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Governmental investments in primary education and children's achievement in India
Short title: Investments in education and achievement

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Abstract

This study examined the importance of governmental investments in school infrastructure, school improvement grants, teachers, and pupil incentives for children's test performance and age-appropriate grade in India. We combined two national datasets, one with district-level data on schools, the other with population-based data on children. Governmental investments accounted for up to 6% of the explained variation in achievement. Improvement grants given to schools and incentives given to pupils tended to have the strongest adjusted associations with test performance and grade progression. With higher investments, higher proportions of children may have basic literacy and numeracy skills and be in the age-appropriate grade. Large investments, like basic school buildings with multiple classrooms, and smaller investments, like stationery and uniforms for pupils were associated with higher achievement.

Key words: education, investment, school, teacher, district, India

INTRODUCTION

Schooling achievement in lower-income countries is associated with many positive outcomes, including lower fertility, greater productivity and earnings, enhanced cognitive skills, and better health and nutrition (Behrman et al. 2010, Caldwell 1980, Lloyd 2000, Lloyd et al. 2005, Schultz 1988). It also is associated with positive intergenerational outcomes, including good child-care practices, child health, and child survival (Desai 1998, King 2001, LeVine et al. 1991, Lloyd et al. 2005).

In the 1960s and 1970s, average schooling achievements were low in most lower-income countries. Since then, young people have experienced substantial increases in schooling enrollment, grade achievement, and time spent in school (eg. Lloyd et al. 2005, Wils & Goujon 1998) The rate of growth in school attendance has been rapid, in some countries exceeding the pace of change that occurred in the historical transition to universal schooling in the West. Despite these gains, approximately 130 million children in lower-income countries still do not complete primary school (UNESCO Institute for Statistics 2004, UNICEF 1999). The National Research Council-Institute of Medicine Panel on Transitions to Adulthood concluded that increasing schooling achievement should be a priority (Lloyd et al. 2005). This recommendation corroborates the United Nations Millennium Development Goal to achieve universal completion of primary school by 2015 (United Nations 2005).

Studies of children's schooling achievement in lower-income countries often have stressed the influence of *parental resources for investments in children* on *children's school attendance*, measured by initial or current enrollment or by the highest grade achieved, with limited information on performance (eg. Afridi 2010). Yet, attending school does not necessarily imply better performance among students, and even in areas where access to schooling has greatly improved, performance continues to be low (Wu et al. 2007). The few studies in lower-income settings that have focused on governmental inputs into schooling did not quantify their implications for children's achievement (Yount et al. 2010). Studies in wealthier settings have stressed the role of *social or public investments in children*, such as effective allocation and targeting of public expenditures (Hannaway & Woodroffe 2003b, Henry & Fortner 2010) lower pupil-to-teacher ratios (Greenwald et al. 1996, Grissmer 1999, Wenglinsky 1997) improved teaching practices and classroom resources (Elliott 1998), pay-for-performance for teachers (Goldhaber & Anthony 2003, Hannaway & Woodroffe 2003a, Poggio 2000) and vouchers and tuition tax credits for students (Hannaway & Woodroffe 2003a).

We evaluated, in the context of India, the associations between *governmental investments in schools* and children's *test performance* in reading, writing and arithmetic and age-appropriate *grade* in school. Being home to about 16% of the world's population, India is a setting where improvements in education can affect an important share of the world's children. In recent decades, India has undergone remarkable increases in school attendance. For example, in 1998–9, a minority of boys (41%) and girls (36%) had finished primary school by age 14 (International Institute for Population Sciences (IIPS) and ORC Macro 2007), but by 2006, 75% of children 11-14 years were still in school (International Institute for Population Sciences (IIPS) and ORC Macro 2007). Nevertheless, school performance has lagged: nationally, the average student responded correctly to only 45% of math questions and 58% of language questions (National Council of Educational Research and Training 2003). Moreover, regional variations in school quality and educational outcomes persist despite substantial governmental efforts to improve education.

Our analysis examined the relationships between multiple district-level governmental investments in schooling – conceptualized as outlays in (1) school infrastructure, (2) school improvement grants, (3) teachers, and (4) incentives for children to enroll and attend school – and objective measures of academic performance. We assessed to what extent governmental investments in schooling added to family and community factors in shaping children's test performance and

grade progression. We also asked which of these four domains of governmental investments are most promising for improving achievement. The analysis used two rich data sources: the *India Human Development Survey* (IHDS), with population-based data on multiple measures of school attendance and performance among children 8–11 years for the 2004/5 academic year and the *District Information Survey on Education* (DISE), with district-level data on over 30 characteristics of schools for the 2004/5 academic year. Our approach, thus, offers a fuller assessment of the relationship between governmental investments and children's education using rich, nationally representative yet under-used data from India.

DETERMINANTS OF SCHOOLING ACHIEVEMENT

Family Investments and Children's Schooling Achievements

Sociologists often view schooling achievement as a process of socialization, in which important role models establish norms for children's behavior and achievement. Within this perspective, parents are typically the primary role models, and their behaviors, aspirations, values, and expectations about schooling directly affect children's development and academic achievement (Jacobs & Harvey 2005, Kaplan et al. 2001, Kloosterman et al. 2011, Sewell 1963). Complementarily, economists often argue that the family is an important determinant of children's schooling achievement (Becker & Tomes 1986). Economic models of household decision-making assume that parents care about the economic capabilities and success of their children, and make "expenditures on their skills, health, learning, motivation, 'credentials,' and many other characteristics" to enhance their children's human capital (Becker & Tomes 1986). The nature, amount, and share of familial resources that are allocated to children, as well as the timing of those allocations, may affect children's achievements, including their entry, progression, and achievement in school. Children also are affected by other family choices concerning, for example, the neighborhood of residence, number of children, and changes in family structure. Although the hypothesized mechanisms in these sociological and economic models differ, their implications are similar regarding the expected importance of family investments.

Examples of role modeling have often been measured in terms of parental, and especially maternal, schooling achievement, which has been significantly associated with children's schooling across settings (Behrman 1997, de Haan 2011, Holmlund et al. 2011). In non-Western countries, these indicators have captured more broadly the schooling of adult men and women in the household (Borooah & Iyer 2005, Dostie & Jayaraman 2006, Dreze & Kingdon 2001, Townsend et al. 2001). In India, caste and religion also are pertinent indicators of family economic resources and educational experience (Borooah & Iyer 2005).

Family income and wealth have been important for children's schooling across a range of settings (Behrman & Knowles 1999, Duncan et al. 2011, Takashi et al. 2010) and may affect schooling through the monetary, time, and instructional resources to which a child has access (Eloundou-Enyegue 2003, Filmer 2001, Pal & Ghosh 2008).

Governmental Investments and Children's Schooling Achievements

In a general critique of the literature on modeling and explaining children's schooling achievements, Haveman and colleagues (1991) argued that economic and sociological models have over-emphasized the influence of parental investments at the expense of other potentially relevant determinants. They propose a more comprehensive framework that also includes *social* investments in children, i.e., government or other societal investments that affect the opportunities available to children and their families. In this framework, public investments affect schooling by expanding school infrastructures and improving school quality. In addition, families' decisions to prioritize children's schooling are influenced by this broader environment of social investment.[4] Despite the conceptual importance of government investments, we know of no studies that have investigated

the direct contributions of governmental investments in children's academic performance in a historically lower-income setting that has undergone dramatic socioeconomic change and expansion in public investments in children.

Within this framework, we propose that government investments are selected based on the needs of existing education facilities, the economic and infrastructural resources on which investments can draw, and expert and lay expectations and priorities about how to improve education. Thus, policymakers choose how to distribute limited resources to accomplish the largest gains in education. These options can include major infrastructural construction and improvement of schools, the hiring and training of teachers, and providing incentives to families to send children to school. The empirical evidence for each of these types of investments across higher- and lower-income settings is summarized below.

Investments in schools

Major investments in schools include the expansion of school infrastructures and improvements in the quality of schools (eg. Behrman 2009, Glewwe & Kremer 2007, Orazem et al. 2007). Few studies have focused on school infrastructure in Western countries, but, in the U.S., investments in physical capital have been associated with student reading and mathematics achievement (Crampton 2009). Newer schools had poorer performance than established ones (Metcalf et al. 1998). On the other hand, investments in schooling in lower-income countries have focused on school infrastructure, especially building new schools. In diverse lower-income settings, including India, researchers have found positive (Kingdon 2007) and negative or negligible (Dreze & Kingdon 2001, Filmer 2007, 1999) associations of investments in school proximity and infrastructure with overall child achievement. In some poor rural areas, the concentration and proximity of schools are more strongly associated with school attendance than are other measures of schooling quality (Handa & Simler 2006, Nielsen 1998).

Investments in teachers

Teacher quality and pupil-to-teacher ratios are believed to contribute to pupil achievement (Clotfelter et al. 2007, Jencks & Phillips 1998, Nye et al. 1999, Rivkin et al. 2005, Wenglinsky 1997), though effects may not be long-term (Jacob et al. 2008). In the U.S., investments in teacher quantity, specifically smaller class size and fewer pupils per teacher, were associated with better test scores across subjects in many (Grissmer 1999, Hannaway & Woodroffe 2003b) but not all (Caldas & Carl 1999) studies. The benefits were particularly strong at lower grades, with longer exposure (Grissmer 1999), and for disadvantaged children (Finn & Achilles 1999, Krueger 1999). There appear to be thresholds for class size effectiveness, with greater benefits for classes under 20 (Betts & Shkolnik 1999), and class sizes may be more important for some subjects than for others (Rice 1999). In Pakistan, India, and South Africa, lower pupil-to-teacher ratios have predicted higher pupil achievement (Alderman et al. 2001, Case & Deaton 1999) and enrollment, especially for girls (Dreze & Kingdon 2001), but similar associations were not found in Nigeria and Swaziland (Lockheed & Komenan 1989). In India, providing an additional teacher to single-teacher schools was positively associated with school completion rates, especially for girls and the poor(Chin 2005), but not with improved performance (Banerjee et al. 2002).

Several studies have reported that teacher quality is the most important determinant of student achievement (Hannaway & Woodroffe 2003b), though defining what makes a good teacher is challenging. There is conflicting evidence that teacher recertification exams, experience, and graduate degree do (Ferguson 1991, Goldhaber & Anthony 2003, Greenwald et al. 1996) and do not (Angrist & Guryan 2004, Hanushek et al. 1998) improve pupil achievement. In lower-income countries, the investments of particular interest have been the presence of female teachers and

teacher training (Dreze & Kingdon 2001, Muliadharan & Sundararaman 2008, UNESCO 1995, Velkoff 1998). In India, the addition of one female teacher was associated with improved literacy and numeracy (Banerjee et al. 2007) Also in India, para-teachers,[1] who receive less training, may be as effective as regular contracted teachers in terms of pupil test performance (Kingdon & Sipahimalani-rao 2010).

Incentives to children

The potential to improve school attendance and performance by providing financial incentives to children has been of interest in higher- and lower-income countries. There is some evidence, including from the U.S. and Colombia, that some pupils who receive tuition vouchers perform better by some measures (Angrist et al. 2002, Greene et al. 1997), though longer term improvements are often small (Metcalf et al. 1998). Providing incentives to study but not rewards for better scores was associated with better performance (Fryer 2010). In poorer settings, incentives such as food and books were associated with enrollment, grade attainment, and test scores (Dreze & Kingdon 2001, Glewwe et al. 2002), though the effect of food incentives may be exaggerated, as teachers have been noted to inflate reports of attendance to ensure that students receive food (Shastry & Linden 2009).

Other Determinants of Children's Academic Achievement

Many researchers have found significant - albeit variable - associations between neighborhood social and economic wellbeing and children's academic achievement (Ainsworth 2002, Crane 1991, Duncan 1994, Harding 2003). A commonly used indicator of economic environment and infrastructure is level of urbanicity. In India, proportion of scheduled castes and tribes captures aspects of the socio-economic and cultural environment (Borooah & Iyer 2005). The sex ratio of the population quantifies differential investments in girls and boys (Echavarri & Ezcurra 2010). Geographic region indicates variations in the social, economic, and cultural environment.

Child characteristics have been shown to correlate with schooling achievement. Age is an important determinant of test scores (Dreze & Kingdon 2001). There may be differences in the investments households make among household children, with differences for example by child's gender and age-order (Duraisamy 1992, see Kingdon 2005 for an exception, Sudha 1997). The language in which a child is tested may be pertinent to performance, possibly capturing differences in education by medium of instruction or in question difficulty.

Remaining questions about investments and child achievement

Our review of the literature exposes several gaps that this analysis aims to fill. Specifically, the influence of most governmental investments are ambiguous, perhaps in part because, in many lower-income countries, educational expenditures are often misallocated, providing facilities and supplies at the wrong place, at the wrong time, to the wrong people, or in inadequate supply (Alderman et al. 2001). In addition, prior studies have tended to focus on a narrow set of governmental investments, and have lacked a focus on children's performance as an outcome. Moreover, the predictive value of the schooling inputs that are relevant to poorer settings for children's achievement is not well documented. To overcome these limitations, we examined the associations between (1) an array of district-level measures of governmental investments in school infrastructure and school improvement grants; teacher quantity and quality; and incentives for children to enroll and attend school with (2) multiple child-level measures of achievement in a nationally representative population-based sample of children in India.

INVESTMENTS IN PRIMARY EDUCATION IN INDIA

The government of India runs one of the largest primary education systems in the world (Department of Education 2003). In 2010, about 150 million Indian children of primary-school-age (6-10 years) were enrolled in nearly 800,000 primary schools (Department of Education 2003, Pratham USA 2005). Still, nearly 14 million children aged 6-10 years are out-of-school, nearly 40 million children do not reach grade 5, and only 58.2% of children complete primary school each year (Department of Education 2003, International Institute for Population Sciences (IIPS) and ORC Macro 2001). Furthermore, basic reading and writing skills are on average low, and many third graders cannot read or write properly (Duflo et al. 2012, Kremer et al. 2005).

In 1968, India's National Policy on Education called for "strenuous efforts" to achieve "free and compulsory education for all children up to the age of 14" (Tilak 1996), and, since then, the government has invested heavily in education. Government investments have resulted in more schools, such that 93% of the rural population lives within one kilometer of a primary school (Chin 2005). Government investments have subsidized the costs of schooling, especially for disadvantaged children, by providing tuition-free or low-tuition education in primary schools and offering various incentive: since 1986, about half of primary schools offered free textbooks and uniforms to poor children (The PROBE Team 1999) and a quarter offered free midday meals (Chin 2005) to encourage daily attendance. Some districts provide other incentives, such as bicycles for girls.

To improve school quality, the government launched in 1987 Operation Blackboard (Chin 2005), which specified that teaching-learning-materials packets be provided to primary schools and an additional teacher be assigned to one-teacher primary schools (Chin 2005). Since 2002, the government raised its investments in education even further, spending 12.7% of total expenditures on education (Crost & Kambhampati 2010). Teaching-Learning-Materials (TLM) grants include materials and equipment to enhance learning and grants for their procurement in the range of 500 Rupees (~US$13). Also available to schools are Development grants for the repair and maintenance of equipment, furniture and musical instruments, school beautification, and overall environmental enhancement, in the range of 1,000 Rupees (~US $26).

Still, most studies of schooling in India have focused on individual, household, and village determinants of schooling (Afridi 2010) and were not designed to quantify the role of public investments for children's achievement. Measuring school investments at the district level is useful because this is the level in India at which decisions about allocations to schools are made (Clots-Figueras 2011).

METHOD

Sample and Data

For this analysis, we combined two rich nationally representative datasets: The 2005 *India Human Development Survey* (IHDS) and the 2004/5 *District Information Survey for Education* (DISE). The IHDS collected self-report and objective information on health, education, employment, economic status, marriage, fertility, gender relations, and social capital from 41,554 households in 1,503 villages and 971 urban neighborhoods across India (Desai et al. 2007). The primary sampling units (PSUs) were villages and urban blocks. In urban areas, a random sample of households was drawn; the rural sample consisted of a sample of households from the Human Development Profile of India 1993-94 survey, freshened to ensure a nationally representative sample. The IHDS was the first in India to collect direct assessments of reading, writing, and arithmetic in children's homes rather than in schools, thus including children who were not attending school. Tests were developed with local consultation and informed by material taught during the first three years of school. The non-profit organization Pratham developed the assessment tools, which were widely pre-tested. Trained assessors administered the tests in 13 languages (Desai et al. 2008). In this study, the IHDS was used

for outcome measures of academic achievement among children 8-11 years and for control variables on children, households and their schools.

The DISE provided district-level measures of governmental inputs to schooling - the exposure variables of interest in this analysis - and control variables at the district level. This is a unique and under-used source of data on recognized schools that impart primary education to children enrolled in grades I-VII and on the children attending these schools.[2] State Education Departments distribute surveys to schools annually. Data are collected on school distances, infrastructure and receipt of grants; teacher diversity, quality, quantity, and tenure; incentives offered to children; and pupil diversity and performance. In 2005, the DISE covered 581 districts in 29 States and Union Territories.

The sample for this analysis was drawn from the 17,117 children aged 8-11 years in IHDS sample households. 72% of children participated in academic tests. Participation was reduced in these modules because interviewers sought parent consent and child assent without pressuring children and also because this was the last module of a long household survey, and some households terminated the interview before completing this module (Desai et al. 2008). Children not currently enrolled in school and those from poorer households were less likely to participate (Desai et al. 2008). The sample for our analysis includes 11,950 children, after 374 children were also dropped because they were not living in districts covered by the DISE in 2005.

Variables

Reading performance was measured on a five-point scale: (1=*Cannot read at all*; 2=*Can read letters but not form words*; 3=*Can put letters together to read words but not read whole sentences*; 4=*Can read a short paragraph of 2-3 sentences but not fluent enough to read a whole page*; 5=*Can read a one page short story*). The writing assessment required children to write a short sentence[3] and their performance was measured on a two-point scale (0=*cannot write; 1=writes with two or less mistakes*). Arithmetic performance was measured on a four-point scale (1=*Cannot read numbers above 10*; 2=*Can read numbers up to 99 but cannot do more complex number manipulation*; 3=*Can subtract a two-digit number from another*; 4=*Can divide a number between 100 and 999 by another number between 1 and 9*). Using information on the child's age and grades completed, we created an indicator of age-appropriate grade progression, indicating for each child whether he or she was in an age-appropriate grade, that is, within two years of he or she would be having entered school at age seven, the standard age of school entry, and progressed one grade per year.

In alternative specifications (shown in Appendices), we replicated the analysis with a set of linearized outcomes, converting each measure of performance into percentile rankings, indicating each child's performance in reading, writing, and arithmetic relative to the population distribution. For grade progression, an eight-year-old was considered on schedule if she had completed first or second grade, was behind if she had not completed first grade, and was ahead if she had completed third grade. Finally, we summed the percentile rankings of reading, writing, arithmetic, and grade progression into one cumulative indicator of achievement, which ranked each child on a scale relative to the population distribution.

District-level governmental investments in schooling were classified into four sets. Measures of *school infrastructure* included the percentage of: schools established since 1995, schools with at least one building, schools with *pucca* (higher quality building materials) building, schools with gender-separate toilets, schools with more than one classrooms, classrooms in good condition or not needing repair, pupils enrolled in schools with at least one blackboard and schools with pre-primary programs. Measures of *school receipt of grants* were development grants and TLM grants. Measures of *investments in teachers* included the percentage of schools with more than one teacher and with at least one female teacher and the number of teachers per 100 pupils (teacher quantity); the percentage of

teachers who were permanent teachers, had in-service training; and who had at least graduated from secondary school (teacher quality). Finally, measures of *incentives* included the number of attendance incentives per 100 pupils and the numbers of free books, free units of stationery, and free uniforms per 100 pupils. These measures corroborate those used in other studies in lower-income countries, though they cover more types of investments than most studies have done individually.

Given the large number of investment indicators, we also used principal components analysis (PCA) to create composite scores reflecting the overall level of investment of each type. Component scores were derived from the scoring coefficients for the first principal component of each set of investments. The Chronbach's alphas and Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy for each of these scores were, respectively: .57 and .65 for school infrastructure, .90 and .50 for grants to schools, .47 and .58 for teacher quantity and quality, and .41 and .50 for incentives to pupils.

Based on the literature, we included control variables that have been associated with academic performance and with investments in schooling. *Child-specific controls* were age in years, gender, age-order among the household's children, and the language of testing among the 13 offered. *Household controls* were a socio-economic quintile scale based on ownership of 30 household consumer goods and assets; household caste/religion (Brahmin or High Caste, OBC (Other backward Classes), Dalit or Adivasi, Muslim, and Sikh, Jain or Christian); the highest grade completed by any adult man and highest grade completed by any adult woman in the household. *School controls* were type of school (government, private, other) and distance to school in kilometers. *District controls* were the average schooling percentile ranking of IHDS respondents, percent of the population living in urban areas, percent of the population from scheduled castes or tribes, sex ratio of the population, geographic region (North, Central, East, Northeast, West, or South), and decadal population growth rate.

Analysis

Sample weights, strata, and PSUs were specified to account for study design in the estimation of all descriptive statistics and multivariate models. The software used was Stata 11. We began with exploratory data analyses to assess the completeness and distributions of all variables, followed by bivariate tests. We used logistic regression to estimate multivariate models for each dichotomous outcome (writing and appropriate grade level) and ordered logistic regression for each categorical outcome (reading and math), $Y_{ijkl,a}$, with a = 1,…, 5 indicators for children's achievement with the general specification:

$$Y_{ijkl,a} = ß_{0a} + ß_{Ia}I_l + ß_{Ca}C_{ijkl} + ß_{Ha}H_{jkl} + ß_{Sa}S_{kl} + ß_{Da}D_l \quad (1)$$

where I_l denotes the vector of explanatory variables for district-level governmental investments in schooling, and the remaining vectors denote child C_{ijkl}, household H_{jkl}, school S_{kl}, and district D_l control variables.

To understand the net population-average contribution of governmental investments in schooling to children's academic performance in the context of other influences from the home, school and district, we performed additional hierarchical multivariate regressions in which we controlled for all other variables and then added sets of investment and control variables. We then computed the proportion of the total R^2 for each outcome attributable to governmental district-level investments in schooling.

To compare the potential of each type of investments to improve children's education, we predicted the educational outcomes that would be associated with an increase in each type of investment to one standard deviation above the current mean. After estimating each model, we computed the predicted distribution of children's reading, writing and math performance and grade

attainment at specific values of each investment PCA variable, holding all other variables at their mean and calculating confidence intervals by the delta method.

Several alternative specifications and robustness checks were used. As an alternative to ordered logistic regressions, we estimated OLS models with the normalized percentile outcome variables described above. Because previous studies often have reported different results for boys and girls, we estimated gender-stratified models. To understand the importance of government investments for children who were directly exposed to them rather than also capturing spillovers from these investments, we have also estimated models for only those children currently attending government schools. Finally, in robustness checks (not shown), we only retained the investments in each domain that were most highly associated with pupil achievement; results were consistent.

RESULTS

Characteristics of children and governmental investments

On average, children were 9.5 years old and had 2.4 older siblings (Table 1). Almost a third of children were living in poverty. About a third of children were from scheduled-caste or scheduled-tribe families, and another third were from OBC. On average, the adult men in children's households had completed 6.7 years of school, and the adult women 4.0 years of school. Almost 70% of children attended government schools and lived on average 1.5 kilometers from school.

[Table 1]

Objective assessments showed wide variation in children's academic performance. In tests of reading and writing, the largest percentage could read stories (33%) and write three sentences correctly (68%), but 10% could not read at all, and a third could not write. On math tests, 18% demonstrated no numeracy, over a third knew the numbers up to 99, and another 22% could perform all basic math skills. About 70% were at the age-appropriate grade or above.

Children were exposed to a range of governmental investments in schooling. The average child lived in a district in which a quarter of schools had been established since 1995, and in which most schools had at least one building (97%), pucca building materials (83%), more than one classroom (89%), classrooms in good condition (65%), at least one blackboard (95%), and had received development (76%) and TLM grants (70%). Still, the average child lived in a district in which only a minority of schools had gender-separate toilets (31%) and pre-primary programs (21%). The average child lived in a district in which the mean pupil-to-teacher ratio was low (2.6 teachers per 100 pupils) and in which some schools had limited faculty, (26% did not have more than one teachers and 34% did not have any female teachers). On average, children lived in districts in which 91% of the teachers were permanent, (not *para-teachers)*, but only 40% of teachers had at least secondary school training. On average, children lived in districts in which 10 incentives to attend were given per 100 pupils, as well as 64 free books, 4 free units of stationery, and 7 free uniforms per 100 pupils.

Governmental investments in schooling and children's academic achievement

Table 2 shows the child-level pair-wise correlations between performance on reading, writing, math and grade progression on one hand and district-level investments in schooling on the other hand. Most investments were significantly and positively correlated with performance and age-appropriate grade level. Measures of test performance were most highly correlated with measures of investments in teachers, especially the use of permanent teachers, while grade progression was most strongly and positively correlated with the pupil-to-teacher ratio ($r = .17$).

[Table 2]

The investment in school infrastructure that correlated most strongly though negatively with children's test scores was the number of schools built in the prior decade (*r* between -.11 and -.15).

These correlations, which corroborate findings from the U.S., may indicate the allocation of new schools to poor-performing areas or may suggest that student performance is poorer in less-established schools. Most highly positively correlated with test results is the percent of schools with at least one school building (r = .13 and .08, for writing and math) and the percent of schools receiving TLM grants (r=.08 for reading). The percentage of classrooms in good condition was the infrastructure variable most strongly correlated with being in the age-appropriate grade (r = .09). Improvement grants to schools, especially TLM grants, were positively associated with test performance and grade progression. Among investments in teachers, permanent teachers and multiple teachers per school was associated with achievement. The incentives that were most strongly and positively correlated with children's test performance (.08-.11) and grade progression (.11) were the numbers of free units of stationery and uniforms per 100 pupils. The component indices showed that investments in teachers, followed by incentives, were most highly and positively associated with children's test performance and school progression.

Table 3 shows the results of multivariate models including all governmental investments as predictors of achievement. After controlling for child, household, school, and other district characteristics and the full set of investments, several governmental investments in schools were significantly associated with children's test performance and school progression. Most important among them were investments in schools with buildings and with multiple classrooms and free stationery and uniforms for children. Some investments, especially in building materials, TLM grants, female teachers and free books were negatively associated with achievement. These associations are consistent with those estimated using linearized outcomes where children's performance is estimated in terms of their percentile ranking relative to the other children who were tested (Appendices 1 and 2).

[Table 3]

When investments in schooling are viewed in sets using the PCA scores (Table 4), the positive associations between investments and children's learning are clearer. Incentives were most strongly and positively associated with math and reading performance and with being at the appropriate grade level, and investments in school infrastructure with writing.

[Table 4]

Contributions of governmental investments to variation in achievement

In hierarchical linear regressions (Table 5), model R^2 statistics indicate that, taken together, governmental investments and the child, household, school and district control variables explained up to 30% of the variation in test performance (.18 – .30) and up to 22% of the variation in staying on schedule in school. Governmental investments accounted for 3% of this explained variation in reading performance, 6% of writing, 3% of mathematics, and 2% of the explained variation in grade progression.

[Table 5]

Predicted performance with higher governmental investments

Figure 1 shows the current distribution of children across levels of performance in reading, writing, math, and grade progression and the predicted distribution of children across levels of performance if investments in each domain were one standard deviation above the current mean. With a one-standard deviation above the mean higher investments in school grants, school infrastructure and teachers, we would expect more children to have some literacy and numeracy skills than they currently do, but not necessarily to perform at the highest level of reading and math (reading a story or doing division). We would also expect children to be more likely to be able to write and to be in the appropriate grade level than they currently are. Among these four types of investments, the smallest benefits are predicted from higher investments in teachers.

[Figure 1]

With higher levels of investments in incentives for pupils, we would expect more children to be able to read whole paragraphs and stories, achieving the highest level of age-appropriate literacy. We would also expect more children to have some numeracy skills than they currently do, but not necessarily to perform at the highest age-appropriate level of math (doing division). We would also expect children to be more likely to write and to be in the appropriate grade level than they currently are.

Other determinants of performance and attainment

The associations between children's performance and attainment and other characteristics are shown in Table 4. Older children performed better by all indicators, and children who were older among the children in their households performed additionally better. Girls performed worse than boys. Performance tended to be higher in wealthier households with more educated adults (especially women) and was lower for children living in poverty. Performance was lower for children from OBC, and especially from scheduled caste, scheduled tribe, and Muslim households relative to Brahmin and High Caste children.

Children who lived farther from school performed worse, as did children who attended government schools. Among district social and economic indicators, a more equitable sex ratio of women to men was most often significantly positively associated with children's performance. Children who lived in districts where the average performance was higher themselves performed better.

Alternative specifications

Comparing the associations between government investments and performance among boys and girls, these investments tend to be associated more often with better performance among boys than among girls (Appendix 3).

When we focus on only children currently attending government schools (Appendix 4), that is, those directly exposed to governmental investments in schools, most investments were associated with better performance by all indicators. Among school infrastructure variables, performance was associated with school size, specifically multi-classroom schools and school buildings. Grants given to schools were associated with some measures of performance, though the direction of the associations is mixed. Measures of investments in teacher quality were associated with some indicators of performance, especially teacher training, education, and contracting. Among incentives to children, provision of free uniforms was associated most often with better performance.

Discussion

Faced with limited resources and a pressing need to improve schooling outcomes, policymakers around the world and especially in lower-income countries often must identify the most promising allocation of these scarce resources for achieving the greatest improvements. This study used a unique dataset combining an array of district-level measures of investments in schooling with nationally representative population-based measures of children's school progression and test performance at ages 8 to 11 years. Both kinds of data are rare for lower-income countries, and their linkage affords a unique opportunity to examine to what extent and which public investments in schooling may be directly associated with children's academic achievement. We explored the associations between governmental investments in schools, teachers, and incentives and children's reading, writing and arithmetic performance and grade progression.

India provides an important context for this study. All children in India are mandated by the constitution to receive free education until the age of fourteen years and the government of India

has made substantial investments in education. Nonetheless, nearly 14 million Indian children are out-of-school, 40 million children leave school before grade 5, and children's basic reading and writing skills are low.

We found that, among the major types of investments in schooling, improvement grants given to schools and incentives given to pupils tended to be most strongly positively associated with student test performance and with grade progression after accounting for family resources and child, school, and community characteristics. In terms of specific investments, large investments - basic school buildings with multiple classrooms - were associated with better test performance, as were smaller investments - stationery and uniforms for pupils.

We found that with investments in schools, teachers, and incentives at one standard deviation above the current mean, we could expect to see a higher proportion of 8-11 year-old children having higher literacy and numeracy skills than they currently do – reading words and paragraphs and being able to do addition and subtraction. However, we would not necessarily see more children being able to achieve the highest level of age appropriate math – doing division. With these higher investments in incentives, we would expect to see more children able to read whole stories, to be able to write, and to be in the appropriate grade level than they currently are. The smallest benefits are expected from higher levels of investments in teachers.

Previous studies have highlighted the importance of the home environment for children's academic performance (Blau 1967, Buchmann 2000, Coleman 1988, Mare & Maralani 2006, Parcel & Dufur 2001), so a goal of this study was to assess the extent to which governmental investments in schooling can add to other contextual factors to improve children's academic achievement. We found that governmental investments in school infrastructure, teachers, and incentives accounted directly for a relatively small portion of the explained variation in children's performance and progression: together, these investments accounted directly for up to 6% of the explained variation. Several investments remained directly associated with children's higher academic achievement after controlling for numerous other factors. Still, the direct, collective role of these investments was substantially less than those of child, family, and community attributes. This finding could be in part because governmental investments exert indirect influences through more micro-level variables, for example motivating families to invest in education. The direct and indirect pathways by which investments in schools account for primary academic achievement should be explored in the future.

The mixed associations between investments and achievement do not necessarily suggest misallocation of resources. The level of investments achieved in some cases may not be sufficient to lead to improved outcomes. Also, governmental investments are often placed specifically to address poor performance (Aiyar et al. 2010) and some time may be required for the positive effects to be observable.

Two examples illustrate this point. One investment strongly and negatively associated with academic achievement is the percentage of schools in the district that were established in the prior 10 years. This variable indicates recent attempts to improve schooling and was substantially more prevalent in poorer-performing districts. It was correlated with poor individual-level performance on all tested measures, even after controlling for other characteristics, indicating that the benefits of the new amenities may not yet have materialized. In addition, research from the U.S. has indicated that pupil performance was lower in newly established schools (Metcalf et al. 1998), which may lack unmeasured aspects of quality present in more established schools.

Another complexity may be operating with respect to pupil-to-teacher ratios. In the U.S., this variable has in many studies been an important predictor of student performance, and it is an investment in which the best-performing districts in India are advantaged (not shown). Indeed, in bivariate correlations, a high pupil-to-teacher ratio was associated with better individual pupil performance and especially with grade progression. However, after controlling for other factors, the

ratio of teachers to pupils was non-significant or negatively associated with academic achievement. This finding may indicate that the positive association documented in correlations was largely a result of the variable's association with family and community resources. Our data show that even the best performing districts have an average of 2.34 teachers per 100 students, or 43 pupils per teacher, and this ratio is as high as 74 pupils per teacher in the worst-performing districts. Studies in the U.S. indicated thresholds for class size effectiveness, with benefits achieved when class sizes are under 20 (Betts & Shkolnik 1999). Therefore, it is not surprising that the pupil-to-teacher ratio was not associated with better individual performance after controlling for other characteristics. Another consideration is that efforts to improve the ratio in India often have relied on using less-qualified para-teachers, who may not be as equipped to make improvements as permanent teachers.

Some limitations of this study provide guidance for future research. First, because we do not have longitudinal data on pupil performance, we cannot quantify the causal effects of the introduction of new investments on children's performance. Nevertheless, the findings from our analysis provide an important platform from which researchers might follow up IHDS respondents to examine how changes in district-level investments as measured annually by the DISE predict changes in individual-level academic performance.

A second limitation is that the children who would have been the poorest performers may have refused to take the test to avoid embarrassment or wasting their time. In fact, those who did not take the tests were less likely to be enrolled in school. To assess the effects of selection bias on our inferences, we estimated alternative models with a Heckman correction, using participation in another direct test of the IHDS, anthropometry, as the selection criterion. We believe that participation in the anthropometric test is a good instrument because it is likely associated with willingness to participate in direct test measures, but not with academic test performance. Indeed, F-tests indicated that this was a good criterion. These alternative specifications did not yield different results.

A third limitation is that, while the PCA scores provide a more global assessment of the contribution of broad types of investments to children's performance, the Chronbach's alpha and KMO measures indicated that their fit is lower than ideal. Therefore, the component scores may not fully capture all of the indicators on which the scores are based.

Taken together, the strengths of our analysis outweigh its weaknesses. To our knowledge, this study has been the first to link a wide range of district-level measures of public investments in schooling with an array of population-based measures of children's academic achievement in a lower-income setting, where investments in schooling have substantial potential to improve the lives of a large percentage of the world's school-aged children. Such datasets are rarely available in lower-income settings, and are even more rare in these settings on a national scale. Indeed, while previous experimental studies have provided information about select inputs, such studies are highly localized and do not allow the examination of multiple types of investments. This analysis provides a complementary approach that contextualizes our understanding of how public investments are associated with child outcomes. An additional strength is that we are able to consider out-of-school children as well as children who are enrolled in school, an important consideration in settings where enrollment is not universal, allowing us to also understand spillovers to children more broadly from investments.

General conclusions can be made in light of our findings. The strongest predictors of reading, writing, math, and being on schedule in school were household socio-economic characteristics, specifically assets, poverty, caste and religion, the educational achievement of household women and men, and the type of school available to the child. In addition to these, government investments did also explain a small component of children's achievement. Investments in grants to improve teaching and materials in schools and investments in incentives for children to

enroll and attend school are associated with both progression and performance and may be cost-effective investments in similar contexts. Other investments, such as efforts to improve pupil-to-teacher ratios, may not be associated with academic performance until such ratios achieve a critical threshold.

Notes

[1.] Many states in India have used para-teachers since the mid-1990s to expand schooling and reduce pupil-teacher ratios. These are individuals whose educational qualifications do not fit government requirements. They are employed at salaries 1/5 to ½ of regular government teachers on renewable 10-month contracts (Kingdon 2007).

[2.] The DISE does not cover unrecognized schools, Education Guarantee Schools, and alternative learning centers, and coverage of private schools is incomplete but increasing; however, a minority of children attend these schools.

[3.] "Children were asked to write simple sentences and were considered able to write if they could write a simple sentence such as 'I like blue color' with zero or one mistakes" (Desai et al 2008).

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Table 1: Descriptive statistics, children aged 8-11 years in India, 2004-05 (n=11,950)

	Mean/Prop	(SE)	Min	Max
Child characteristics				
Age	9.47	(.02)	8.00	11.00
Girl	.47	(.01)	.00	1.00
Age order among household children	2.40	(.04)	1.00	13.00
Test-based school performance				
Test results – reading				
Cannot read	.10	(.01)		
Reads letters	.14	(.00)		
Reads words	.21	(.01)		
Reads paragraphs	.22	(.01)		
Reads stories	.33	(.01)		
Percentile	58.78	(.82)	1.00	10.00
Test results – writing				
Cannot write	.32	(.01)		
Writes with <3 mistakes	.68	(.01)		
Percentile	77.42	(.66)	3.00	10.00
Test results – math				
No numeracy	.18	(.01)		
Knows numbers	.34	(.01)		
Subtraction	.26	(.01)		
Division	.22	(.01)		
Percentile	63.81	(.77)	2.00	10.00
Academic progression				
Behind for age (including those not in school)	.18	(. 01)		
On schedule or ahead for age	.82	(. 01)		
Percentile	69.62	(.50)	2.00	10.00
Total percentile rank	269.62	(2.44)	62.00	40.00
Household characteristics				
Economic situation				
Household assets count	11.60	(.06)	.00	3.00
Living in poverty	.29	(.01)	.00	1.00
Caste/Religion				
Brahmin or High Caste	.19	(.01)		
OBC (other backward classes)	.36	(.01)		
Dalit (scheduled castes) or Adivasi (scheduled tribes)	.30	(.01)		
Muslim	.13	(.01)		
Sikh, Jain, or Christian	.02	(.01)		
Education				
Highest years completed by adult men > age 21	6.65	(.05)	.00	15.00
Highest years completed by adult women > age 21	4.02	(.04)	.00	15.00
School characteristics				
School type				
Government	.69	(.02)		
Private	.24	(.01)		
Other	.07	(.01)		
Distance to school (km)	1.46	(.02)	1.00	4.00
District characteristics				
Percent urban	27.95	(1.11)	.00	100
Sex ratio, females to males	932.45	(.78)	752.00	1147.00
% of population scheduled caste or scheduled tribe	29.33	(.37)	.00	10.00
Decadal growth rate	924.77	(1.38)	922.06	927.48
Total percentile rank for district IHDS respondents	27.09	(18.62)	128.77	351.92
District-level governmental investments in schooling				
School infrastructure				

% schools established since 1995	22.07	(.39)	.00	71.20
% schools with ≥ 1 building	97.20	(.10)	59.50	10.00
% schools made of pucca	82.86	(.24)	.00	10.00
% schools with gender-separate toilets	3.91	(.62)	.00	87.60
% schools with > 1 classroom	88.55	(.42)	22.00	1.00
% classrooms in good condition	65.39	(.29)	4.40	99.80
% students in schools with ≥ 1 blackboard	95.07	(.23)	29.00	10.00
% schools with pre-primary programs	17.98	(.38)	.00	99.30
Grants to schools				
% schools receiving development grants	76.47	(.28)	.00	10.00
% schools receiving TLM grants	69.45	(.55)	.00	10.00
Teachers				
Teachers/100 pupils	2.58	(.04)	.80	12.99
% schools with > 1 teacher	84.85	(.26)	17.50	10.00
% schools with ≥ female teacher	65.08	(.55)	25.80	10.00
% teachers that are permanent teachers	91.31	(.41)	36.16	10.00
% teachers with in-service training	58.48	(.23)	29.64	92.51
% teachers who are ≥ secondary school graduates	39.87	(.37)	.70	83.92
Incentives for pupils				
Incentives to attend/100 pupils	1.40	(.59)	.00	99.16
Free books /100 pupils	63.36	(.35)	.02	136.97
Free stationery /100 pupils	4.01	(.08)	.00	79.88
Free uniforms /100 pupils	7.16	(.26)	.00	83.95

Note: Data Source IHDS, 2005 and DISE 2004-05. Statistics are survey-adjusted.

Table 2: Child-level pairwise correlation coefficients between child academic achievements and district-level investments in schooling, children aged 8 – 11 years in India, 2004-05[1] (n=11,950)

	Math	Reading	Writing	Grade level
School infrastructure				
% schools established since 1995	**-0.15***	**-0.11***	**-0.13***	-0.02*
% schools with ≥ 1 building	0.08*	0.05*	**0.13***	0.06*
% schools made of *pucca*	-0.05*	-0.07*	-0.06*	-0.04*
% schools with > 1 classroom	-0.01	0.03*	-0.04*	-0.03*
% classrooms in *good condition*	-0.03*	0.02*	-0.03*	**0.09***
% students enrolled in schools with ≥ 1 blackboard	-0.02*	0.03*	0.02*	0.04*
% schools with gender-separate toilets	0.06*	0.04*	0.05*	0.04*
% schools with pre-primary programs	0.00	-0.00	-0.01	0.06*
School infrastructure PCA	-0.01	0.00	-0.02	0.03*
Improvement grants given to schools				
% schools receiving development grants	0.04*	0.04*	0.04*	0.04*
% schools receiving TLM grants	**0.07***	**0.08***	**0.07***	**0.07***
Grants to schools PCA	0.06*	0.07*	0.06*	0.06*
Teacher quantity and quality				
% schools with > 1 teacher	0.13*	0.08*	0.12*	0.04*
Teachers/100 pupils	0.09*	0.10*	0.08*	**0.16***
% schools with ≥ 1 female teacher	0.09*	**0.12***	0.09*	0.13*
% teachers that are permanent teachers	**0.16***	**0.12***	**0.15***	0.12*
% teachers with in-service training	-0.06*	-0.05*	-0.03*	-0.08*
% teachers who are ≥ secondary school graduates	-0.04*	-0.06*	-0.12*	-0.07*
Teachers PCA	0.17*	0.16*	0.18*	0.18*
Incentives given to pupils				
Incentives to attend/100 pupils	-0.07*	-0.02*	-0.06*	-0.04*
Free books/100 pupils	-0.04*	0.01	-0.06*	0.03*
Free stationery/100 pupils	**0.09***	**0.11***	0.04*	0.10*
Free uniforms/100 pupils	0.07*	0.06*	**0.08***	**0.11***
Incentives given to pupils PCA	0.11*	0.10*	0.08*	0.13*

Note: Data Source IHDS 2005 and DISE 2004-05.

*p < .05

[1]The variable in each domain of investments with the highest correlations to each measure of achievement are bolded.

Table 3: Estimates of children's achievement and district-level investments in schooling, children aged 8 – 11 years in India, 2004-05: Results from survey-adjusted ordered logistic (for math and reading) and logistic regressions (for writing and grade level) (n=11,950)

	(1) Math	(2) Reading	(3) Writing	(4) Grade level
School infrastructure				
% schools established since 1995	1.00	1.00	1.01	0.99
	(0.00)	(0.00)	(0.00)	(0.00)
% schools with ≥ 1building	1.02*	1.01	1.04**	1.02
	(0.01)	(0.01)	(0.01)	(0.02)
% schools made of pucca	0.99+	0.99*	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.01)
% schools with > 1classroom	1.01	1.01**	1.01*	1.00
	(0.00)	(0.00)	(0.01)	(0.01)
% classrooms in good condition	0.99	1.00	0.99	1.00
	(0.00)	(0.00)	(0.00)	(0.01)
% students in schools with ≥ 1blackboard	1.01	1.00	1.01	0.99
	(0.01)	(0.01)	(0.01)	(0.01)
% schools with gender-separate toilets	1.01*	1.00	1.01	1.01
	(0.00)	(0.00)	(0.00)	(0.00)
% schools with pre-primary programs	1.00	1.00	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
Improvement grants given to schools				
% schools receiving development grants	1.00	1.00	1.00	1.01**
	(0.00)	(0.00)	(0.00)	(0.00)
% schools receiving TLM grants	1.00	1.00	1.01	0.99*
	(0.00)	(0.00)	(0.00)	(0.00)
Teacher quantity and quality				
% schools with more than one teacher	0.99	1.00	1.00	0.99
	(0.00)	(0.00)	(0.01)	(0.01)
Teachers/100 pupils	1.01	1.03	0.99	1.10
	(0.04)	(0.04)	(0.06)	(0.08)
% schools with at least one female teacher	0.99**	1.00	1.01+	0.99
	(0.00)	(0.00)	(0.01)	(0.01)
% teachers that are permanent teachers	1.01*	1.00	0.99	1.00
	(0.00)	(0.00)	(0.01)	(0.01)
% teachers with in-service training	1.00	1.01	1.00	1.01+
	(0.00)	(0.00)	(0.01)	(0.01)
% teachers who are at least secondary school graduates	1.00	1.00	1.00	1.01
	(0.00)	(0.00)	(0.00)	(0.01)
Incentives given to pupils				
Incentives to attend/100 pupils	1.00	1.00	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
Free books/100 pupils	1.00	1.00	0.99**	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
Free stationery/100 pupils	1.00	1.01*	1.01	1.00
	(0.00)	(0.00)	(0.01)	(0.01)
Free uniforms/100 pupils	1.01*	1.01*	1.00	1.01+
	(0.00)	(0.00)	(0.01)	(0.01)

Note: Data Source IHDS, 2005 and DISE 2004-05.
Standard errors in parentheses. Statistics are adjusted for survey design. Models control for individual, household, school, and other district variables, as summarized in Table 1.
+ p < .1; *p < .05; **p < .01

Table 5: Estimates of children's achievement and sets of governmental investments into each domain of schooling, children aged 8 – 11 years in India, 2004-05: Results from survey-adjusted ordered logistic (for math and reading) and logistic regressions (for writing and grade level) using PCA scores for investments (n=11,950)

	(1) Math	(2) Reading	(3) Writing	(4) Grade level
District-level investments in schooling				
School infrastructure PCA	1.04	1.00	1.19**	1.05
	(0.04)	(0.04)	(0.06)	(0.05)
Improvement grants given to schools PCA	1.05+	1.06*	1.08*	1.02
	(0.03)	(0.03)	(0.04)	(0.04)
Teachers PCA	1.05	0.97	1.08	0.94
	(0.04)	(0.04)	(0.05)	(0.06)
Incentives given to pupils PCA	1.10**	1.15**	1.05	1.16*
	(0.04)	(0.04)	(0.05)	(0.07)
Child characteristics				
Age	1.60**	1.60**	1.41**	0.53**
	(0.03)	(0.04)	(0.04)	(0.02)
Girl	0.74**	0.88**	0.85**	0.87
	(0.04)	(0.04)	(0.05)	(0.08)
Age order among household children	0.95+	0.93**	0.96	0.95
	(0.03)	(0.02)	(0.03)	(0.03)
Household characteristics				
Economic situation				
Household assets count	1.07**	1.05**	1.05**	1.06**
	(0.01)	(0.01)	(0.01)	(0.01)
Living in poverty	0.83**	0.73**	0.68**	0.84*
	(0.05)	(0.05)	(0.06)	(0.07)
Caste/Religion (Ref= Brahmin or High Caste)				
OBC (other backward classes)	0.85*	0.91	0.80+	0.87
	(0.06)	(0.07)	(0.09)	(0.12)
Dalit (scheduled castes) or Adivasi (scheduled tribes)	0.68**	0.76**	0.78+	0.90
	(0.06)	(0.07)	(0.11)	(0.14)
Muslim	0.61**	0.70**	0.62**	0.56**
	(0.06)	(0.07)	(0.08)	(0.09)
Sikh, Jain, or Christian	0.82	0.96	1.47	0.95
	(0.14)	(0.16)	(0.49)	(0.30)
Education				
Highest education of adult men > age 21 (grades)	1.04**	1.03**	1.03**	1.01
	(0.01)	(0.01)	(0.01)	(0.01)
Highest education of adult women > age 21 (grades)	1.05**	1.07**	1.07**	1.09**
	(0.01)	(0.01)	(0.02)	(0.02)
School characteristics				
School type (Ref= Government)				
Private	1.62**	1.67**	1.56**	0.46**
	(0.12)	(0.13)	(0.18)	(0.05)
Other	1.47**	1.19+	1.12	0.58**
	(0.15)	(0.11)	(0.16)	(0.10)
Distance to school (km)	1.02	1.03	1.01	1.09*
	(0.01)	(0.02)	(0.03)	(0.04)
District characteristics				
Percent urban	1.00	1.01**	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
Sex ratio, females to males	1.00	1.00**	1.00+	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
% of population scheduled caste or scheduled tribe	1.00	1.01**	1.00	1.00

	(0.00)	(0.00)	(0.00)	(0.00)
Decadal population growth	1.00	1.00	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
Total percentile rank for district IHDS respondents	1.01**	1.01**	1.01**	1.01*
	(0.00)	(0.00)	(0.00)	(0.00)

Note: Data Source IHDS, 2005 and DISE 2004-05.
Standard errors in parentheses. Statistics are adjusted for survey design. Models control for region, language of testing, and missing values.
*p < .05; **p < .01[1]

Table 5: Total R-squared from each model and percentage of it attributable to each investment, India, 2004-05 (n=11,950)

	Total R^2	% of total R^2 attributable to school investments
Reading performance ranking	27.40	2.55%
Writing performance ranking	18.50	6.49%
Math performance ranking	3.20	2.65%
Grade progression ranking	22.50	1.78%

Note: Data Source IHDS, 2005 and DISE 2004-05.

Appendix 4: Estimates of children's achievement and district-level investments in schooling, children aged 8 – 11 years currently attending government school in India, 2004-05: Results from survey-adjusted ordered logistic (for math and reading) and logistic regressions (for writing and grade level) (n=6,967)

	(1) Math	(2) Reading	(3) Writing	(4) Grade level
School infrastructure				
% schools established since 1995	1.00	1.00	1.01+	1.00
	(0.00)	(0.00)	(0.01)	(0.01)
% schools with ≥ 1 building	1.02	1.01	1.04*	1.03
	(0.01)	(0.02)	(0.02)	(0.02)
% schools made of pucca	0.99+	0.99*	0.99	1.00
	(0.00)	(0.00)	(0.01)	(0.01)
% schools with > 1 classroom	1.01+	1.01**	1.01*	1.01
	(0.00)	(0.00)	(0.01)	(0.01)
% classrooms in good condition	1.00	1.00	1.00	0.99
	(0.00)	(0.00)	(0.01)	(0.01)
% students in schools with ≥ 1blackboard	1.01	1.01	1.02	0.98+
	(0.01)	(0.01)	(0.01)	(0.01)
% schools with gender-separate toilets	1.01	1.00	1.01	1.00
	(0.00)	(0.00)	(0.00)	(0.01)
% schools with pre-primary programs	1.00	1.00	1.00	0.99
	(0.00)	(0.00)	(0.00)	(0.00)
Improvement grants given to schools				
% schools receiving development grants	1.00	1.00	1.00	1.02**
	(0.00)	(0.00)	(0.00)	(0.01)
% schools receiving TLM grants	1.00	1.01*	1.01*	0.99*
	(0.00)	(0.00)	(0.00)	(0.01)
Teacher quantity and quality				
% schools with more than one teacher	0.99	1.00	1.00	0.99
	(0.01)	(0.01)	(0.01)	(0.01)
Teachers/100 pupils	0.98	1.11+	1.03	1.15
	(0.05)	(0.06)	(0.08)	(0.12)
% schools with at least one female teacher	0.99	1.00	1.01	0.99
	(0.01)	(0.00)	(0.01)	(0.01)
% teachers that are permanent teachers	1.01*	1.00	1.00	1.00
	(0.01)	(0.00)	(0.01)	(0.01)
% teachers with in-service training	1.00	1.01*	1.01	1.01
	(0.01)	(0.01)	(0.01)	(0.01)
% schools who are at least secondary school graduates	1.00	1.01+	1.00	1.01
	(0.00)	(0.00)	(0.01)	(0.01)
Incentives given to pupils				
Incentives to attend/100 pupils	0.99	0.99	1.00	1.00
	(0.00)	(0.00)	(0.01)	(0.01)
Free books/100 pupils	1.00	1.00	0.99+	0.99
	(0.00)	(0.00)	(0.00)	(0.00)
Free stationery/100 pupils	1.00	1.01	1.01	1.01
	(0.00)	(0.00)	(0.01)	(0.01)
Free uniforms/100 pupils	1.01*	1.01**	1.01	1.01
	(0.00)	(0.01)	(0.01)	(0.01)

Note: Data Source IHDS, 2005 and DISE 2004-05.
Standard errors in parentheses. Statistics are adjusted for survey design. Models control for individual, household, school, and other district variables, as summarized in Table 1.
+ p < .1; *p < .05; **p < .01
[1] This cumulative indicator of academic achievement is based on the sum of the percentile rankings of reading, writing, arithmetic, and grade progression.

Appendix 1: Estimates of children's achievement and district-level investments in schooling, children aged 8 – 11 years in India, 2004-05: Results from survey-adjusted OLS regressions (N=11,950)

	(1) Reading ranking	(2) Writing ranking	(3) Math ranking	(4) Grades ranking	(5) Total score ranking[1]
School infrastructure					
% schools established since 1995	-.09+	.05	-.03	-.03	-.10
	(.05)	(.05)	(.04)	(.04)	(.15)
% schools with ≥ 1building	.16	.52**	.29**	.16	1.13**
	(.16)	(.17)	(.12)	(.14)	(.44)
% schools made of pucca	-.11**	-.06	-.07+	.02	-.24+
	(.05)	(.05)	(.04)	(.04)	(.14)
% schools with > 1classroom	.15**	.12*	.07	.03	.39*
	(.06)	(.06)	(.04)	(.05)	(.16)
% classrooms in good condition	-.01	-.07	-.05	-.05	-.17
	(.05)	(.06)	(.04)	(.06)	(.16)
% students in schools with ≥ 1blackboard	.04	.09	.07	-.13	.03
	(.09)	(.12)	(.08)	(.09)	(.29)
% schools with gender-separate toilets	-.00	.09+	.07*	.04	.21+
	(.04)	(.05)	(.03)	(.04)	(.12)
% schools with pre-primary programs	-.06+	-.01	-.02	-.00	-.07
	(.03)	(.03)	(.02)	(.03)	(.08)
Improvement grants given to schools					
% schools receiving development grants	-.02	-.03	.02	.09*	.08
	(.05)	(.05)	(.03)	(.04)	(.12)
% schools receiving TLM grants	.06	.08	.00	-.07*	.06
	(.05)	(.05)	(.03)	(.03)	(.10)
Teacher quantity and quality					
% schools with more than one teacher	-.01	-.05	-.08	-.05	-.13
	(.07)	(.07)	(.05)	(.06)	(.18)
Teachers/100 pupils	.19	-.23	.18	.61	1.32
	(.58)	(.63)	(.48)	(.52)	(1.58)
% schools with at least one female teacher	-.00	.09	-.12*	-.05	-.07
	(.05)	(.06)	(.05)	(.05)	(.16)
% teachers that are permanent teachers	-.03	-.08	.10+	.01	-.05
	(.07)	(.08)	(.05)	(.07)	(.20)
% teachers with in-service training	.10	.02	.02	.09	.21
	(.06)	(.07)	(.05)	(.06)	(.18)
% teachers who are at least secondary school graduates	.09+	.01	.03	.08+	.21
	(.05)	(.06)	(.04)	(.05)	(.14)
Incentives given to pupils					
Incentives to attend/100 pupils	.01	.07	-.05	-.03	.01
	(.05)	(.05)	(.04)	(.05)	(.14)
Free books/100 pupils	.03	-.11**	.01	.03	-.05
	(.032)	(.04)	(.03)	(.03)	(.09)
Free stationery/100 pupils	.13*	.09	.01	.01	.22
	(.057)	(.06)	(.04)	(.04)	(.14)
Free uniforms/100 pupils	.11+	.07	.10*	.11**	.35*
	(.06)	(.06)	(.05)	(.04)	(.18)
Total R-squared	.274	.185	.302	.225	.297

Note: Data Source IHDS, 2005 and DISE 2004-05.
Standard errors in parentheses. Statistics are adjusted for survey design. Models control for individual, household, school, and other district variables, as summarized in Table 1.
+ $p < .1$; * $p < .05$; ** $p < .01$
[1] This cumulative indicator of academic achievement is based on the sum of the percentile rankings of reading, writing, arithmetic, and grade progression.

Appendix 2: Estimates of children's achievement and sets of governmental investments into each domain of schooling, children aged 8 – 11 years in India, 2004-05: Results from survey-adjusted OLS regressions with principal component analyses (n=11,950)

	(1) Reading ranking	(2) Writing ranking	(3) Math ranking	(4) Grades ranking	(5) Total score ranking[1]
District-level investments in schooling					
School infrastructure PCA	.06	2.22**	.55	.45	3.27*
	(.54)	(.64)	(.46)	(.47)	(1.59)
Improvement grants given to schools PCA	.97**	.94*	.55+	.07	2.52*
	(.36)	(.44)	(.33)	(.38)	(1.07)
Teachers PCA	-.49	1.06+	.66	-.57	.66
	(.57)	(.64)	(.50)	(.56)	(1.69)
Incentives given to pupils PCA	1.96**	.55	1.18**	1.30**	4.98**
	(.54)	(.56)	(.46)	(.41)	(1.41)
Child characteristics					
Age	7.20**	4.46**	5.76**	-6.03**	11.39**
	(.33)	(.39)	(.26)	(.33)	(.91)
Girl	-1.85**	-2.06**	-4.05**	-.80	-8.76**
	(.70)	(.78)	(.64)	(.73)	(2.14)
Age order among household children	-1.04**	-.53	-.59+	-.49+	-2.65*
	(.33)	(.43)	(.32)	(.30)	(1.08)
Household characteristics					
Economic situation					
Household assets count	.69**	.51**	.84**	.48**	2.52**
	(.12)	(.13)	(.10)	(.10)	(.35)
Living in poverty	-5.15**	-5.61**	-2.61**	-1.93*	-15.30**
	(.94)	(1.17)	(.82)	(.86)	(2.82)
Caste/Religion (Ref= Brahmin or High Caste)					
OBC (other backward classes)	-1.13	-2.14	-1.90*	-1.50	-6.68*
	(1.13)	(1.31)	(.91)	(1.04)	(3.19)
Dalit (scheduled castes) or Adivasi (scheduled tribes)	-3.91**	-3.01+	-4.98**	-.94	-12.85**
	(1.29)	(1.69)	(1.06)	(1.25)	(4.14)
Muslim	-5.09**	-5.28**	-6.00**	-5.93**	-22.30**
	(1.43)	(1.61)	(1.28)	(1.46)	(4.30)
Sikh, Jain, or Christian	-.12	1.66	-1.78	-1.36	-1.61
	(2.21)	(2.78)	(2.11)	(1.89)	(6.74)
Education					
Highest education of adult men > age 21 (grades)	.44**	.39**	.55**	.25*	1.64**
	(.11)	(.13)	(.09)	(.11)	(.32)
Highest education of adult women > age 21 (grades)	1.05**	.74**	.61**	.59**	2.99**
	(.13)	(.17)	(.11)	(.12)	(.39)
School characteristics					
School type (Ref= Government)					
Private	7.73**	5.74**	5.91**	-7.07**	12.31**
	(1.17)	(1.36)	(.97)	(1.12)	(3.33)
Other	2.75+	1.85	4.98**	-4.19**	5.40
	(1.48)	(1.72)	(1.25)	(1.41)	(3.98)
Distance to school (km)	.37+	.03	.23	.41*	1.03*
	(.21)	(.23)	(.16)	(.17)	(.52)
District characteristics					
Percent urban	.07*	-.01	-.03	.02	.06
	(.03)	(.04)	(.03)	(.03)	(.09)
Sex ratio, females to males	.05**	.03*	-.00	.01	.10**
	(.01)	(.01)	(.01)	(.01)	(.03)

% of population scheduled caste or scheduled tribe	.10**	-.00	.02	-.03	.09
	(.03)	(.034)	(.03)	(.03)	(.11)
Decadal population growth	-.02	.03	.02	.02	.05
	(.02)	(.02)	(.02)	(.02)	(.05)
Total percentile rank for district IHDS respondents	.15**	.16**	.13**	.09**	.53**
	(.02)	(.03)	(.02)	(.029)	(.07)
Constant	-108.00**	-73.84**	-52.27**	68.14**	-165.96**
	(14.46)	(14.83)	(9.19)	(13.32)	(4.55)
Total R-squared	.269	.178	.290	.219	.291

Note: Data Source IHDS, 2005 and DISE 2004-05.

Standard errors in parentheses. Statistics are adjusted for survey design. Models control for region, language of testing, and missing values.

*p < .05; **p < .01¹This cumulative indicator of academic achievement is based on the sum of the percentile rankings of reading, writing, arithmetic, and grade progression.

Appendix 3: Estimates of boys' (n=6,325) and girls' (n=5,625) achievement and district-level investments in schooling, children aged 8 – 11 years in India, 2004-05: Results from survey-adjusted ordered logistic (for math and reading) and logistic regressions (for writing and grade level) (n=11,950)

	Math		Reading		Writing		Grade level	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
School infrastructure								
% schools established since 1995	1.00	1.00	1.00	1.00	1.00	1.01	1.00	0.99*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
% schools with ≥ 1 building	1.02	1.03*	1.01	1.01	1.04*	1.06**	1.02	1.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
% schools made of pucca	0.99	0.99*	0.99	0.99*	1.00	0.99*	0.99	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
% schools with > 1 classroom	1.01	1.00	1.01*	1.01	1.02*	1.01+	1.00	1.01
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
% classrooms in good condition	0.99	0.99+	1.00	1.00	1.00	0.99	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
% students in schools with ≥ 1blackboard	1.00	1.00	1.00	1.00	1.00	1.01	0.98+	1.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
% schools with gender-separate toilets	1.01*	1.01	1.00	1.00	1.00	1.01	1.01	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
% schools with pre-primary programs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Improvement grants given to schools								
% schools receiving development grants	1.00	1.01*	1.00	1.00	1.00	1.00	1.01*	1.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
% schools receiving TLM grants	1.00	1.00	1.00	1.00	1.00	1.01	0.99	0.99+
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Teacher quantity and quality								
% schools with more than one teacher	0.99+	1.00	0.99	1.00	1.00	0.99	0.99	1.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Teachers/100 pupils	1.14*	0.97	1.09	0.97	1.01	1.00	1.11	1.09
	(0.06)	(0.05)	(0.06)	(0.05)	(0.08)	(0.07)	(0.12)	(0.09)
% schools with ≥ 1 female teacher	0.99*	0.99	1.00	1.00	1.02*	1.01	1.00	0.99
	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
% teachers that are permanent teachers	1.01	1.01	1.00	1.00	1.00	0.99	1.02+	0.98+
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
% teachers with in-service training	1.00	1.00	1.01	1.01	1.00	1.01	1.01	1.02+
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
% schools who are at least secondary school graduates	1.00	1.01*	1.00	1.01*	0.99+	1.01	1.01	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Incentives given to pupils								
Incentives to attend/100 pupils	0.99	1.00	0.99	1.01	1.00	1.01*	0.99	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Free books/100 pupils	1.00	1.00	1.00	1.00	0.99	0.99**	1.00	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Free stationery/100 pupils	1.00	1.00	1.00	1.01*	1.00	1.01+	1.00	1.01
	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Free uniforms/100 pupils	1.00	1.01+	1.01*	1.01	1.00	1.00	1.03*	1.00
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)

Note: Data Source IHDS, 2005 and DISE 2004-05.
Standard errors in parentheses. Statistics are adjusted for survey design. Models control for individual, household, school, and other district variables, as summarized in Table 1.
+ p < .1; *p < .05; **p < .01

Figure 1: Children's performance and grade progression currently and predicted levels associated with investments in each domain one standard deviation above the mean