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Gender Differences in Mathematics Performance: Evidence from Rural India

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Gender differences in mathematics performance: Evidence from Rural India

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Abstract

There is limited evidence on gender differences in mathematics scores, especially in the Indian context. Performance in mathematics at school and early ages is positively associated with higher earnings for an individual. This paper attempts to examine gender disparity in mathematics scores among rural children at an all-India level. Our findings from rural India show significant gender gap in mathematics. The same gap is not observable for reading skills and observable only to a smaller extent with respect to writing skills. The results remain robust under various specifications- within social groups, type of school attendance, expenditure quantiles, and birth orders. Further, our inferences also hold for girls and boys belonging to the same household. We explore many mechanisms and find indicative evidence of gender role stereotyping in the society, lower nutrition levels for girls in childhood and possibly higher participation of male children in petty works outside home and in sports. The findings indicates the need for affirmative action policies to both test and monitor these differences and design interventions such as changes in delivery or pedagogy of the subject to understand this gap better. These results assume even greater significance in the current contestations around the New Education Policy in India.

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Introduction

Learning outcomes or cognitive skills are said to give a more accurate picture of the learning experience as opposed to other educational indicators like school enrolment or years of schooling. There is growing evidence which shows learning outcomes play a major role in shaping up individual earnings, development and hence quality of life (Hanushek and Woessemann, 2008; Stiglitz *et al.* 2010). Among various subjects, performance in mathematics is positively associated with higher earnings for an individual (Mulligan, 1999; Lazear, 2003). Studies have also found that female students report high anxiety over mathematics than the male students (Stoet et al., 2016). These differences might lead to a significant drop in skills developed by a female student and further affect performance in mathematics and related subjects, which negatively affect future earnings and their economic wellbeing. In fact studies have found that part of gender wage gap can be explained through observed difference in mathematical skills (Murnane et al. 1995; Altonji and Blank, 1999; Murnane et al. 2000)

This paper draws motivation from this aspect and attempts to examine gender disparity in cognitive ability in mathematics among rural children at an all-India level. More specifically it attempts to find if mathematics score for female children is lesser in comparison to the male children with respect to standardised tests that has conducted all over India in 2011-12. The paper also looks at the association of gender of the child and learning outcomes in reading and writing and explore if gender gap is evident in other subjects apart from mathematics.

The question becomes pertinent as gender has been one of the most pervasive forms of inequality across all classes, social groups and communities and in different dimensions like labour market, health and education. For example gender bias in labour market and health inputs like immunisation has been found to be highly prevalent in India (Sengupta and

Das, 2014; Borooah, 2004;). With respect to education as well, studies have shown substantial gender discrimination in resource allocation, enrolment in private schools and continuation of schooling (Kingdon 1994; Dreze and Gazdar, 1997 Azam and Kingdon 2013; Sahoo 2016). Hence examining and analysing gender disparity in learning outcomes especially that in mathematics, which is highly associated with future well being forms the central part of this paper.

Our findings show significant chances of female children scoring poorly in mathematics as compared to a similar male child. We find our inferences holding for households of different socio-economic structure and also observe evidence of girls performing poorly than boys belonging to the same households. Some earlier work attributing these differences to innate abilities (or biological differences) has been criticised for its inability to factor in systematic differences of resources accessible to boys and girls. After controlling for a range of factors that were not incorporated in some of these earlier workswe too rule this out as a mechanism as we do not find the same significant differences forchildren residing in urban areas This leaves us with three potential reasons which might explain these differences: gender stereotyping emanating from households (mainly parents) or in school; lower allocation of resources and nutrition towards the female as kids and more involvement of boys in activities (such as petty work) or chores which involve simple mathematical skills like identification of numbers, addition and subtraction at an early age. These findings assume even greater significance given the contestations around the New Education Policy (the new national policy on education) in India.

The structure of the paper is as follows. Section 2 discusses the literature related to differences in mathematics learning among females. Section 3 talks about the data used in the paper and then discusses about the variables used in the paper. Section 4 presents the econometric methodology used in the paper. Section 5 discusses the results obtained from the econometric exercise and contexualises it with literature and rural India. The paper ends with a discussion and conclusion through section 6.

2Difference in mathematics learning among females

One of the earliest works which analysed differences across gender in terms of mathematical scores is the one by Benbow and Stanley (1980) who found 'sex differences' in mathematics using the math component of the SAT examination, which is a standardized test for college admission in the United States. Eccles and Jacobs (1986) questioned the study on many fronts. Firstly scores in the SAT examination may not an appropriate measure of mathematical aptitude. Secondly the students who took the tests may not have similar learning experiences. Finally they also questioned the conclusion on reasons for females taking fewer math courses to be due to sex differences in mathematical reasoning. They find that a lot of it is influenced by perception of parents of the mathematical ability of their child and the value they ascribe to mathematics as a subject. Mother's belief and confidence would have an even greater influence which is more susceptible be impacted negatively through media reports attributing these differences to the innate abilities and biological factors.

Fryer and Levitt (2010) find no difference in math scores between boys and girls in the United States upon entry to school but an emergence of gender gap is found in early years of schooling. They find parental expectations with regards to math be lower for girls and even for girls whose mothers are in math-related professions, the results do not change. Bharadwaj et al. (2016) also find the existence of gender gap in mathematics using data across low and middle income countries and find the emergence of this gender gap in scores to come by 4th grade. Similar results were found in Baltimore and Chile as well (Entwisel et al. 1994; Bharadwaj et al. 2016).

Literature in the Indian context is limited. Muralidharan and Seth (2016) using a 5 year panel data in Andhra Pradesh find that girls score equally to boys in math at the end of first grade but perform significantly worse by the end of 5 grade. Accordingly, the National Curriculum Framework (NCF) set up by the National Council of Educational Research and Training (NCERT) in India discusses issues related to issues in mathematics learning, pedagogy and curriculum. The study sheds light on difference in the learning experience between males and females and the possibility of higher mathematical phobia or anxiety among female children that results from gender stereotyping in the household or in school (NCERT, 2005). Literature suggests lower mathematical skills can lead to reduction of future earnings and may be one of the determinants of gender wage gap that is prevalent in and elsewhere (Bharadwaj et al. 2012).

It is in this context that our paper attempts to examine gender inequality in mathematics scores among rural children at an all-India level. Literature on this issue from India is limited to Muralidharan and Seth (2016) whose primary interest was to look at the role of teacher gender to reduce gender gaps in learning and focussed on the state of Andhra Pradesh. Hence this paper is among the first attempts to empirically examine if girl children score significantly lesser in mathematics than a similar boy child at the primary level and explore the possible reasons, in the Indian context.

3. Data and variables

This paper uses data from the Indian Human Development Survey conducted in 2011-12, produced jointly by National Council of Applied Economic Research (NCAER) and University of Maryland covered over 40,000 households gathered data on education, health, economic wellbeing, social status, and various other domains. Short tests capturing learning outcomes on reading, math and writing for children aged 8-11 years were also administered in the survey. These simple tests were conducted in 14 languages (where children could choose to write the test in a language that they chose) and each test was successfully administered to over 11,500 children (over 8000 children belonged to rural households) at their homes. These test scores serve as the outcome variables of the paper. While our main variable of interest is mathematics scores, we also look at scores in reading and writing to gain a better understanding of differences (if any).

Outcome Variable

Outcomes on reading skills have been coded into five categories from 0 to 4, which includes those who cannot read at all (=0), those who can recognise letters but not words (=1), those can read words but not a paragraph (=2), those who can read a paragraph but not a story (=3) and those who can read a story (=4). Math scores are coded into four categories from 0 to 3 which includes those who are unable to recognise numbers (=0), those who recognise numbers but are unable to do arithmetic (=1), those who can do a subtraction problem but not division (=2)and those who can solve a division problem (=3).Writing has been coded into 3 categories ranging from 0 to 2, which includes those who cannot write (=1), those who can write a sentence but make one or two mistakes (=1) and those who write without mistakes (=2).

The reading and mathematics tests have been widely used by Pratham (a non-governmental organisation) which conducts assessment tests across the country for their widely popular Annual Status of Education Report (ASER). The highest level of reading corresponds to what a child learns in grade 2. The highest level in the mathematics test corresponds to what a child learns in grade 3 or 4, depending on the state (province).

Controls

The main explanatory variable of interest is the gender of the child, which would indicate gender based differences arising out of the factors controlled for. Drawing from the vast literature on determinants of learning outcomes and factors that influence education for children in the Indian context (Chudgar and Quin, 2012; Dreze and Kingdon 2001; Govinda and Bandyopadhyay 2008; Chudgar, 2011), we include a number of controls such as birth order, age and sibling composition, caste and religion, household size, the State which household resides in, consumption expenditure, age and level of education of household head is also be taken.

Female children's disadvantage in access to resources for education particularly through the disparity at household level during allocation of resources or educational expenditure has been well documented in the Indian context; labour market discrimination and son-preference are too major mechanisms used to explain the reason for gender gap in educational expenditure (Kingdon, 2002). Thus we control for expenditure incurred on school fees and private tuition fees which constitutes a major share of education related expenditure at the primary level.

Several scholars have studied the many other determinants that can affect learning outcomes among children, which we include in our analysis as controls. Apart from basic economic characteristics and wellbeing of the household, social group or caste (Gangopadhyay and Sarkar, 2014) Teacher knowledge (Metzler and Woessman, 2012), availability of schools (Burde and Linden, 2013), school management (Muralidharan and Sundararaman, 2015) family size and birth order (Black et al., 2005), household headship (Chudgar, 2011; Singh et al. 2013), parental education (Maitra and Sharma, 2009), private coaching (Dongre and Tewary, 2015), and access to computers (Banerjee et al. 2007) may be some other factors that are important to account for. Caste and religion are integral to this debate and many studies have noted (e.g. - Tilak, 2002) the importance of investigating these aspects in context of gender bias, especially when looking at rural Indian households.

Further, factors that are direct inputs towards learning such as number of hours spent- at school, doing homework and attending private tuitions. School related factor such as the grade that child studies in and medium of instruction is also included. Lastly, a variable capturing short term illness (fever) that may temporarily affect the cognitive abilities of the child is controlled for. Children having major morbidity problems such as mental illnesses, cancer, paralysis and heart diseases, and children who are not attending any schools have been dropped from the analysis due to less observations and the high impact it might have on the dependent variable (learning outcomes/ test scores).

We further control for teacher absenteeism, and gender of the teacher at school. These are limited factors that are being controlled for at the school level. Results could be driven by any systematic difference in schooling of the boy and the female child but we control it to the best of our capabilities by including homework hours, school management (private, government or others), expenditure on school fees, years of schooling, distance to school that would capture school quality and access, limiting the chances of any confounding factors that are systematically different across both the genders. Further, we run our analysis (regressions) within each school type which would help control some of the differences arising from systematic differences across school managements. However what will not be captured is if there is any systematic difference within private and government schools based on the gender of the child. While literature has found girls to have a disadvantage when it comes to private school attendance (Maitra et al., 2016), there is no literature that has discussed any systematic differences based on gender with regards to the quality of private school. Controlling for expenditure on school tuition would help minimise any such differences.

A significant factor that could deter spending time with school related activities is that girls could be spending more time cooking at home or doing chores within the house which has not been captured directly but the time spent on doing various activities such as tuition, homework and school which are included should serve as good proxies. But outside of the controls used and considered, there are many studies that discuss the different roles played by teenagers and above based on gender that require different set of skills or efforts, there are no studies that discuss particular differences of effort or household level work at such younger ages. There are two variables that capture household chores- whether the child is involved in collecting fuel from outside the household and whether it is usual practice for the household to send their girl (or boy) under the age of 15 to collect water. The first variable is not taken due to the limited number of observations (under 1% of the sample) and the second variable is not included as it does not correspond directly to the studied child. This means that even if the household admits to sending boys (or girls) below 15 to fetch water outside of the house, it still may be the case that the child aged 8-11 years may not be the one doing the activity. However, what cannot be controlled for is other chores- where it could be that boys do more activities that require application of mathematical concepts like going to the store to purchase goods.

3 Methods and Empirical Analysis

As mentioned earlier, the dependent variables are learning outcomes namely reading, writing and mathematics skills for rural children of 8 to 11 years. In the survey these variables have multiple levels which are ordered. Hence to find the association of gender of the child with the learning outcomes, we use ordinal logistic (or ordered logit) models separately for the three outcomes.

Let us consider that the number of children is N. Since for each level of outcome of the *N* children, we have *J* achievement levels ordered in a meaningful way (ranked) for the ordinal dependent variable, we model them using ordinal logistic regression (Maddala 1986). Consider y_i is the observed ordered variable (scores in tests designed to measure reading skills, mathematics skills and writing skills) for child, i. The model can be specified as below:

$$y_i^* = \lambda FEMALE + \beta X_i + \varepsilon_i \qquad (1)$$

where y_i^* is the continuous unmeasured latent variable, whose value determine the level of y_i. In equation (1), X is the matrix of corresponding household and child level control variables pertaining to child, i (as listed in Table 1) and β is the vector of coefficients associated with these child and household specific characteristics. The variable $FEMALE$ is a dummy to indicate if the child, i is a female or not and λ is the coefficient. The random error term, ε_i follows a standard logistic distribution.

Results

Descriptive Statistics

Table 1 presents the mean levels of scores in reading, writing and mathematics across gender.[1] It is found that the average score for all subjects including mathematics is higher for boys than girls **Regression analysis**

As indicated earlier we run ordered logistic regression for reading, writing and mathematics scores on a dummy to indicate whether the child is male or female. A host of controls as discussed have been incorporated in the regressions. Table 2 shows the odds ratio from

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[1] For descriptive statistics of other variables, refer table A1.

regression results for reading, writing and mathematics scores. An odds ratio greater than 1 indicates a positive relationship (implying a greater chance of achieving a higher outcome as against other outcome level than the reference group) and that less than 1 indicates a negative relationship (a lower chance of achieving a higher outcome level as against other outcome level than the reference group). In terms of estimates, an odds ratio of "x" would imply that chances of achieving the highest outcome level as against the lower outcomes is "x" times than that for the reference group.

Two specifications have been used for regression of each of these subject scores: one with mother characteristics like her age, education and whether the mother is involved in working outside home and the other without these variables. For reading scores, we find females performing worse than male children but the level of significance is 10%. For writing as well, we find similar significant results at 5% level of significance. However for mathematics we find the strongest negative association at 1% level of significance. The odds ratio values suggest that the odds for scoring highest in mathematics versus other lower scores for females is about 0.77 times that for male children, controlling for other factors. For reading and writing scores, this odds of scoring highest for girls is 0.9 times that for boys indicating performance in mathematics for the former is substantially worse than the latter. The extent of scoring lower is reading or writing is much lesser as against mathematics. The coefficients of the control variables behave as expected: age and standard of the child, attendance in private schools, ownership of television and homework hours per week are positively correlated with test scores in all subjects.

[Table 2 here]

To see whether the results hold for earlier years as well, we run similar regression using IHDS data that was collected in 2004-05. Table 3 presents the regression results.

Gender gap is found to be prevalent not only in mathematics but also in reading and writing skills. This indicates that our finding of lower mathematics score for females in comparison to the male children is robust not only across specifications but also across time. However this opens up a question whether this relationship holds in general for all females or whether this holds for certain types of households. Hence in the next section of our analysis, examine if gender gap in mathematics is prevalent across households and children of different groups using the 2011-12 dataset.

[Table 3 here]

(i) Private and Government Schools

As discussed earlier, we found schools to be a significant predictor of scores for children as those studying in private schools faring better than those studying in government schools. We extend this further to explore if females studying in private or government run schools perform better or are at par with the males studying in private or government run schools respectively. For this purpose we run regressions using children studying in private and government run schools separately. Table 4 shows the odds ratio for both these types of regressions.

For children studying in government run schools, we find similar results to that corresponding for table 2. Females tend to score lesser in all the subjects but the negative relationship is strongest in mathematics. For those from private schools, we find insignificant difference between boys and girls in terms of scores in reading and writing. However for mathematics, even females studying in private schools are found to score lesser on average than similar males and the relationship holds at 1% level of significance.

[Table 4 here]

(ii) Social groups

As discussed, social groups which categorises households into different caste and religion constitute an important dimension in the Indian society. A plethora of literature has suggested households belonging to backward castes including SC, ST and Muslim religion suffer from deprivation, discrimination and subsequently face inequality in opportunities in terms of health, education and employment (Thorat and Neuman, 2012; Banerjee et al. 2009). Accordingly, we run separate regressions for children belonging to the following:

(a) Brahmin caste, Christian religion and other forward caste

(b) Muslim and OBCs

(c) Dalits (SCs) and adivasis (STs)

Individuals belonging to the first group on average are economically and socially better off as compared to those belonging to the other two groups. Dalits and adivasis form arguably the worst off group both socially as well as economically.

Table 5 presents the odds ratio from the regressions run separately for these three groups. Our findings again seem to suggest female children from all these groups performing significantly worse in mathematics than their male counterparts. In terms of reading, no significant difference is found between boys and girls cross all social groups. We observe similar findings for writing except for dalits and adivasis, where girls seem to score significantly lesser than boys.

[Table 5 here]

(iii) Economic groups

Arguably one of the best indicators of economic wellbeing is household Monthly Per-capita Consumption Expenditure (MPCE), which has also been used to estimate official poverty levels in India (Planning Commission, 2014). In the context of this paper, it might be argued that the difference in mathematics scores across gender is heterogeneous for households of different economic position. In poorer households, males might be treated better than females since the former can be seen as the source of future economic support and the latter a source of financial liability. Since parents might perceive mathematical skills to be important pre-requisite for getting jobs in the future, education investment in terms of money and time might be relatively more for boys than that for girls especially when resources to meet educational needs is scarce.

We test if at all there is a heterogeneous association of girls scoring lesser in mathematics across different households in terms of their economic position. For this purpose, we divide the distribution of household MPCEs into four equally divide quantiles and run similar but separate regressions for each of these four groups of households. Table 6 gives the results from the regressions. Interestingly, contrary to our hypothesis, we find girls from all the type of households score significantly lesser than male children (at 1% or 5% level of significance). In fact, for girl children from the richest 25% of the households, the odds ratio of scoring highest mathematics as against lower scores is 0.74 times lower than that for male children. For poorer households, this value varies from 0.77 to 0.82.

[Table 6 here]

(iv) Households with at least one boy and one girl

In the next set of analysis, we separate out households with at least one boy and one girl aged between 8 to 11 years (which was the test taking criteria) and run similar regression to examine the mathematical performance of girls from such households. For this we use household fixed effects wherein all the household level unobserved as well as observed variables would be controlled for automatically. As an instance, factors like social groups, MPCE, household head's gender and education or main income source of the household among others that are invariant across children within a household would be automatically controlled in the regression. Hence, it would enable us to capture purely the effect of factors which vary across the children within households. Table 7 shows the odds ratio from the regression.

[Table 7 here]

Our findings again suggest difference in scores in reading and writing is insignificant across girls and boys. However, in mathematics girl children are found to score lesser on average than boys. Interestingly we find the strength of this relationship is weaker as we find the odds for females to score high in mathematics as against other lower scores is about 0.92 times than that for males. In other cases, we have seen this value ranging from about 0.77 to 0.80. Further the results are found to be significant at 5% level as against 1% in other cases. Nevertheless, the gender gap in mathematics score prevails.

(v) Households with only male or female children

Similarly to the last section where we concentrated only on households with at least one male and one female child, in the next set of regressions, we separate out households with only male or female children and compare them. It is likely that in households with only female children investment in education would be lesser on average than those with only male children, due to which difference in learning outcomes might be prevalent across gender. Table 8 which presents the odds ratio from the regression taking these types of households show exactly what we hypothesized. The odds for females to score highest in mathematics as against all other scores are found to be only 0.76 times that for male children.

This holds at 1% level of significance. Interestingly, we find similar results for reading and writing as well though the level of significance is higher at 10% and 5% respectively.

[Table 8 here]

(vi) Birth order

Literature indicates various hypothesis about the impact of birth order on children educational expenditure and achievements. Those predicting a negative hypothesis suggest reasons such as greater parental involvement and responsibility towards children of lower birth order. The parents also get older when they rear the children of higher birth order. However, those predicting a positive relationship put forward reasons like growth of family income over the life cycle, experience gained by parents towards child rearing and assistance provided by the older children in terms of finance and caring (Booth and Kee 2009). Accordingly, we examine if the phenomenon of difference in mathematics scores for female children is heterogeneous across children of different birth order. For this purpose we categorise children into three groups: those with birth order of one, those with birth order of two and those with birth order of three and above. Table 9 presents the odds ratio from ordered logistic regression for these three types of children.

[Table 9 here]

Our findings seem to suggest that mathematics scores for girls across children of different birth order is lower than that for boys and the difference is significant at 1% level. The odds for females to score high in mathematics as against obtaining lower scores increase with higher birth order. For females of the first birth order, the odds is 0.71 times than that for boys of same birth order, controlling for other relevant factors. It goes upto 0.76 and then for females of higher birth order, the value stands at about 0.84 times than that for boys of similar birth order.

Possible Mechanisms

Our analysis finds a substantial gap in learning outcomes among females, which is evident with respect to mathematics and to a much lesser extent in other subjects. The findings shows that the gap is significant across all types of households and the inferences even hold for children of different groups. This raises a question as to why is this so?

(i) Biological Differences

The first reason that we inquire into is the biological or exogenous differences across males and females. They argue that there is an innate difference in ability, brain development, hormone levels and higher order thinking which is much superior for male children (Witelson 1976; Johnson and Meade 1987; Gur et al 1999; Davison and Susman 2001; De Bellis et al 2001; Cahill 2005; Gallagher and Kaufman 2005; Lawton and Hatcher 2005). Hence the difference gets reflected in mathematics which is more analytical than other skills like reading and writing. We tried to explore if this is true and for that purpose we run the same regressions on the urban children, the data for which is taken from the same survey. Table 10 presents the odds ratio for the regressions.

The findings from the regression results reveal that there is no significant difference in mathematics scores between urban boys and girls. This holds true for reading scores as well. In fact girls are found score higher with respect to writing scores. We repeat the same exercise for children from urban metropolitan cities and the results remain similar. Hence, we rule this mechanism out as one of the explanations

[Table 10 here]

(ii) Gender stereotyping

Literature also suggests societal factors, which leads to gender stereotyping can explain this difference. For example, Gneezy et al. (2003) argue males are more competitive which lead to better performance in mathematics, which is often perceived to be an indicator of intelligence and important in the job market. Explanation on this ground emphasizes on how girls are made to believe mathematics is not useful and is not a part of a girl's identity (Wilder and Powell, 1989).

Studies have shown that gender role stereotypes emanating parents is prevalent (Eccles and Jacobs 1986; Eccles et al. 1990; Parsons et al 1982; Muller 1998; Bouffard and Hill 2005; Bhanot and Jovanovic 2005). It is also found that in naturally occurring conversations, parents are three times more likely to discuss science and related issues to boys in comparison to girls (Crowley et al. 2001). In India as well, studies have shown gender stereotyping is deeply rooted in families and gender bias at home is a key element of the on-going socialisation process for girls (Mishra et al. 2012).

To get an indication of this, we divide the states based on the rural sex ratio as enumerated in Census 2011. Gender stereotyping from states with high rural sex ratio is expected to be low and high for those with lower sex ratio. Table 11 presents results from separate regression for the seven states with highest sex ratio and seven with lowest figures. The results indicate that gender difference in mathematics scores is insignificant for the states with higher sex ratio. For states with lower sex ratio, similar to previous results, girls are found to score significantly lower as compared to boys. While we are unable to directly prove or disprove the argument of gender stereotyping due to paucity of data, this result could be indicative that societal factors and parental role leading to gender stereotyping may play an important role within the society and family. However, to establish this, further research is essential.

[Table 11 here]

(iii) Early childhood nutrition

Another argument often put forward by development scholars is the lack in nutrition level in the early childhood, which may have detrimental effects on brain development and learning capacity for children (Popkin and Lim-Ybanez, 1982; Glewwe et al. 2001). One major reason for female children scoring lower than the male children in mathematics might be accrued to lack of nutrition for these females. Lack of nutrition which affects educational performance may show up in mathematics, which is considered to more analytical and difficult than reading or writing.

To get an indication if this is true, we exploit the individual level panel data of IHDS. The first round of survey was conducted in 2004-05 and the second round in 2011-12. In the 2005 survey, anthropometric measures like weight and height of the children were collected using which the zscores including the Height for Age (HAZ), Weight for Age (WAZ), Weight for Height (WHZ) and Body Mass Index (BMIZ) have been calculated. From the matched sample of 5377 children, children with a zscore below -6 0r above 6 are dropped from the sample after which the sample size reduces to 4547. Each of the zscores is then classified as 0 if the value is below the median and 1 if the value is above the median. After that we categorise the merged sample of children into three groups: (i) the ones with poor scores, defined as those for whom each of the zscores is below the median or only one of them is above median; (ii) the ones with middle scores defined as those for whom either two of the zscores or three are above median and (iii) the ones for whom all the four zscores lie above the median value.

First we run separate regressions using the sample of children with the three categories of anthropometric measures. Table 12 presents the results from the regressions. The findings suggest that among children with poor zscores, the gender gap in mathematics scores seems insignificant. However for better off children in terms of anthropometric scores, the gap becomes significant at 1% level. The fact that at higher levels of zscores, we observe the differences in test scores point to the probable prevalence of gender stereotyping at home: even when the female children are taken care from the childhood, gender ole stereotyping which encourages male children to devote more time in science and mathematics cannot be probably ignored.

[Table 12 here]

We use these zscores obtained to also find whether there is gender gap in mathematics scores comparing females with better scores with males of lower zscores. Table 13 presents the results from these regressions. In the first column, we compared females in the second category (two or three scores above median) with males in the first category (atmost one score is above median). In the second column, we compare females with highest zscores (all above median) with the male children in the first category. In the third, females in the third category are compared with males in the second category. The results suggest females with better anthropometric score as a kid are likely to score equally well as males with a worse score. This probably indicates an independent role of nutrition and health during childhood which might manifest as better scores in mathematics. However to establish this, further research which controls the unobservable factors affecting mathematics scores can be pursued.

[Table 13 here]

(iv) Non household activities and sports

Since household chores are mostly carried out by girls, it is likely that boys are involved in non-household activities like helping the father in agriculture or working as a help in a local shop. In fact Entwisel et al. (1994) find learning outcomes in mathematics for boys are more sensitive to environment (particularly resources) available and accessed outside the home than for girls. Boys in the middle- school age are found to spend more time outside in neighborhood as compared to girls and this could help the boys to perform better in mathematical reasoning. Playing games outside or getting more exposure to the outside environment may positively impact the development of numerical and also spatial abilities, and could benefit from activities such as carrying out transactions in stores or paying for the bus (Bing, 1963). Apart from this, playing and watching sports like cricket which is by far the most popular sports in the country may help the boys learn the very basic mathematics at a faster pace than that for girls.

In this regard, we run separate regressions for children scoring 0 or 1 (cannot identify numbers compared to those who can), 1 or 2 (those who can identify numbers compared to those can subtract) and 2 or 3 (those who can subtract to those who can divide) in mathematics, from the dataset. For the first regression, the dependent variable is whether the child 0 or 1. Similarly, in the second regression, the probability of children scoring 2 as compared to 1 for all children is modelled and for the third regression, we estimate the probability of children scoring 3 as compared 2. The odds ratio obtained from these regressions is given in table 14.

[Table 14 here]

Our findings reveal that in the first set of regression, the odds for females to score '1' in mathematics against zero is 0.79 times lesser in comparison to male children. For the other regression, a girl child is less likely to score '2' in mathematics in comparison to boys of similar characteristics. However this association fades away when children scoring '2' or higher is taken into consideration. Here we find no significant association of gender of the child and scores in mathematics. This can be seen in the light of the previous argument. It is possible that once a boy child starts spending time outside playing and involving himself in petty works like agriculture or running a petty shop in the village, they would have an advantage over the basic mathematics involving addition and subtraction. For higher levels, which involve division, no such significant gain is found for boy children.

Conclusion

In the light of studies finding strong correlation in acquiring mathematical skills and its importance in getting employed and earning better in future, this paper examines if there are any differences in mathematics scores based on gender. Using nationally representative data for 2011-12 and applying standard econometric techniques to control for observable characteristics and a battery of checks, we find performance of rural females to be worse than similar male children in mathematics.

These findings corroborate with the limited and scattered evidence which examines the prevalence of higher mathematical anxiety among girl students in other countries and schooling levels. We explore many mechanisms but are unable to isolate a single one due to the paucity of data. A common mechanism used to explain these differences is due to the stereotyping and "systematic devaluation" of girls in school and household due to which they develop higher anxiety towards mathematical subjects. Further, better nutrition in childhood among male children and their participation of petty activities and attachment towards sports may partly explain the differences in mathematics scores across gender. Nevertheless, further research to attribute the exact reasons explaining the gender difference needs to be carried out.

As noted earlier, addressing the lack of reference to female mathematicians in text books, female names and characters in word problems among other simple tweaks might be a good place to start in order to address these issues (NCERT, 2005). Further, the government should spend more and prioritise higher spending on girls and policies related to removing this stigma. Educational policies need to include provisions to have sensitisation of teachers and talk about equality of sexes at the very fundamental level starting from the family and society to reduce gender role stereotyping emanating from the parents and neighborhood.

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Table 1: Descriptive statistics

Test Scores (Mean)	Male children	Female children
Reading	2.46	2.34
Writing	1.09	1.02
Math	1.46	1.31
Observations	4,268	3,908

Note: *The actual number of observations for each variable may vary slightly*

Table 2 Overall Regressions

	Reading level	Reading level	Writing level	Writing level	Math level	Math level
Ref: Male						
Female	0.920*	0.919*	0.912*	0.912*	0.774***	0.772***
	(0.044)	(0.044)	(0.044)	(0.044)	(0.036)	(0.036)
Controls						
Ref. Brahmins, Other Forward Castes, Jains, Christians and Sikhs						
Muslims	0.841	0.868	0.688***	0.712***	0.841	0.881
	(0.099)	(0.102)	(0.087)	(0.089)	(0.099)	(0.103)
Other Backward Classes	1.029	1.065	0.850*	0.874	1.014	1.050
	(0.086)	(0.090)	(0.074)	(0.077)	(0.081)	(0.084)
Scheduled Castes	0.804**	0.848*	0.716***	0.752***	0.834**	0.876
	(0.073)	(0.077)	(0.066)	(0.071)	(0.075)	(0.079)
Schedule Tribe *(Adivasi)*	0.742**	0.793*	0.583***	0.617***	0.725**	0.767**
	(0.099)	(0.106)	(0.085)	(0.091)	(0.091)	(0.097)
Birth Order	0.892***	0.960	0.920***	0.983	0.922***	0.986
	(0.020)	(0.028)	(0.021)	(0.028)	(0.021)	(0.029)
Age	1.103***	1.134***	1.139***	1.168***	1.104***	1.134***
	(0.030)	(0.031)	(0.032)	(0.033)	(0.030)	(0.032)
Grade	1.556***	1.548***	1.316***	1.309***	1.466***	1.458***
	(0.035)	(0.035)	(0.030)	(0.030)	(0.033)	(0.033)
Short Term Morbidity Fever last 30 days	0.991	0.985	0.947	0.942	0.949	0.944
	(0.063)	(0.063)	(0.060)	(0.060)	(0.061)	(0.061)
Child uses computer	1.919***	1.948***	1.317	1.306	1.596***	1.558**
	(0.440)	(0.450)	(0.296)	(0.291)	(0.285)	(0.285)
House is *pucca*	1.159**	1.140**	1.063	1.042	1.053	1.031
	(0.074)	(0.073)	(0.072)	(0.071)	(0.069)	(0.068)
Household owns TV	1.306***	1.241***	1.206***	1.149**	1.315***	1.250***
	(0.083)	(0.079)	(0.079)	(0.076)	(0.085)	(0.082)
Ref: Child Attends government school						
Private school	2.516***	2.465***	2.110***	2.070***	2.184***	2.134***
	(0.224)	(0.220)	(0.172)	(0.168)	(0.192)	(0.188)
Private aided and other schools	1.207	1.215	1.408**	1.416**	1.405**	1.400**

	(0.173)	(0.175)	(0.216)	(0.220)	(0.199)	(0.201)
Ref: Medium of instruction at school: Not English						
English	0.751**	0.739***	0.895	0.869	0.803*	0.781**
	(0.085)	(0.084)	(0.100)	(0.099)	(0.093)	(0.090)
Private tuition hours (log)	1.062*	1.045	1.057	1.044	1.056	1.042
	(0.034)	(0.034)	(0.040)	(0.040)	(0.037)	(0.037)
Distance to school (log)	1.002	0.997	1.067	1.059	1.042	1.034
	(0.051)	(0.051)	(0.056)	(0.055)	(0.051)	(0.051)
Teacher gender	1.049	1.038	1.099	1.088	1.075	1.060
	(0.060)	(0.060)	(0.064)	(0.063)	(0.060)	(0.060)
Household Size	0.971**	0.960***	0.996	0.986	0.969**	0.961***
	(0.013)	(0.013)	(0.015)	(0.016)	(0.012)	(0.012)
Income Source; Ref. Organised Business, Salaried or Professional						
Cultivation and Allied Agriculture	0.902	0.912	0.814**	0.830*	0.903	0.924
	(0.091)	(0.093)	(0.084)	(0.085)	(0.088)	(0.092)
Agriculture Wage Labour	0.803*	0.825	0.805*	0.835	0.729***	0.759**
	(0.099)	(0.102)	(0.098)	(0.101)	(0.087)	(0.091)
Non-agriculture wage labour	0.744***	0.766***	0.773**	0.800**	0.746***	0.778**
	(0.075)	(0.078)	(0.080)	(0.082)	(0.075)	(0.079)
Artisan/Independent, Petty Shop, Pension/Rent, or Other sources	0.829*	0.826*	0.814*	0.820*	0.963	0.974
	(0.087)	(0.087)	(0.087)	(0.087)	(0.100)	(0.102)
Yearly per capita expenditure of Household (log)	1.164**	1.172**	1.079	1.080	1.139**	1.141**
	(0.073)	(0.074)	(0.069)	(0.070)	(0.074)	(0.074)
Homework hours/week	1.029***	1.028***	1.034***	1.033***	1.040***	1.039***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
School hours/week	1.004	1.003	1.013***	1.013***	1.000	1.000

	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Age of the household head	1.010***	1.012***	1.009***	1.010***	1.011***	1.011***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Sex of the household head is female	1.178*	1.140	1.203**	1.161*	1.189**	1.132
	(0.099)	(0.098)	(0.105)	(0.103)	(0.102)	(0.098)
Education Level of the HH Head; Ref. No Education						
Up to 8th Grade	1.411***	1.295***	1.144**	1.060	1.249***	1.142**
	(0.086)	(0.081)	(0.075)	(0.071)	(0.075)	(0.070)
10th Grade	1.844***	1.647***	1.475***	1.318***	1.736***	1.535***
	(0.164)	(0.149)	(0.133)	(0.123)	(0.151)	(0.136)
12th Grade	2.050***	1.812***	1.377***	1.219	1.869***	1.604***
	(0.239)	(0.217)	(0.168)	(0.153)	(0.223)	(0.196)
Undergraduate or higher	2.548***	2.223***	2.459***	2.097***	2.572***	2.139***
	(0.397)	(0.355)	(0.406)	(0.359)	(0.382)	(0.328)
Mother's age		0.982***		0.984***		0.985**
		(0.006)		(0.006)		(0.006)
Education Level of the Mother; Ref. No Education						
Up to 8th Grade		1.355***		1.306***		1.397***
		(0.088)		(0.087)		(0.094)
10th Grade		1.398***		1.400***		1.463***
		(0.140)		(0.144)		(0.149)
12th Grade		1.273*		1.481**		1.729***
		(0.178)		(0.235)		(0.246)
Undergraduate or higher		1.590*		1.760**		1.860***
		(0.386)		(0.430)		(0.427)
Mother does activity other than housework		0.921		0.949		0.996
		(0.058)		(0.066)		(0.062)
Pseudo R^2	0.113	0.115	0.118	0.120	0.137	0.140
N	6651	6651	6602	6602	6630	6630

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level.

Table 3. Overall regression (2004-05)

	Reading level	Writing level	Math level
Ref: Male			
Female	0.813***	0.802***	0.685***
	(0.037)	(0.046)	(0.031)
Household, Individual an School Controls	Yes	Yes	Yes
Mother's education levels and household activity status	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
N	7,575	7,499	7,543
Pseudo R^2	0.141	0.195	0.152

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level.

Table 4. Regressions within types of school attendance

	Private Schools			Government Schools		
	Reading level	Writing level	Math level	Reading level	Writing level	Math level
Ref: Male						
Female	1.029	1.022	0.769***	0.894*	0.879**	0.786***
	(0.109)	(0.104)	(0.074)	(0.051)	(0.051)	(0.046)
Household, Individual an School Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mother's education levels and household activity status	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	1774	1760	1769	4526	4499	4512
Pseudo R^2	0.115	0.100	0.135	0.112	0.119	0.140

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 5 Regression within social groups

	Brahmin caste, Christian religion and other forward caste			**Muslim and OBCs**			**Schedule Caste groups (Dalits) and Schedule Tribes (Adivasis)**		
	Reading level	Writing level	Math level	Reading level	Writing level	Math level	Reading level	Writing level	Math level
Ref: Male									
Female	1.010	1.167	0.720***	0.922	0.915	0.832***	0.895	0.841**	0.704***
	(0.129)	(0.157)	(0.092)	(0.066)	(0.063)	(0.058)	(0.071)	(0.068)	(0.057)
Household, Individual and School level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mother's education levels and household activity status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1147	1131	1145	3082	3064	3070	2338	2328	2331
Pseudo R^2	0.127	0.125	0.125	0.114	0.112	0.135	0.119	0.132	0.152

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 6 Regressions within Economic Groups

	Quantile 1 (Poorest 25%)			Quantile 2			Quantile 3			Quantile 4 (Richest 25%)		
	Reading level	Writing level	Math level	Reading level	Writing level	Math level	Reading level	Writing level	Math level	Reading level	Writing level	Math level
Ref: Male												
Females	0.953	0.860	0.774***	0.863	0.815**	0.767***	0.914	1.047	0.817**	0.981	0.999	0.741***
	(0.089)	(0.083)	(0.076)	(0.086)	(0.083)	(0.074)	(0.090)	(0.106)	(0.079)	(0.100)	(0.112)	(0.078)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1661	1654	1656	1622	1614	1617	1638	1628	1635	1646	1627	1638
Pseudo R^2	0.113	0.123	0.144	0.111	0.104	0.130	0.115	0.116	0.126	0.113	0.131	0.131

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 7 Regressions for household with at least two test-takers (at least one boy and one girl)

	Reading level	Writing level	Math level
Ref: Male			
Females	-0.089	-0.031	-0.079**
	(0.062)	(0.037)	(0.040)
Controls	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Adjusted R^2	0.523	0.468	0.563
N	1345	1332	1341

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 8 Regressions for household with only boy(s) or girl(s) testtaker

	Reading level	Writing level	Math level
Ref: Male			
Females	0.899*	0.891**	0.758***
	(0.050)	(0.050)	(0.042)
Controls	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
N	5179	5146	5163
		0.123	0.143

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 9 Regressions within Birth Orders

	Birth Order: 1			**Birth Order: 2**			**Birth Order: 3**		
	Reading level	Writing level	Math level	Reading level	Writing level	Math level	Reading level	Writing level	Math level
Ref: Male									
Females	0.966	0.985	0.713***	0.934	0.900	0.763***	0.892	0.872	0.837**
	(0.079)	(0.083)	(0.057)	(0.079)	(0.076)	(0.064)	(0.076)	(0.078)	(0.073)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2248	2234	2245	2143	2125	2135	2260	2243	2250
r2	0.119	0.127	0.129	0.115	0.114	0.151	0.121	0.131	0.147

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 10 Regressions for urban children

	Urban areas			Metro cities		
	Reading level	Writing level	Math level	Reading level	Writing level	Math level
Ref: Male						
Females	1.100	1.267***	0.999	0.976	1.573**	0.916
	(0.079)	(0.097)	(0.073)	(0.159)	(0.294)	(0.164)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	2893	2862	2879	570	568	567
Pseudo R^2	0.131	0.114	0.164	0.146	0.150	0.195

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 11: Regressions in states

	States with high sex ratio Math level	States with low sex ratio Math level
Ref: Male		
Females	0.890	0.671***
	(0.108)	(0.046)
Controls	Yes	Yes
State Fixed Effects	Yes	Yes
N	1143	2837
Pseudo R^2	0.126	0.175

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 12: Regressions for different anthropometric measure categories

	Low scores: none or one above median Math level	Middle scores: two or three above median Math level	High scores: all above median Math level
Ref: Male			
Females	0.861	0.757***	0.716**
	(0.092)	(0.068)	(0.115)
Controls	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
N	1340	1777	712
Pseudo R^2	0.128	0.145	0.157

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 13: Regressions comparing girl;s with better zscores with boys of lower values

	Girls with middle scores vs. boys with low scores	Girls with high scores vs. boys with low scores	Girls with high scores vs. boys with middle scores
Ref: Male			
Females	1.087	0. 902	0. 904
	(0.155)	(0.091)	(0.120)
Controls	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
N	1048	1612	1213
Pseudo R^2	0.145	0.137	0.144

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level

Table 14 Regressions for Separate Math levels

	Level 0 to 1 (Those who cannot and can recognise numbers)	Level 1 to 2(Those who can recognise numbers and those can subtract)	Level 2 to 3(Those who can subtract and those can divide)
Ref: Male			
Females	0.791***	0.851**	0.924
	(0.062)	(0.059)	(0.078)
Controls	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
N	3717	4313	2841
Pseudo R^2	0.118	0.114	0.100

Note: ***1 % Significance ** 5% Significance *10% significance. Standard errors of odds ratios are in parenthesis and have been clustered at the village level