per family is over three, and the average child is about 9.5 years old. The average age of the mothers is 34 and of the fathers 39. The average schooling of mothers is low, at 3.9 years. The fathers, on average, have just over 6 years of schooling.

Table 4: Characteristics of Test-Taking Children - Pooled sample

Variables	Mean (all)	Mean (girls)	Mean (boys)	T-test (girls-boys)
#Children in household	3.29	3.45	3.15	16.31***
	(1.438)	(1.459)	(1.404)	
Child's age	9.488	9.481	9.494	-0.88
	(1.077)	(1.072)	(1.081)	
Male=1	0.525			
	[0.003]			
Mother's age	34.29	34.19	34.38	-2.336**
	(6.04)	(5.93)	(6.13)	
Mother's schooling (years)	3.93	3.9	3.95	-0.893
	(4.56)	(4.54)	(4.58)	
Father's schooling (years)	6.23	6.2	6.26	-0.945
	(4.85)	(4.82)	(4.88)	
Birth order: 1	0.337	0.343	0.33	2.14**
	[0.003]	[0.004]	[0.004]	
2	0.316	0.312	0.319	-1.08
	[0.003]	[0.004]	[0.004]	
3	0.2	0.2	0.202	-0.77
	[0.003]	[0.004]	[0.004]	
4	0.092	0.091	0.093	-0.76
	[0.002]	[0.003]	[0.003]	
5	0.037	0.039	0.036	1.36
	[0.001]	[0.002]	[0.002]	
Siblings Has older sisters	0.441	0.427	0.454	-4.17***
	[0.003]	[0.005]	[0.004]	
Has younger sisters	0.369	0.403	0.338	10.4***
	[0.003]	[0.005]	[0.004]	
Has older brothers	0.43	0.436	0.425	1.75*
	[0.003]	[0.005]	[0.004]	
Has younger brothers	0.447	0.525	0.376	23.31***
	[0.003]	[0.005]	[0.004]	
# Observations (Minimum)	23,723	11,247	12,476	

Note: Standard deviations are in () parentheses, standard errors in [] parentheses; *** - significant at the 99% level; **- significant at the 95% level; * - significant at the 90% level.
Source: Authors.

The proportion of first-borns is skewed towards girls, which is consistent with girls coming from bigger families as couples have more children to achieve the desired number of sons. However, girls and boys constitute similar shares of higher birth parities.[7] These trends are consistent with boys having more older sisters and girls having more younger siblings in general.

Table 5 presents more summary characteristics of households with test-taking children. About 38% of the sample comes from joint family households. This is an important variable for our analysis since the effects of birth order can get muddled when children reside with their cousins and household decision-making involves multiple adults. About 29% of households live in urban areas. The distribution of household expenditures is positively skewed. Nearly half the households in the sample own or cultivate land and own livestock, which is consistent with the predominant share of the population living in rural areas. The caste distribution is skewed towards other backward castes whilst Hindus are the dominant religious group.[8]

The household questionnaire asks the respondent whether certain cultural practices are common in the household's community. Chances of eliciting truthful responses to these sensitive questions are much higher when the questions are framed in terms of the community and not the household. Many of these practices reflect traditional and/or patriarchal views and are likely to be correlated with families' beliefs regarding the benefits of investing in educating girl children. Table 5 reveals that women cover their faces in public (practice purdah) in about 64% of households, that cousin marriage is common in about 35% of households, that about 47% of households prefer to get daughters married to someone from the same village or neighbourhood, and that over 86% of households give some form of dowry to the groom's family when the daughter gets married.

[7] We note that these characteristics pertain to surviving children.

[8] The scheduled castes and scheduled tribes are historically disadvantaged people recognized in the Constitution of India. Other backward castes is a collective term used by the Government of India to classify castes, other than scheduled castes and scheduled tribes, which are educationally and socially disadvantaged relative to Brahmins and other forward castes.

Table 5: Characteristics of Test-Taking Households

Variable	Obs	Mean	Std. Dev.	Min	Max
Joint family household	24,101	0.382	0.486	0	1
Urban	24,101	0.291	0.454	0	1
HH consumption expenditure quintiles:					
Q1	24,090	0.256	0.436	0	1
Q2	24,090	0.227	0.419	0	1
Q3	24,090	0.202	0.402	0	1
Q4	24,090	0.177	0.381	0	1
Q5	24,090	0.139	0.346	0	1
HH owns/cultivates land	24,100	0.491	0.5	0	1
HH owns livestock	24,101	0.5	0.5	0	1
HH owns non-farm business	24,101	0.107	0.309	0	1
HH's caste:					
Brahmin	24,088	0.049	0.215	0	1
OBC	24,088	0.413	0.492	0	1
SC	24,088	0.224	0.417	0	1
ST	24,088	0.08	0.272	0	1
Other	24,088	0.235	0.424	0	1
HH's religion:					
Hindu	24,101	0.79	0.407	0	1
Muslim	24,101	0.15	0.357	0	1
Christian	24,101	0.02	0.142	0	1
Sikh	24,101	0.025	0.157	0	1
Buddhist/Jain	24,101	0.007	0.085	0	1
Other	24,101	0.007	0.084	0	1
Common practice in HHs community					
to give dowry	24,057	0.862	0.344	0	1
to get daughter married to village/neighborhood native	24,101	0.469	0.499	0	1
to get daughter married to cousin	24,101	0.348	0.476	0	1
for women to practice purdah	23,425	0.644	0.479	0	1

Note: Obs = observations; Std Dev. = standard deviation; Min = minimum; Max = maximum. Source: Authors.

Table 6 presents summary values of families' average educational expenditures on children, by total number of surviving children. For each family size group (defined by number of children), we present average expenditures by the number of boys. We have limited the table to families with four children or fewer since we have few observations per cell beyond this size. The tables can be read across columns as indicating Q-Q trade-offs, and downward as the impact of additional brothers. The numbers imply a Q-Q trade-off; moving from one child to four children decreases average educational expenditures by 13% and 15% in waves 1 and 2, respectively. The variation due to sibling sex composition is equally noteworthy, with average expenditures increasing with the number of boys. Even amongst four-children families, for example, spending on education when all the children are male, is about 6% (wave I) and 9% (wave II) higher than when all the children are female.

Table 6: Impact of Number of Brothers on Log (Educational Expenditures)

Wave I	**#Children**			
#Boys	1	2	3	4
0	7.248	6.927	6.405	6.132
	(1.705)	(1.903)	(1.707)	(1.6)
1	7.43	7.097	6.63	6.337
	(1.653)	(1.633)	(1.513)	(1.528)
2		7.141	6.708	6.471
		(1.689)	(1.524)	(1.496)
3			6.805	6.45
			(1.443)	(1.5)
4				6.53
				(1.322)
Mean	7.357	7.089	6.673	6.418
	(1.676)	(1.691)	(1.525)	(1.502)
Wave II (weighted)		**#Children**		
#Boys	1	2	3	4
0	7.773	7.625	6.823	6.427
	(2.128)	(1.917)	(1.978)	(2.036)
1	8.008	7.74	7.176	6.626
	(1.973)	(1.893)	(1.762)	(1.877)
2		7.811	7.198	6.768
		(1.848)	(1.904)	(1.751)
3			7.38	6.803
			(1.878)	(1.705)
4				6.992
				(1.599)
Mean	7.912	7.747	7.188	6.731
	(2.041)	(1.883)	(1.858)	1.789)

Note: Standard deviations are in parentheses.
Source: Authors.

4. Empirical Specification

We estimate within-family differences in educational expenditures on children in the family, as well as test outcomes. As noted by Jensen (2003) and Congdon Fors and Lindskog (2017), birth order is correlated with family size. In countries like India, where sons are preferred, sex composition of children is also correlated with family size. To see how birth order and gender of children contribute to the family size effect on children's outcomes, we estimate the following linear model:

$$y_{ij} = \alpha n_{ij} + X_{ij}\beta + \gamma male_{ij} + bo\ sc_{ij}\nu + \mu_{ij}, \qquad (1)$$

where y_{ij} is the outcome for child i in family j, n_{ij} is the size of child i0s family j (measured as number of children in the family), X_{ij} is a set of controls, $male$ is an indicator variable that equals 1 if child i is male and 0 otherwise, bo sc_{ij} is, alternatively, either the birth order (bo) of child i in family j or the sibling sex composition (sc), denoted by indicators for whether child i in family j has an older brother, an older sister etc., and μ_{ij} is an idiosyncratic error term.

Equation 2 is a generalised version of equation 1, derived by specifying an unrestricted model of family size (Mogstad and Wiswall, 2016). To this end, we replace nij in equation 1 with a set of dummy variables, one for each family size as follows:

$$y_{ij} = \Sigma\delta_k d^k + X_{ij}\beta + \gamma male_{ij} + bo\ sc_{ij}\nu + \mu_{ij}, \qquad (2)$$

where $d^k = 1\{nij \geq k\}$. This implies that the coefficients δ_k estimate the marginal effect of a family size of k instead of $k - 1$. The linear model specified in equation 1 restricts the marginal effects to be constant, $\delta_k = \alpha$ for all k.

5. Results

5.1. Estimates of Quantity–Quality Trade-offs

Table 7, Table 8, and Table 9 report OLS estimates of Q-Q trade-offs for wave I, wave II, and the pooled sample from both waves, respectively, based on the linear (equation 1) and unrestricted (equation 2) models. The sample in each table comprises all children 18 years of age or younger. Standard errors are clustered at the household level.

In all three tables, the coefficients of family size (number of children) in column 1, which is based on a parsimonious specification, suggest a Q-Q trade-off that is increasing over time; an additional child reduces educational expenditures on the sampled child by about 16%, 25%, and 20%, respectively. Once we add controls for household and parent characteristics and urban location (columns 3 in all tables) and the community cultural variables (columns 5), the implied trade-off declines to about a third of the size in column 1, indicating significant heterogeneity amongst households.

Estimates from the unrestricted model in column 2, whilst also all negative, indicate a non-linear relationship between family size and children's expenditures. In Table 7, for example, the marginal effect of a second child is about –18%, whilst the marginal effect of the third, fourth, and fifth child is –28%, –18%, and –15%, respectively. The corresponding coefficients in Table 8 and Table 9 are smaller for the second child but notably bigger for the third child onwards.

Families invest more in male children and this effect is robust across specifications, with the coefficient increasing in magnitude when more controls are added. In contrast, the private school premium declines with the addition of household income and other controls. In terms of community practices, the practice of giving dowry for a daughter's wedding is associated with bigger expenditures on children's education. This is probably due to a wealth effect, since the dowry is often meant as an investment in the married couple's future, which includes their children's well-being.

The practice of female seclusion or purdah is reflective of patriarchal norms. It is rationalised in terms of women's safety and 'purity' but it effectively constrains their autonomy in several spheres (Kishor, 1993; Jayachandran, 2015). Whilst the practice only affects women, it reflects a less progressive attitude in general and belief in a more traditional way of life. It is, therefore, consistent with lower investments in human capital. The same is true of the practice of marrying a cousin. These variables are associated with lower expenditures in all tables.

Table 7: Ordinary Least Squares Estimates of Family Investment in Children's Education, Wave I

Dependent variable: ln (Investment/annum)

Variables	Linear	Unrestricted	Linear	Unrestricted	Linear	Unrestricted
	(1)	(2)	(3)	(4)	(5)	(6)
#Children	-0.164*** (0.007)		-0.043*** (0.007)		-0.038*** (0.007)	
>=2 children		-0.175*** (0.032)		-0.088*** (0.031)		-0.085*** (0.032)
>=3 children		-0.278*** (0.022)		-0.058*** (0.021)		-0.059*** (0.021)
>=4 children		-0.176*** (0.027)		-0.035 (0.026)		-0.041 (0.026)
>=5 children		-0.152*** (0.033)		-0.051 (0.031)		-0.033 (0.033)
Age	0.157*** (0.002)	0.157*** (0.002)	0.129*** (0.003)	0.130*** (0.003)	0.130*** (0.003)	0.131*** (0.003)
Male	0.013 (0.013)	0.008 (0.013)	0.059*** (0.013)	0.059*** (0.013)	0.065*** (0.013)	0.064*** (0.013)
Type of school:						
Private	1.708*** (0.018)	1.699*** (0.018)	1.155*** (0.018)	1.155*** (0.018)	1.112*** (0.018)	1.112*** (0.018)
Other	-0.007 (0.074)	-0.013 (0.075)	-0.105 (0.067)	-0.106 (0.067)	-0.088 (0.071)	-0.088 (0.071)
Junior college	1.025*** (0.036)	1.014*** (0.036)	0.618*** (0.034)	0.617*** (0.034)	0.663*** (0.037)	0.663*** (0.037)
Joint family=1					0.133*** (0.019)	0.133*** (0.019)
HH owns/cultivates land			-0.067*** (0.023)	-0.066*** (0.023)	-0.045* (0.024)	-0.044* (0.024)
HH owns livestock			0.127*** (0.023)	0.126*** (0.023)	0.054** (0.024)	0.054** (0.024)
HH owns non-farm business			-0.148* (0.085)	-0.149* (0.084)	-0.116 (0.086)	-0.116 (0.086)
Common practice in HH's community						
to give dowry					0.166*** (0.025)	0.166*** (0.025)
to get daughter married to village native					0.052*** (0.018)	0.050*** (0.018)
to get daughter married to cousin					-0.369*** (0.024)	-0.369*** (0.024)
for women to wear purdah					-0.068*** (0.020)	-0.067*** (0.020)
Observations	39,631	39,631	36,268	36,268	33,904	33,904
R-squared	0.363	0.364	0.475	0.475	0.494	0.494

Note: Cluster (household)-robust standard errors are in parentheses; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level. The regressions in column (3) to column (6) also control for household expenditure quintiles, urban location, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

Table 8: Ordinary Least Squares Estimates of Family Investment in Children's Education, Wave II

Dependent variable: ln (Investment/annum)

Variables	Linear	Unrestricted	Linear	Unrestricted	Linear	Unrestricted
	(1)	(2)	(3)	(4)	(5)	(6)
#Children	-0.249*** (0.009)		-0.102*** (0.011)		-0.090*** (0.011)	
>=2 children		-0.093*** (0.032)		-0.083** (0.035)		-0.071** (0.035)
>=3 children		-0.381*** (0.035)		-0.124*** (0.037)		-0.113*** (0.037)
>=4 children		(0.025) -0.291***		(0.026) -0.142***		(0.026) -0.130***
>=5 children		-0.288*** (0.050)		-0.126** (0.051)		-0.110** (0.051)
Age	0.163*** (0.003)	0.164*** (0.003)	0.151*** (0.003)	0.151*** (0.003)	0.152*** (0.003)	0.152*** (0.003)
Male	0.047*** (0.016)	0.037** (0.016)	0.096*** (0.016)	0.091*** (0.016)	0.099*** (0.016)	0.094*** (0.016)
Type of school:						
Private	2.224*** (0.021)	2.211*** (0.021)	1.714*** (0.023)	1.713*** (0.023)	1.691*** (0.023)	1.690*** (0.023)
Other	-0.444*** (0.113)	-0.460*** (0.113)	-0.514*** (0.124)	-0.519*** (0.124)	-0.490*** (0.124)	-0.494*** (0.124)
Junior college	1.389*** (0.050)	1.380*** (0.050)	0.933*** (0.054)	0.931*** (0.054)	0.921*** (0.054)	0.919*** (0.054)
Joint family=1					0.116*** (0.023)	0.116*** (0.023)
HH owns/ cultivates land			0.128*** (0.030)	0.129*** (0.030)	0.111*** (0.030)	0.112*** (0.030)
HH owns livestock			0.066** (0.029)	0.066** (0.029)	0.030 (0.029)	0.030 (0.029)
HH owns non-farm business			0.150*** (0.025)	0.148*** (0.025)	0.130*** (0.025)	0.129*** (0.025)
Common practice in HH's community						
to give dowry					0.290*** (0.048)	0.289*** (0.048)
to get daughter married to village native					0.084*** (0.027)	0.082*** (0.027)
to get daughter married to cousin					-0.237*** (0.031)	-0.238*** (0.031)
for women to wear purdah					-0.070*** (0.025)	-0.065*** (0.025)
Observations	43,019	43,019	37,386	37,386	37,253	37,253
R-squared	0.375	0.377	0.441	0.441	0.447	0.447

Note: Cluster (household)-robust standard errors are in parentheses; ***** - significant at the 99% level; **** - significant at the 95% level; *** - significant at the 90% level. The regressions in column (3) to column (6) also control for household expenditure quintiles, urban location, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

Table 9: Ordinary Least Squares Estimates of Family Investment in Children's Education, Pooled Sample

Dependent variable: ln (Investment/annum)

Variables	Linear	Unrestricted	Linear	Unrestricted	Linear	Unrestricted
	(1)	(2)	(3)	(4)	(5)	(6)
#Children	-0.202*** (0.006)		-0.069*** (0.006)		-0.062*** (0.007)	
>=2 children		-0.126*** (0.024)		-0.084*** (0.025)		-0.076*** (0.025)
>=3 children		-0.331*** (0.017)		-0.093*** (0.017)		-0.089*** (0.017)
>=4 children		-0.218*** (0.022)		-0.078*** (0.022)		-0.076*** (0.023)
>=5 children		-0.221*** (0.030)		-0.094*** (0.029)		-0.079*** (0.030)
Age	0.160*** (0.002)	0.161*** (0.002)	0.140*** (0.002)	0.140*** (0.002)	0.142*** (0.002)	0.142*** (0.002)
Male	0.037*** (0.01)	0.029*** (0.01)	0.083*** (0.01)	0.080*** (0.01)	0.088*** (0.011)	0.085*** (0.011)
Type of school:						
Private	1.972*** (0.014)	1.961*** (0.014)	1.447*** (0.015)	1.446*** (0.015)	1.424*** (0.015)	1.424*** (0.015)
Other	-0.170*** (0.064)	-0.180*** (0.064)	-0.233*** (0.063)	-0.235*** (0.063)	-0.226*** (0.066)	-0.227*** (0.066)
Junior college	1.165*** (0.030)	1.154*** (0.030)	0.743*** (0.030)	0.741*** (0.030)	0.767*** (0.032)	0.766*** (0.032)
Wave II						
HH owns/ cultivates land	0.315*** (0.015)	0.312*** (0.015)	0.355*** (0.017)	0.354*** (0.017)	0.364*** (0.017)	0.363*** (0.017)
HH owns livestock			0.038** (0.019)	0.039** (0.019)	0.038* (0.020)	0.040** (0.020)
HH owns non-farm business			0.100*** (0.019)	0.100*** (0.019)	0.043** (0.019)	0.043** (0.019)
Joint family=1			0.171*** (0.024)	0.170*** (0.024)	0.144*** (0.025) 0.128*** (0.015)	0.144*** (0.025) 0.127*** (0.015)
Common practice in HH's community...						
to give dowry					0.213*** (0.025)	0.212*** (0.025)
to get daughter married to village native					0.084*** (0.016)	0.082*** (0.016)
to get daughter married to cousin					-0.305*** (0.02)	-0.306*** (0.02)
for women to wear purdah					-0.061*** (0.016)	-0.058*** (0.016)
Observations	80,660	80,660	71,812	71,812	69,324	69,324
R-squared	0.374	0.376	0.453	0.453	0.463	0.463

Note: Cluster (household)-robust standard errors are in parentheses; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level. The regressions in column (3) to column (6) also control for household expenditure quintiles, urban location, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Author.

Table 10 presents OLS estimates of the Q-Q trade-offs from the unrestricted models for the sample of pooled observations from both waves, controlling for birth order (columns 1–4) and the sibling sex composition (columns 5–8). We estimate these effects with different sub-samples, going from lower to higher birth parities across the columns. This is a less restrictive approach than using sibship fixed effects to address the issue that only larger families can contribute to the estimation of higher birth order effects.

Estimates of the marginal effects of each additional child in Table 10 indicate that some of the Q-Q trade-offs are driven by birth order and sibling composition; this is evident from comparing these estimates with those in column 6, Table 9. At lower birth parities (up to birth order 4), the marginal effect of each additional child is incrementally negative. Moreover, these effects are robust from the third child onwards. The birth order effects in columns 1–4 are all negative and increasing in magnitude. Thus, after controlling for the age of the child, there is evidence of a first-born premium; relative to the eldest, the other children have less invested towards their education. The gender composition effects in columns 5–8 are also consistent with the birth order effects; having an older brother or an older sister lowers parental expenditure on the sampled child and this effect is robust across samples. There is evidence of a sibling-rivalry effect at lower birth orders; having a younger sibling lowers educational expenditures on the sampled child in column 5 and a younger sister has a negative but much smaller effect in column 6. These effects do not carry over when other siblings are included in the sample.

Table 10: Ordinary Least Squares Estimates of Birth Order and Sibling Sex Composition on Children's Education Expenditures, Pooled Sample

Dependent variable: ln (Investment/annum)

	Birth order effects				Sibling sex composition effects			
Variables	**Birth order≤2** (1)	**Birth order≤3** (2)	**Birth order≤4** (3)	**Birth order≤5** (4)	**Birth order≤2** (5)	**Birth order≤3** (6)	**Birth order≤4** (7)	**Birth order≤5** (8)
>=2 children	-0.056** (0.025)	-0.037 (0.026)	-0.043* (0.026)	-0.044* (0.026)	0.019 (0.030)	-0.010 (0.028)	-0.048* (0.028)	-0.057** (0.028)
>=3 children		-0.085*** (0.017)	-0.064*** (0.018)	-0.066*** (0.018)		-0.060*** (0.019)	-0.069*** (0.019)	-0.078*** (0.019)
>=4 children			-0.088*** (0.021)	-0.059** (0.023)			-0.096*** (0.022)	-0.071*** (0.023)
>=5 children				-0.084*** (0.032)				-0.079** (0.031)
Male	0.096*** (0.017)	0.084*** (0.017)	0.079*** (0.017)	0.078*** (0.017)	0.064** (0.028)	0.084*** (0.025)	0.083*** (0.025)	0.093*** (0.025)
Birth order:								
Two	-0.100*** (0.017)	-0.086*** (0.017)	-0.081*** (0.017)	-0.081*** (0.017)				
Three		-0.136*** (0.024)	-0.118*** (0.024)	-0.115*** (0.024)				
Four			-0.144*** (0.037)	-0.131*** (0.037)				
≥Five				0.003 (0.056)				
Male* Two	0.030 (0.025)	0.028 (0.025)	0.027 (0.025)	0.027 (0.025)				
Male* Three		0.042 (0.030)	0.033 (0.030)	0.030 (0.030)				
Male* Four			0.027 (0.044)	0.016 (0.044)				
Male* ≥Five				-0.121* (0.071)				
Sibling composition:								
Has older brother					-0.123*** (0.025)	-0.082*** (0.023)	-0.055** (0.023)	-0.039* (0.023)
Has older sister					-0.159*** (0.022)	-0.116*** (0.018)	-0.077*** (0.018)	-0.058*** (0.018)
Has younger brother					-0.070*** (0.024)	-0.034 (0.023)	0.002 (0.022)	0.013 (0.022)
Has younger sister					-0.095*** (0.020)	-0.048** (0.019)	0.001 (0.018)	0.014 (0.018)
Male* Older brother					0.002 (0.032)	-0.021 (0.025)	-0.015 (0.024)	-0.030 (0.023)
Male* Older sister					0.065** (0.032)	0.062** (0.024)	0.058** (0.023)	0.044* (0.023)
Male* Younger brother					-0.008 (0.027)	-0.024 (0.024)	-0.026 (0.024)	-0.031 (0.024)
Male* Younger sister					0.058** (0.026)	0.030 (0.023)	0.016 (0.023)	0.009 (0.022)

Type of school:								
Private	1.407*** (0.017)	1.406*** (0.016)	1.410*** (0.016)	1.415*** (0.016)	1.408*** (0.017)	1.407*** (0.016)	1.410*** (0.016)	1.415*** (0.016)
Other	-0.250*** (0.082)	-0.229*** (0.070)	-0.226*** (0.067)	-0.226*** (0.067)	-0.250*** (0.082)	-0.228*** (0.070)	-0.226*** (0.067)	-0.226*** (0.067)
Junior college	0.784*** (0.036)	0.780*** (0.033)	0.768*** (0.032)	0.766*** (0.032)	0.784*** (0.036)	0.779*** (0.033)	0.767*** (0.032)	0.766*** (0.032)
Joint family=1	0.133*** (0.016)	0.135*** (0.015)	0.130*** (0.015)	0.126*** (0.015)	0.132*** (0.016)	0.135*** (0.015)	0.130*** (0.015)	0.127*** (0.015)
HH owns/ cultivates land	0.002 (0.021)	0.017 (0.020)	0.033* (0.020)	0.036* (0.020)	0.003 (0.020)	0.017 (0.020)	0.033* (0.020)	0.036* (0.020)
HH owns livestock	0.040** (0.020)	0.053*** (0.019)	0.048** (0.019)	0.047** (0.019)	0.045** (0.020)	0.054*** (0.019)	0.048** (0.019)	0.047** (0.019)
HH owns non-farm business	0.158*** (0.025)	0.155*** (0.024)	0.146*** (0.024)	0.146*** (0.024)	0.160*** (0.025)	0.155*** (0.024)	0.145*** (0.024)	0.145*** (0.024)
Common practice in HH's community								
to give dowry	0.213*** (0.026)	0.212*** (0.025)	0.218*** (0.025)	0.214*** (0.025)	0.211*** (0.026)	0.211*** (0.025)	0.218*** (0.025)	0.214*** (0.025)
to get daughter married to village native	0.099*** (0.017)	0.090*** (0.016)	0.084*** (0.016)	0.082*** (0.016)	0.094*** (0.017)	0.088*** (0.016)	0.083*** (0.016)	0.081*** (0.016)
to get daughter married to cousin	-0.310*** (0.020)	-0.308*** (0.019)	-0.309*** (0.020)	-0.306*** (0.020)	-0.311*** (0.020)	-0.309*** (0.019)	-0.310*** (0.020)	-0.306*** (0.020)
for women to wear purdah	-0.062*** (0.016)	-0.058*** (0.016)	-0.055*** (0.016)	-0.056*** (0.016)	-0.055*** (0.017)	-0.055*** (0.016)	-0.054*** (0.016)	-0.055*** (0.016)
Observations	49,091	61,530	66,567	68,424	49,091	61,530	66,567	68,424
R-squared	0.461	0.462	0.462	0.462	0.462	0.462	0.462	0.462
Other	-0.250***	-0.229***	-0.226***	-0.226***	-0.250***	-0.228***	-0.226***	-0.226***

Note: Cluster (household)-robust standard errors are in parentheses; ***** - significant at the 99% level; **** - significant at the 95% level; *** - significant at the 90% level. The regressions also control for sampled child's age, indicator for survey year, household expenditure quintiles, urban location, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Author.

We make a number of observations based on the estimates from this table. The evidence is consistent with son preference amongst families; the estimates of the male indicator variable are stable, sizeable, and robust across the samples in columns 1–8. There is consistent evidence of negative birth order effects even after we control for age. Estimates of the interaction of the birth order variables with the gender dummy are all statistically insignificant, suggesting that the birth order effects are not driven by gender. The sibling sex composition effects suggest a more nuanced effect; boys with older sisters benefit from 4%–6% additional resources on their education. This points to a clear gender divide in families' assignment of educational expenditures on their children.

These results do not support the hypothesis of either reinforcing or compensating behaviour by families based on children's academic endowments (Dizon-Ross, 2014). An alternative explanation is household economies of scale in educational expenditures; the negative effects of having an older sibling could be due to younger children using their older siblings' textbooks and uniforms, for example, thus lowering parental expenditures on later-born children. However, the interaction effects are not entirely consistent with this hypothesis; having an older sister increases expenditures on boys whilst having an older brother has no effect. The results are consistent with families sending their sons to private schools and their daughters to government schools, as revealed by the summary statistics in Table 1.

Table 11 presents estimates of the Q-Q trade-off, sequentially adding controls for birth order and sibling sex composition, based on OLS models as well as 2SLS models that address the endogeneity of family size. Here, we use the linear measure of family size based on equation 1, since it is infeasible to find exclusion restrictions for every family size threshold that is required for using models based on equation 2. We use the incidence of twin births as an IV for family size. Several papers have used this variable as an exclusion restriction, on the assumption that multiple births from one pregnancy are usually unplanned and this event can therefore be considered to lead to an exogenous increase in family size.[10] The OLS estimate for family size in the first column indicates that an additional child decreases investment in each child by about 6%. However, when we instrument for family size (column 2), the effect goes away, suggesting that there is no Q-Q trade-off. Unobserved heterogeneity accounts for all the trade-off seen in the OLS results.[11] When we control for birth order (column 3) and sibling sex composition (column 5), the OLS estimates of family size are smaller in magnitude but still sizeable and significant whilst the corresponding IV estimates reinforce the conclusion that there is no Q-Q trade-off in terms of children's educational expenditures. The negative birth order effects up to the fourth birth parity (column 3) and the negative impact of having an older sibling (column 5) are also eliminated when we control for the endogeneity of number of children. On the other hand, IV estimates of the male premium are bigger than the corresponding OLS estimates, providing strong evidence of son preference.

[10] Rosenzweig and Wolpin (1980), Black et al. (2005), and Makino (2018), amongst others, use the incidence of twin births as an IV for family size.
[11] We emphasize that this result may not extend to non-linear family size effects.

Table 11: Ordinary Least Squares & Instrumental Variable Estimates of Family Size, Birth Order and Sibling Sex Composition on Children's Education Expenditure, Pooled Sample

Dependent variable: ln (Investment/annum)

Variables	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Twin birth (IV)		0.773***		0.35***		0.291***
		(0.074)		(0.045)		(0.059)
F-test of excluded instruments Prob > F	F(1, 35354)	109.6 0.00	F(1, 35344)	61.34 0.00	F(1, 35346)	24.69 0.00
#Children	-0.062***	-0.027	-0.052***	0.043	-0.047***	0.080
	(0.007)	(0.093)	(0.008)	(0.206)	(0.009)	(0.247)
Male	0.088***	0.098***	0.080***	0.108*	0.099***	0.110***
	(0.011)	(0.026)	(0.017)	(0.062)	(0.025)	(0.033)
Birth order:						
Two			-0.082***	-0.126		
			(0.017)	(0.096)		
Three			-0.124***	-0.238		
			(0.024)	(0.247)		
Four			-0.143***	-0.344		
			(0.037)	(0.438)		
Five			-0.001	-0.294		
			(0.057)	(0.636)		
≥Six			0.021	-0.397		
			(0.083)	(0.908)		
Male*Two			0.029	0.029		
			(0.025)	(0.025)		
Male*Three			0.030	0.026		
			(0.030)	(0.031)		
Male*Four			0.014	0.004		
			(0.044)	(0.049)		
Male*Five			-0.136*	-0.145**		
			(0.071)	(0.074)		
Male*≥Six			-0.001	-0.027		
			(0.100)	(0.114)		
Sibling compostion:						
Has older brother					-0.054**	-0.182
					(0.022)	(0.251)
Has older sister					-0.076***	-0.223
					(0.018)	(0.286)
Has younger brother					-0.002	-0.144

					(0.022)	(0.278)
Has younger sister					-0.005 (0.018)	-0.163 (0.309)
Male* Older brother					-0.034 (0.023)	-0.045 (0.031)
Male* Older sister					0.043* (0.022)	0.037 (0.026)
Male* Younger brother					-0.035 (0.023)	-0.036 (0.024)
Male* Younger sister					0.009 (0.022)	0.019 (0.030)
Type of school:						
Private	1.424*** (0.015)	1.424*** (0.015)	1.420*** (0.015)	1.415*** (0.020)	1.420*** (0.015)	1.418*** (0.016)
Other	-0.226*** (0.066)	-0.228*** (0.066)	-0.226*** (0.066)	-0.234*** (0.068)	-0.227*** (0.066)	-0.232*** (0.067)
Junior college	0.767*** (0.032)	0.768*** (0.032)	0.767*** (0.032)	0.771*** (0.033)	0.767*** (0.032)	0.765*** (0.032)
Joint family=1	0.128*** (0.015)	0.131*** (0.017)	0.126*** (0.015)	0.131*** (0.019)	0.127*** (0.015)	0.128*** (0.015)
HH owns/cultivates land	0.038* (0.020)	0.037* (0.020)	0.039* (0.020)	0.035* (0.021)	0.038* (0.020)	0.039* (0.020)
HH owns livestock	0.043** (0.019)	0.035 (0.028)	0.043** (0.019)	0.031 (0.033)	0.043** (0.019)	0.031 (0.031)
HH owns non-farm business	0.144*** (0.025)	0.139*** (0.029)	0.144*** (0.025)	0.136*** (0.031)	0.144*** (0.025)	0.136*** (0.030)
Common practice in HH's community						
to give dowry	0.213*** (0.025)	0.215*** (0.025)	0.213*** (0.025)	0.219*** (0.027)	0.213*** (0.025)	0.215*** (0.025)
to get daughter married to village native	0.084*** (0.016)	0.091*** (0.025)	0.084*** (0.016)	0.099*** (0.037)	0.084*** (0.016)	0.091*** (0.022)
to get daughter married to cousin	-0.305*** (0.020)	-0.306*** (0.020)	-0.304*** (0.020)	-0.301*** (0.020)	-0.304*** (0.020)	-0.305*** (0.020)
for women to wear purdah	-0.061*** (0.016)	-0.070** (0.029)	-0.060*** (0.016)	-0.077* (0.041)	-0.060*** (0.016)	-0.069*** (0.025)
Observations	69,324	69,324	69,324	69,324	69,324	69,324
R-squared	0.463	0.462	0.463	0.461	0.463	0.460

Note: Cluster (household)-robust standard errors are in parentheses; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level. The regressions also control for sampled child's age, indicator for survey year, household expenditure quintiles, urban location, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

We also note the robustness of certain estimates – those of households owning non-farm businesses and joint families investing more in children's education, and especially those of the community practices variables – that are similar across the OLS and IV specifications. These estimates attest to the importance of cultural factors in influencing families' views on gender equality and human capital investments. The IV is significant in all specifications and the F-test of excluded instrument indicates that the IV is valid.

Our result that families favour boys over girls in terms of educational expenditures is consistent with that of Congdon Fors and Lindskog (2017), who used a sibship fixed effects estimation strategy with data from the same two waves of the IHDS as we do in this paper. However, whilst they found consistently negative birth order effects on educational expenditures, our IV estimates indicate otherwise.[12]

In unreported results, we re-estimated all our specifications, replacing total educational expenditures with private tuition expenditures as the dependent variable. Our results were qualitatively the same. Families spend more on private tuition for boys than for girls, regardless of the specification.

5.2. Estimates of Test Scores

We now focus on children's test scores in reading, writing, and maths. Table 12 presents OLS estimates for all the test results based on a parsimonious specification. These are based on linear as well as unrestricted specifications of family size. We present estimates from the wave I sample in the top panel and from the wave II sample in the bottom panel.

[12] We can replicate their results using a sibship fixed effects model with our data sample. However, the interaction of the gender variable with the birth order indicator variables are all statistically insignificant. Congdon Fors and Lindskog (2017) did not specify interaction terms.

Table 12: Regression Estimates of Children's Test Scores

Variables	Reading		Writing		Math	
	Wave I					
Ln (Educ expend)	0.052*** (0.003)	0.052*** (0.003)	0.053*** (0.004)	0.053*** (0.004)	0.064*** (0.003)	0.064*** (0.003)
#Children	-0.035*** (0.002)		-0.040*** (0.004)		-0.032*** (0.003)	
≥ 2 children		0.034*** (0.014)		0.025 (0.020)		0.002 (0.015)
≥ 3 children		-0.053*** (0.008)		-0.062*** (0.011)		-0.050*** (0.008)
≥ 4 children		-0.028*** (0.009)		-0.059*** (0.014)		-0.029*** (0.010)
≥ 5 children		-0.071*** (0.011)		-0.048*** (0.017)		-0.052*** (0.012)
Age = 9	0.099*** (0.009)	0.099*** (0.009)	0.095*** (0.013)	0.094*** (0.013)	0.096*** (0.009)	0.095*** (0.009)
Age = 10	0.0151*** (0.008)	0.0152*** (0.008)	0.0146*** (0.011)	0.0147*** (0.011)	0.0158*** (0.008)	0.0158*** (0.008)
Age = 11	0.206*** (0.009)	0.206*** (0.009)	0.189*** (0.013)	0.190*** (0.013)	0.217*** (0.009)	0.218*** (0.009)
Male	-0.005 (0.006)	-0.005 (0.006)	-0.003 (0.009)	-0.005 (0.009)	0.017*** (0.006)	0.016*** (0.006)
Type of school:						
Private	0.034*** (0.009)	0.034*** (0.009)	0.049*** (0.012)	0.048*** (0.012)	0.045*** (0.009)	0.045*** (0.009)
Other	-0.108*** (0.025)	-0.107*** (0.025)	-0.054 (0.036)	-0.051 (0.036)	-0.058** (0.025)	-0.057** (0.025)
Observations	9,654	9,654	9,565	9,565	9,606	9,606
R-squared	0.180	0.182	0.098	0.100	0.209	0.209
Wave II						
Ln (Educ expend)	0.036*** (0.002)	0.036*** (0.002)	0.036*** (0.003)	0.036*** (0.003)	0.035*** (0.002)	0.035*** (0.002)
#Children	-0.038*** (0.003)		-0.045*** (0.003)		-0.041*** (0.003)	
≥ 2 children		-0.001 (0.012)		0.013 (0.014)		-0.010 (0.011)
≥ 3 children		-0.036*** (0.008)		-0.050*** (0.010)		-0.054*** (0.008)
≥ 4 children		-0.045*** (0.010)		-0.054*** (0.012)		-0.049*** (0.010)
≥ 5 children		-0.072*** (0.013)		-0.082*** (0.015)		-0.057*** (0.012)
Age = 9	0.088*** (0.009)	0.087*** (0.009)	0.087*** (0.010)	0.086*** (0.010)	0.080*** (0.008)	0.080*** (0.008)
Age = 10	0.135*** (0.008)	0.135*** (0.008)	0.118*** (0.009)	0.118*** (0.009)	0.125*** (0.007)	0.126*** (0.007)

Age = 11	0.204*** (0.009)	0.204*** (0.009)	0.174*** (0.010)	0.174*** (0.010)	0.185*** (0.008)	0.185*** (0.008)
Male	-0.015** (0.006)	-0.016*** (0.006)	-0.023*** (0.007)	-0.025*** (0.007)	0.003 (0.006)	0.002 (0.006)
Type of school:						
Private	0.062*** (0.008)	0.061*** (0.008)	0.064*** (0.010)	0.063*** (0.010)	0.053*** (0.008)	0.052*** (0.008)
Other	-0.110*** (0.033)	-0.112*** (0.033)	-0.081** (0.033)	-0.084*** (0.032)	-0.071*** (0.026)	-0.075*** (0.025)
Observations	10,703	10,703	10,603	10,603	10,659	10,659
R-squared	0.169	0.168	0.127	0.128	0.179	0.180

Note: Cluster (household)-robust standard errors are in parentheses; ***** - significant at the 99% level; **** - significant at the 95% level; *** - significant at the 90% level.
Source: Authors.

Results from the linear specification of family size from the wave I sample indicate that an additional child lowers test scores by 1/25th to 1/30th of a standard deviation (SD). The marginal effects of an additional child – from the unrestricted model – are non-linear in each proficiency and vary significantly across proficiencies; for instance, a second child increases reading scores by 1/30th of an SD on average; a third, fourth, and fifth child lower this score by 1/20th, 1/35th, and 1/14th of an SD, respectively; and the marginal effect of a second child on writing and maths is imprecisely estimated. In general, the marginal effect of the third child appears to be the most detrimental for all three proficiencies. Unsurprisingly, children get more proficient as they grow older. Children also do better when families spend more on their education, with the returns to investment being the highest in maths. Children enrolled in private schools do better in all three proficiencies than those enrolled in government schools.

Estimates from the wave II sample reveal some notable changes over time. Here, the returns to parental investments are similar for all three proficiencies but are significantly lower than the corresponding estimates from the wave I sample. Whilst the linear estimates of family size are negative and similar in magnitude to those in the top panel, the marginal effects of an additional child are increasingly negative, starting from the third child onwards. The returns to private schooling are much higher than the corresponding estimates from the wave I sample.

Table 13 presents OLS estimates of family size on test scores, using a sample of data pooled from both waves, based on linear as well as unrestricted family size specifications. We also present estimates from a detailed specification (column 3 under each proficiency) that controls for household, parent, and community characteristics, to understand how these variables modify the impact of family size on proficiencies. An additional child lowers test scores for all three proficiencies by about 1/25th of an SD. However, estimates from the unrestricted model indicate highly non-linear marginal effects, which are significant from the third child onwards. These marginal effects vary markedly across proficiencies. The addition of controls for household, parental, and community practice variables significantly reduces the magnitude of the marginal effects of additional children by well over a half on several margins. It also lowers the return to family investment in children's education by about a half, and reduces the private school premium in writing by about a third, in maths by about a fourth, and in reading to zero. Boys retain an advantage in maths over girls and this difference is bigger in the detailed specification (column 9).

Table 13: Ordinary Least Squares Estimates of Family Size on Children's Test Scores, Pooled Sample

Variables	Reading			Writing			Math		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Ln (Educ expend)	0.042*** (0.002)	0.042*** (0.002)	0.027*** (0.002)	0.042*** (0.002)	0.042*** (0.002)	0.025*** (0.003)	0.046*** (0.002)	0.046*** (0.002)	0.026*** (0.002)
#Children	-0.037*** (0.002)			-0.043*** (0.002)			-0.037*** (0.002)		
≥ 2 children		0.013 (0.009)	0.002 (0.010)		0.017 (0.012)	-0.006 (0.014)		-0.004 (0.009)	-0.019* (0.010)
≥ 3 children		-0.044*** (0.006)	-0.014** (0.006)		-0.054*** (0.008)	-0.017** (0.008)		-0.051*** (0.006)	-0.015** (0.006)
≥ 4 children		-0.039*** (0.007)	-0.017** (0.008)		-0.060*** (0.009)	-0.031*** (0.010)		-0.042*** (0.007)	-0.018** (0.007)
≥ 5 children		-0.070*** (0.009)	-0.054*** (0.009)		-0.063*** (0.011)	-0.042*** (0.012)		-0.052*** (0.008)	-0.037*** (0.009)
Age = 9	0.094*** (0.006)	0.094*** (0.006)	0.095*** (0.007)	0.091*** (0.008)	0.090*** (0.008)	0.092*** (0.009)	0.089*** (0.006)	0.088*** (0.006)	0.091*** (0.006)
Age = 10	0.145*** (0.006)	0.146*** (0.006)	0.152*** (0.006)	0.133*** (0.007)	0.134*** (0.007)	0.137*** (0.008)	0.142*** (0.005)	0.143*** (0.005)	0.149*** (0.006)
Age = 11	0.207*** (0.006)	0.207*** (0.006)	0.211*** (0.007)	0.183*** (0.008)	0.183*** (0.008)	0.188*** (0.009)	0.201*** (0.006)	0.202*** (0.006)	0.205*** (0.007)
Male	-0.009** (0.004)	-0.010** (0.004)	0.000 (0.005)	-0.013** (0.006)	-0.014** (0.006)	0.003 (0.006)	0.011** (0.004)	0.009** (0.004)	0.019*** (0.005)
Type of school:									
Private	0.050*** (0.006)	0.050*** (0.006)	0.010 (0.007)	0.058*** (0.008)	0.057*** (0.008)	0.018** (0.009)	0.049*** (0.006)	0.049*** (0.006)	0.011* (0.007)
Other	-0.107*** (0.021)	-0.107*** (0.020)	-0.100*** (0.021)	-0.067*** (0.025)	-0.067*** (0.025)	-0.067** (0.028)	-0.062*** (0.018)	-0.063*** (0.018)	-0.050** (0.020)
Wave 2	-0.075*** (0.005)	-0.075*** (0.005)	-0.076*** (0.006)	-0.188*** (0.006)	-0.187*** (0.006)	-0.179*** (0.007)	-0.081*** (0.005)	-0.081*** (0.005)	-0.074*** (0.005)
Underweight			0.017** (0.008)			-0.003 (0.011)			-0.017** (0.008)
Overweight			-0.014 (0.015)			0.026 (0.021)			0.005 (0.015)

HH consumption expenditure quintiles:									
Q2			0.035*** (0.008)			0.043*** (0.010)			0.031*** (0.007)
Q3			0.054*** (0.008)			0.060*** (0.011)			0.059*** (0.008)
Q4			0.047*** (0.009)			0.053*** (0.012)			0.056*** (0.009)
Q5			0.036*** (0.010)			0.039*** (0.013)			0.058*** (0.010)
Urban			0.014** (0.007)			0.009 (0.009)			0.020*** (0.007)
HH owns/cultivates land			0.016** (0.006)			0.014* (0.008)			0.002 (0.006)
HH owns livestock			0.005 (0.006)			-0.019** (0.008)			0.003 (0.006)
HH owns non-farm business			0.033*** (0.008)			0.013 (0.010)			0.022*** (0.008)
Father's schooling			0.008*** (0.001)			0.007*** (0.001)			0.007*** (0.001)
Mother's schooling			0.009*** (0.001)			0.011*** (0.001)			0.009*** (0.001)
Mother's age			0.012*** (0.004)			0.016*** (0.005)			0.011*** (0.003)
(Mother's age)^2			-0.0*** (0.0)			-0.0*** (0.0)			-0.0*** (0.0)
Joint family=1			0.005 (0.005)			0.011 (0.007)			0.003 (0.005)
HH's caste:									
OBC			-0.031*** (0.010)			-0.015 (0.015)			-0.056*** (0.011)
SC			-0.048*** (0.011)			-0.016 (0.016)			-0.064*** (0.012)

ST			-0.059*** (0.014)			-0.050** (0.019)			-0.102*** (0.014)
Other			-0.032*** (0.011)			0.017 (0.015)			-0.047*** (0.012)
HH's religion:									
Muslim			-0.016* (0.009)			-0.027** (0.012)			-0.011 (0.009)
Christian			0.008 (0.017)			-0.003 (0.022)			0.009 (0.017)
Sikh			0.003 (0.014)			-0.005 (0.020)			0.034** (0.015)
Buddhist/Jain			0.026 (0.021)			0.042 (0.031)			0.009 (0.023)
Other			0.058* (0.033)			0.139*** (0.045)			0.122*** (0.033)
Common practice in HH's community									
to give dowry			0.010 (0.008)			0.036*** (0.011)			0.037*** (0.008)
to get daughter married to village native			0.014** (0.006)			0.017** (0.008)			0.023*** (0.006)
to get daughter married to cousin			-0.035*** (0.007)			-0.002 (0.009)			-0.034*** (0.006)
for women to wear purdah			-0.009 (0.006)			-0.022*** (0.008)			-0.022*** (0.006)
Observations	19,918	19,918	16,624	19,732	19,732	16,466	19,828	19,88	16,556
R-squared	0.176	0.176	0.230	0.138	0.139	0.185	0.192	0.192	0.260

Note: Cluster (household)-robust standard errors are in parentheses; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level.
Source: Authors.

We included body mass index indicators to control for nutritional factors that may influence test scores, but we observe no clear pattern in these estimates. There is a significant deterioration in proficiency across all three domains over time, as indicated by the coefficients on the survey year variable. This is consistent with the lowered returns to educational investments, noted in Table 12 for the wave II sample. Estimates of the community practice variables on test scores are largely in the same direction as those on educational expenditures. In contrast, there are no spillover effects of being in a joint family in terms of learning outcomes. There is a clear wealth gradient; test scores of children from wealthier quintile households are consistently higher than those of children from the lowest wealth quintile.

In Table 14, we present OLS as well as IV estimates of family size of test scores. Similar to the estimates in Table 11, whilst the OLS estimates of family size are negative and significant for all three test scores, the IV estimates are all statistically insignificant, implying that the OLS estimates are biased and that family size has no effect on test scores. The returns to educational expenditures are, unsurprisingly, positive, and the IV estimates are marginally higher than the OLS ones for all three outcomes. The OLS estimate of the male advantage in maths is underestimated, according to the IV estimate. Notably, private school enrolment has no impact on test scores. The significant drop in learning outcomes in wave II relative to wave I – particularly in writing – is noteworthy, pointing to a secular decline in learning outcomes in India, and is consistent with the findings of Shah and Steinberg (2019).

Table 14: Ordinary Least Squares & Instrumental Variable Estimates of Family Size on Children's Test Scores, Pooled Sample

Variables	Reading		Writing		Math	
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Twin birth (IV)		0.816*** (0.135)		0.805*** (0.139)		0.822*** (0.135)
F-test of excluded instruments		F(1,13689) 36.48		F(1,13565) 33.7		F(1,13630) 36.85
Prob > F		0.00		0.00		0.00
Ln (Educ expend)	0.026*** (0.002)	0.027*** (0.003)	0.025*** (0.003)	0.025*** (0.003)	0.026*** (0.002)	0.028*** (0.003)

#Children	-0.022*** (0.002)	-0.006 (0.030)	-0.023*** (0.003)	-0.011 (0.040)	-0.020*** (0.002)	0.024 (0.028)
Male	-0.000 (0.005)	0.005 (0.010)	0.003 (0.006)	0.006 (0.013)	0.019*** (0.004)	0.031*** (0.009)
Type of school:						
Private	0.010 (0.007)	0.008 (0.008)	0.018** (0.009)	0.017* (0.010)	0.011* (0.007)	0.005 (0.008)
Other	-0.101*** (0.021)	-0.103*** (0.021)	-0.068** (0.028)	-0.070** (0.028)	-0.050*** (0.019)	-0.055*** (0.020)
Wave II	-0.077*** (0.006)	-0.073*** (0.010)	-0.180*** (0.007)	-0.176*** (0.013)	-0.075*** (0.005)	-0.063*** (0.010)
Joint family=1	0.005 (0.005)	0.006 (0.006)	0.011 (0.007)	0.012 (0.008)	0.003 (0.005)	0.006 (0.006)
Common practice in HH's community						
to give dowry	0.009 (0.008)	0.010 (0.008)	0.036*** (0.011)	0.036*** (0.011)	0.037*** (0.008)	0.038*** (0.008)
to get daughter married to village native	0.014** (0.006)	0.017* (0.009)	0.017** (0.008)	0.020* (0.012)	0.023*** (0.006)	0.033*** (0.008)
to get daughter married to cousin	-0.034*** (0.007)	-0.034*** (0.007)	-0.001 (0.009)	-0.000 (0.009)	-0.034*** (0.006)	-0.033*** (0.007)
for women to wear purdah	-0.009 (0.006)	-0.012 (0.009)	-0.022*** (0.008)	-0.025** (0.012)	-0.022*** (0.006)	-0.032*** (0.009)
Observations	16,624	16,624	16,466	16,466	16,556	16,556
R-squared	0.230	0.227	0.185	0.183	0.261	0.238

Note: Cluster (household)-robust standard errors are in parentheses; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level. The regressions also control for sampled child's age, body mass index, household expenditure quintiles, urban location, whether household owns/cultivates land, owns livestock or a non-farm business, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

Table 15 shows OLS and IV estimates of family size on test scores, controlling for birth order. The OLS estimates of family size are marginally higher than the corresponding estimates in Table 14. But the IV estimates again imply that there is no relationship between family size and test scores. Both OLS and IV estimates indicate no birth order effects. Other estimates are qualitatively similar to those in Table 14.

Table 15: OLS & IV Estimates of Family Size and Birth Order on Children's Test Scores, Pooled Sample

Variables	Reading		Writing		Math	
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Twin birth (IV)		0.376*** (0.08)		0.362*** (0.082)		0.377*** (0.08)
F-test of excluded instruments		F(1, 13679) 21.99		F(1, 13555) 19.42		F(1, 13620) 22.03
Prob > F		0.0		0.0		0.0
Ln (Educ expend)	0.027*** (0.002)	0.028*** (0.003)	0.025*** (0.003)	0.026*** (0.003)	0.026*** (0.002)	0.028*** (0.003)
#Children	-0.026*** (0.003)	0.009 (0.066)	-0.030*** (0.004)	-0.003 (0.089)	-0.022*** (0.003)	0.072 (0.062)
Male	-0.009 (0.007)	0.002 (0.022)	-0.005 (0.010)	0.004 (0.029)	0.014* (0.007)	0.043** (0.021)
Birth order:						
Two	-0.003 (0.008)	-0.019 (0.031)	-0.005 (0.011)	-0.017 (0.042)	-0.007 (0.008)	-0.050* (0.030)
Three	0.009 (0.011)	-0.032 (0.079)	0.027* (0.014)	-0.005 (0.105)	0.003 (0.011)	-0.108 (0.074)
Four	0.018 (0.015)	-0.055 (0.137)	0.020 (0.020)	-0.035 (0.184)	-0.002 (0.015)	-0.196 (0.129)
Five	0.011 (0.023)	-0.094 (0.201)	0.005 (0.029)	-0.076 (0.269)	-0.001 (0.020)	-0.285 (0.189)
≥ Six	0.064* (0.034)	-0.085 (0.283)	0.121*** (0.043)	0.006 (0.380)	0.052* (0.030)	-0.348 (0.267)
Male*Two	0.009 (0.011)	0.010 (0.011)	0.010 (0.014)	0.011 (0.015)	0.006 (0.011)	0.008 (0.011)
Male*Three	0.016 (0.013)	0.016 (0.013)	-0.004 (0.017)	-0.004 (0.017)	0.004 (0.013)	0.002 (0.013)
Male*Four	0.017 (0.018)	0.013 (0.019)	0.034 (0.024)	0.031 (0.025)	0.016 (0.017)	0.006 (0.019)
Male*Five	-0.011 (0.027)	-0.015 (0.028)	0.005 (0.036)	0.002 (0.038)	0.010 (0.025)	-0.001 (0.028)
Male*≥Six	-0.011 (0.040)	-0.021 (0.044)	-0.031 (0.051)	-0.039 (0.058)	-0.034 (0.034)	-0.062 (0.040)
Type of school:						
Private	0.010 (0.007)	0.007 (0.009)	0.019** (0.009)	0.016 (0.012)	0.011* (0.007)	0.002 (0.009)
Other	-0.099*** (0.021)	-0.109*** (0.028)	-0.066** (0.028)	-0.073** (0.037)	-0.050** (0.019)	-0.074*** (0.026)
Wave II	-0.077*** (0.006)	-0.072*** (0.011)	-0.179*** (0.007)	-0.175*** (0.016)	-0.075*** (0.005)	-0.060*** (0.011)
Joint family=1	0.005 (0.005)	0.007 (0.006)	0.010 (0.007)	0.012 (0.009)	0.003 (0.005)	0.008 (0.006)
Common practice in HH's community						

to give dowry	0.009 (0.008)	0.011 (0.008)	0.036*** (0.011)	0.037*** (0.011)	0.037*** (0.008)	0.040*** (0.008)
to get daughter married to village native	0.013** (0.006)	0.019 (0.013)	0.016** (0.008)	0.020 (0.017)	0.023*** (0.006)	0.038*** (0.012)
to get daughter married to cousin	-0.035*** (0.007)	-0.032*** (0.008)	-0.001 (0.009)	0.000 (0.010)	-0.034*** (0.006)	-0.028*** (0.008)
for women to wear purdah	-0.008 (0.006)	-0.014 (0.011)	-0.021*** (0.008)	-0.025 (0.016)	-0.021*** (0.006)	-0.035*** (0.011)
Observations	16,624	16,624	16,466	16,466	16,556	16,556
R-squared	0.231	0.222	0.186	0.183	0.261	0.201

Note: Cluster (household)-robust standard errors are in parentheses; ***** - significant at the 99% level; **** - significant at the 95% level; *** - significant at the 90% level. The regressions also control for respondent child's age, body mass index, household expenditure quintiles, urban location, whether household owns/cultivates land, owns livestock or a non-farm business, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

Table 16 presents OLS and IV estimates of family size on scores, controlling for sibling sex composition. Here, again, the IV estimates indicate no trade-off between family size and learning outcomes. We no longer see a boy child's advantage in maths that was evident in Table 14 and Table 15. According to the IV estimates, having an older brother or a younger sibling has a big (1/8th to 1/7th of an SD) but marginally significant negative spillover on maths proficiency. However, a male child with a younger sister does better on the maths test, suggesting that having a younger sister is detrimental only to a girl child's maths proficiency.

Table 16: Ordinary Least Squares & Instrumental Variable Estimates of Family Size and Sibling Sex Composition on Children's Test Scores, Pooled Sample

Variables	Reading		Writing		Math	
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Twin birth (IV)		0.353*** (0105)		0.363*** (0.109)		0.357*** (0.106)
F-test of excluded instruments		F(1, 3681) 11.26		F(1, 3557) 11.1		F(1, 3622) 11.38
Prob > F		0.0		0.0		0.0
Ln (Educ expend)	0.026*** (0.002)	0.027*** (0.002)	0.025*** (0.003)	0.025*** (0.003)	0.025*** (0.002)	0.027*** (0.002)
#Children	-0.021*** (0.003)	0.017 (0.069)	-0.017*** (0.004)	0.015 (0.087)	-0.016*** (0.003)	0.085 (0.065)
Male	-0.023** (0.010)	-0.018 (0.014)	-0.034** (0.013)	-0.029** (0.018)	-0.02 (0.010)	0.011 (0.013)
Sibling composition:						
Has older brother	-0.003 (0.009)	-0.041 (0.071)	-0.015 (0.012)	-0.048 (0.089)	-0.019** (0.008)	-0.121* (0.067)
Has older sister	0.004 (0.008)	-0.041 (0.083)	-0.009 (0.011)	-0.047 (0.103)	0.000 (0.008)	-0.119 (0.078)
Has younger brother	-0.007 (0.008)	-0.048 (0.075)	-0.033*** (0.011)	-0.067 (0.093)	-0.022*** (0.008)	-0.129* (0.070)
Has younger sister	-0.025*** (0.008)	-0.072 (0.085)	-0.038*** (0.011)	-0.077 (0.107)	-0.018** (0.008)	-0.141* (0.080)
Male* Older brother	0.006 (0.010)	0.003 (0.011)	0.007 (0.013)	0.004 (0.015)	0.011 (0.010)	0.003 (0.011)
Male* Older sister	0.010 (0.009)	0.007 (0.011)	0.018 (0.013)	0.016 (0.014)	-0.001 (0.009)	-0.009 (0.011)
Male* Younger brother	0.009 (0.010)	0.007 (0.010)	0.016 (0.013)	0.014 (0.014)	0.017* (0.009)	-0.009 (0.011)
Male* Younger sister	0.031*** (0.010)	0.034*** (0.011)	0.043*** (0.013)	0.045*** (0.015)	0.019** (0.010)	0.027** (0.011)
Wave II	-0.077*** (0.006)	-0.073*** (0.010)	-0.179*** (0.007)	-0.176*** (0.012)	-0.075*** (0.005)	-0.063*** (0.009)
Type of school:						
Private	0.010 (0.007)	0.008 (0.008)	0.019** (0.009)	0.017* (0.0010)	0.011* (0.007)	0.006 (0.008)
Other	-0.100*** (0.021)	-0.100*** (0.021)	-0.067** (0.028)	-0.067** (0.028)	-0.050** (0.019)	-0.049** (0.021)
Joint family=1	0.005 (0.005)	0.006 (0.006)	0.011 (0.007)	0.011 (0.007)	0.003 (0.005)	0.005 (0.006)
Common practice in HH's community						

to give dowry	0.009 (0.008)	0.009 (0.008)	0.036*** (0.011)	0.036*** (0.011)	0.036*** (0.008)	0.036*** (0.008)
to get daughter married to village native	0.013** (0.006)	0.015** (0.007)	0.016** (0.008)	0.017* (0.009)	0.022*** (0.006)	0.028*** (0.007)
to get daughter married to cousin	-0.034*** (0.007)	-0.034*** (0.007)	-0.001 (0.009)	-0.001 (0.009)	-0.034*** (0.006)	-0.032*** (0.007)
for women to wear purdah	-0.009 (0.006)	-0.011 (0.007)	-0.021*** (0.008)	-0.023** (0.010)	-0.021*** (0.006)	-0.027*** (0.007)
Observations	16,624	16,624	16,466	16,466	16,556	16,556
R-squared	0.231	0.223	0.186	0.183	0.261	0.207

Note: Cluster (household)-robust standard errors are in parentheses; ***** - significant at the 99% level; **** - significant at the 95% level; *** - significant at the 90% level. The regressions also control for respondent child's age, body mass index, household expenditure quintiles, urban location, whether household owns/cultivates land, owns livestock or a non-farm business, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

Our results on test scores differ from those of Congdon Fors and Lindskog (2017), who found negative birth order effects across samples defined by different family sizes, using a sibship fixed effects estimation approach. Our IV estimates are largely in line with those of Makino (2018), with the exception that she found negative birth order effects for the second- and third-born, relative to the eldest, in maths.[13]

5.3. The Private School Effect

Some studies have found that families express their preference for sons by enrolling them into private schools, which are perceived to provide higher-quality education and are more expensive, whilst sending their daughters to government schools, which provide either free or very low-cost education.[14] This intra-household budgeting is hypothesised to create a gender gap in achievement in favour of boys. We test this hypothesis. Table 17 presents OLS and IV estimates of test scores, controlling for child's gender interacted with type of school.

[13] Her estimates of sibling sex composition are based on OLS models, estimated separately for different-sized households and, hence, not directly comparable to ours.
[14] See Azam and Kingdon (2013) and Maitra et al. (2016).

Table 17: Ordinary Least Squares & Instrumental Variable Estimates of School Type on Children's Test Scores, Pooled Sample

Variables	Reading		Writing		Math	
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Twin birth (IV)		0.816*** (0.135)		0.805*** (0.139)		0.822*** (0.135)
F-test of excluded instruments		F(1, 13687) 36.6		F(1, 13563) 33.78		F(1, 13628) 36.95
Prob > F		0.0		0.0		0.0
Ln (Educ expend)	0.027*** (0.002)	0.027*** (0.003)	0.025*** (0.003)	0.025*** (0.003)	0.026*** (0.002)	0.028*** (0.003)
#Children	-0.022*** (0.002)	-0.006 (0.030)	-0.023*** (0.003)	-0.011 (0.040)	-0.020*** (0.002)	0.023 (0.028)
Male	0.005 (0.006)	0.010 (0.011)	0.003 (0.008)	0.006 (0.014)	0.023*** (0.006)	0.036*** (0.010)
Type of school:						
Private	0.020** (0.009)	0.019** (0.009)	0.019* (0.011)	0.018 (0.012)	0.020** (0.008)	0.015* (0.009)
Other	-0.109*** (0.033)	-0.110*** (0.033)	-0.084** (0.040)	-0.086** (0.041)	-0.063** (0.029)	-0.066** (0.029)
Male*Private	-0.018* (0.010)	-0.019* (0.010)	-0.000 (0.013)	-0.001 (0.013)	-0.015 (0.009)	-0.018* (0.010)
Male*Other	0.013 (0.041)	0.012 (0.041)	0.029 (0.053)	0.029 (0.053)	0.022 (0.037)	0.020 (0.038)
Wave II	-0.077*** (0.006)	-0.073*** (0.010)	-0.180*** (0.007)	-0.176*** (0.013)	-0.075*** (0.005)	-0.062*** (0.010)
HH owns/cultivates land	0.016** (0.006)	0.016** (0.006)	0.014* (0.008)	0.014* (0.008)	0.002 (0.006)	0.002 (0.006)
HH owns livestock	0.006 (0.006)	0.003 (0.009)	-0.019** (0.008)	-0.022* (0.012)	0.004 (0.006)	-0.005 (0.008)
HH owns non-farm business	0.034** (0.008)	0.032*** (0.009)	0.013 (0.010)	0.012 (0.011)	0.023*** (0.008)	0.017** (0.009)
Joint family=1	0.005 (0.005)	0.006 (0.006)	0.011 (0.007)	0.012 (0.008)	0.003 (0.005)	0.006 (0.006)
Common practice in HH's community						
to give dowry	0.009 (0.008)	0.010 (0.008)	0.036*** (0.011)	0.036*** (0.011)	0.037*** (0.008)	0.038*** (0.008)
to get daughter married to village native	0.014** (0.006)	0.017* (0.009)	0.017** (0.008)	0.020* (0.012)	0.023*** (0.006)	0.033*** (0.008)
to get daughter married to cousin	-0.034*** (0.007)	-0.034*** (0.007)	-0.001 (0.009)	-0.000 (0.009)	-0.034*** (0.006)	-0.033*** (0.007)
for women to wear purdah	-0.008 (0.006)	-0.012 (0.009)	-0.022*** (0.008)	-0.025** (0.012)	-0.022*** (0.006)	-0.031*** (0.009)
Observations	16,624	16,624	16,466	16,466	16,556	16,556
R-squared	0.230	0.227	0.185	0.183	0.261	0.239

Note: Cluster (household)-robust standard errors are in parentheses; *** - significant at the 99% level; ** - significant at the 95% level; * - significant at the 90% level. The regressions also control for respondent child's age, body mass index, household expenditure quintiles, urban location, father's and mother's schooling, mother's age, mother's age squared, the caste and religion of the household.
Source: Authors.

The OLS estimates indicate that boys do better in maths on average than girls. The IV estimate suggests that the advantage is bigger, about 1/25th of an SD. Children enrolled in private schools do better in all three tests but particularly in reading and maths, according to the OLS estimates. However, this result is not driven by boys, who underperform girls in reading and maths, although the estimates are imprecisely estimated for maths. The IV estimates of the interaction of the gender dummy with the indicator for private school are more negative than the OLS estimates and significant at the 90% level of significance, implying that girls may be driving the better test results of private school pupils found in the literature, and that boys' advantage in maths may be due to boys enrolled in government schools.[15]

6. Conclusions and Discussion

We use two waves of the IHDS to investigate the effect of family size on parental expenditures on children's education, and on children's learning outcomes. The learning outcomes are measured by scores on standardised, age-appropriate tests in reading, writing, and maths for children in the 8–11 age group. The first of these investigations – the impact of family size on children's educational expenditures – amounts to a test of the Q-Q trade-off proposed by Becker and Lewis (1973).

We control for a number of confounding variables such as parental education, household income, cultural norms, and other household characteristics that are likely to be highly correlated with the household's views regarding the importance of human capital attainment. We also control for birth order and sibling sex composition, to understand how much of the family size effect is due to these factors. We estimate linear family size effects as well as unrestricted family size effects to test for non-linear Q-Q trade-off effects. We estimate OLS models, as well as 2SLS models to control for unobserved heterogeneity amongst households.

Our OLS estimates from a sample of children aged 18 years or under, pooled from both waves, indicate sizeable and significant Q-Q trade-offs in educational

[15] See Muralidharan and Kremer (2006) for an analysis of rural private schools in India. In unreported results, we found that in rural areas, students enrolled in private schools do marginally better in reading and maths (at the 90% level of significance) than those enrolled in government schools, with no significant gender interaction effects.

expenditures. A comparison of the linear family size specification with an unrestricted specification provides evidence of non-linear family size effects, indicating heterogeneous effects of an additional child, depending on the margin. There is a robust male premium, with families spending more on sons. Controlling for household wealth and cultural norms lowers the Q-Q trade-offs but increases the male premium. Birth order effects are negative, sizeable, and significant, suggesting that families spend the most on the first-born's education. Sibling sex composition effects are broadly consistent with birth order effects; having an older sibling is associated with lower expenditures on the sampled child.

Estimates from our 2SLS models using IV indicate no Q-Q trade-offs, no birth order effects, and no impact of sibling sex composition of family expenditures on education, implying that all the estimates from the OLS models are due to unobserved heterogeneity amongst households. However, the IV estimates of the male premium are bigger than the corresponding OLS estimates and significant, implying a strong pro-son bias in educational investments. Estimates of variables measuring cultural norms are similar across OLS and 2SLS models, attesting to the importance of these variables in influencing household behaviour.

OLS estimates of test scores of 8–11-year-old children in reading, writing, and maths proficiency indicate negative spillovers from additional children. Here, again, there is evidence of a non-linear spillover effect of an additional child at different margins. Returns to educational expenditures are positive and significant but there is evidence of a decline over time. Boys appear to have a significant advantage over girls in maths. Children enrolled in private schools do better on all tests relative to their government school counterparts, and this private school premium has increased over time. There is a robust household wealth gradient, with children from wealthier households doing better on all tests.

The IV estimates that control for the endogeneity of family size, however, suggest no effect of additional children on test scores. Neither the OLS nor the IV estimates indicate any birth order effects on proficiencies. In terms of sibling sex composition effects, the IV estimates suggest that boys with younger sisters appear to do better on all tests. However, the male advantage in all proficiencies indicated in Table 2 is not borne out by the estimates generally. There is also strong evidence of a secular decline in learning outcomes, to the extent of 1/6th of an SD in writing between the two waves, and about 1/15th of an SD in reading and maths.

There is evidence of a private school advantage in writing and maths from the detailed OLS specification. However, the IV estimates find only a marginal advantage to private schools in writing, and none in reading and maths. Moreover, the advantage that boys appear to have over girls in maths is eroded in private schools, with girls outperforming boys in reading and maths. Thus, the male advantage in maths appears to arise from boys enrolled in government schools. As with educational expenditures, household cultural norms are strongly associated with children's learning outcomes, across OLS as well as 2SLS models.

The Right to Education Act guarantees access to free schooling for all children aged 6–14. This has led to a proliferation of new schools, a sharp increase in enrolment – especially of girls – and a significant drop in test scores in reading and maths (Shah and Steinberg, 2019). Our results on test scores are consistent with their findings. Chatterjee et al. (2020) contended that the expanded access to education for poorer children increased competitive pressures amongst the better-off households, causing them to expend more resources on their children's education, primarily through private tutoring classes. Whilst they do not examine gender differences in these outcomes, our results on private tuitions suggest that families invest in these supplementary resources more for boys than girls.

In summary, our findings imply that family expenditures on children's education are strongly influenced by son preference. Families invest more in sons, primarily by choosing to enrol their sons in private schools at higher rates than their daughters and also spending more on private tuitions for them. However, these higher investments do not translate to better learning outcomes for boys. Whilst families may have myriad reasons – other than improving academic abilities – for investing more in sons, their decisions create distortions at the aggregate level. They lead to gross underinvestment in girl children, resulting in big gender gaps in human capital achievement. Our finding that girls outperform boys in reading and maths in private schools may be partly driven by selection. But clearly, in many households, girls do not have the option of attending private schools and, hence, it is not their poor academic ability that is influencing the family's decision to send them to government schools. This implies that they may not be getting the resources necessary to develop their abilities to their full potential. Government efforts to close these gender gaps by offering more support to girl students may have exacerbated these gaps by allowing families to spend more on boys.

The absence of Q-Q trade-offs in household educational expenditures, combined with a strong son-biased expenditure pattern, implies a strong and continued role for public policy in improving learning outcomes for all children and in closing the gender gap. Changing parents' perception regarding the poor quality of government schools requires making innovative investments to improve infrastructure, teacher incentives, and pedagogical methods in these schools. At the same time, given the proliferation of private schools in India, Muralidharan and Kremer (2006) and Muralidharan (2013) advocated the introduction of a voucher-based system that would give parents more options and lower the cost of sending their children, including their daughters, to private schools.

The importance of closing the gender achievement gap goes beyond human capital attainment. There is evidence that sex-selective abortions have been rising steadily in India (Nagpal, 2013). India's sex ratio (number of girls for every 1,000 boys in the 0–6 age range, for example) declined substantially in 1990–2005; according to Jha et al. (2011), the conditional sex ratio for second-order births when the first-born was a girl, fell from 906 per 1,000 boys in 1990 to 836 in 2005. Historically, female infanticide or neglect of girl children in early years was used as the means to skew the sex ratio in favour of boys (Gupta, 1987; Sen, 1992). Over the last few decades, a desire for a smaller family amongst educated and wealthier families, in conjunction with a preference for at least one son, has intensified the use of sex-selective abortions (Jha et al., 2011).

In addition to abhorrent practices such as sex-selective abortions that lead to excess mortality of girls, discrimination against surviving girl children implies that women face barriers throughout their lives in terms of accessing health care, participating in the labour force, and having agency over important life decisions such as marriage and childbirth (Dhar et al., 2018). Redressing the gender gap in education and allowing girls to achieve their full academic potential would go a long way in correcting other gender inequities and improving women's status in the long term.

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