The Impact of School Quality, Socio-Economic Factors and Child Health on Students' Academic Performance: Evidence from Sri Lankan Primary Schools

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Abstract

One of the eight Millennium Development Goals is that all children in developing countries should complete primary education. Much progress has been made toward this goal, but completing primary school does not ensure that students attain basic literacy and numeracy skills. Indeed, there is ample evidence that many children in developing countries are not learning these basic skills. This raises the question: What can schools and communities do to increase the learning that takes place in schools? Sri Lanka exemplifies these issues. It has achieved universal primary completion, but many Sri Lankan primary school students perform poorly on academic tests. This paper uses unusually rich data from Sri Lanka to investigate the determinants of academic performance, as measured by achievement tests, of grade 4 students. At the child and household level, educated parents, better nutrition, high daily attendance, enrollment in private tutoring classes, exercise books, electric lighting and children's books at home all appear to increase learning, while hearing problems have a strong negative effect. Among school variables, principals' and teachers' years of experience, collaborating with other schools in a "school family", and meetings between parents and teachers all appear to have positive impacts on students' scores. Estimates that exclude some of the variables available in the unusually rich data yield different results, which suggests that results based on less complete data are likely to suffer from omitted variable bias. A final section provides recommendations for education policies in Sri Lanka.

I. Introduction

Academic economists and international development agencies claim that education is essential for economic growth and, more generally, a higher quality of life (Lucas, 1988; Barro, 1991; Mankiw, Romer and Weil, 1992; UNDP, 2003; World Bank, 2001). One of the eight Millennium Development Goals is that all children in developing countries should finish primary school. Yet developing country students who finish primary school often have weak academic skills (Glewwe and Kremer, 2006), which may sever the link between education and economic growth. This raises the question: What can developing countries do to promote learning in their schools?

This paper investigates the determinants of learning among Sri Lankan fourth grade students. Sri Lanka has already attained universal primary completion (Bruns, Mingat and Rakotomalala, 2003), but many Sri Lankan students display weak academic performance, and it is unclear what education policies would improve their performance. This paper uses unusually comprehensive and detailed data from Sri Lanka to study the impact of school quality, child health, and other factors on student learning in Sri Lanka.

The paper is organized as follows. Section II reviews the literature on learning in developing countries. Section III describes Sri Lanka's educational system. Section IV discusses the data and methodological issues. Sections V and VI present the results and discuss their policy implications, and Section VII summarizes the findings and concludes.

II. Previous Research on Academic Performance in Developing Countries

Many studies have attempted to estimate the impact of school and teacher characteristics on student performance, yet most have serious estimation problems that

cast doubt on their results (see Glewwe, 2002, and Glewwe and Kremer, 2006). Most are "retrospective," that is based on data collected from schools without attempting to alter those schools' characteristics. Yet even the best retrospective studies offer only limited guidance due to their estimation problems, the most serious being omitted variable bias and measurement error. This has led to wide variation in the estimated impacts of key variables. For example, of 30 developing country studies reviewed by Hanushek (1995), 8 found significantly positive impacts of the pupil-teacher ratio on student learning, 8 found significantly negative impacts, and 14 found no impacts.

More recently, researchers have evaluated natural experiments and randomized trials. The former use "natural" variation in a school characteristic that is unlikely to be correlated with any other determinants of learning. One example is assigning students by lottery to different schools. Three recent natural experiments suggest that: 1. Increasing school resources (measured by student-teacher ratios) raises reading (but not math) skills among black South African students (Case and Deaton, 1999); 2. Vouchers that provide funds for Colombian secondary students to attend private schools raise reading skills (Angrist et al, 2002); and 3. Reducing class size raises reading (and perhaps math) scores of Israeli students, but computers have no effect (Angrist and Lavy, 1999; 2002).

Randomized trials have been implemented in several developing countries. Randomized studies in Kenya and Latin America show sizeable impacts on school enrollment from reducing schooling costs (including subsidies conditional on regular school attendance). Regarding learning outcomes, workbooks and radio instruction in Nicaragua significantly increased pupils' math scores. Provision of textbooks increased learning in the Philippines, but in Kenya textbooks helped only the better students.

Evidence from Kenya also suggests little impact on test scores of reductions in class size, flip charts and deworming medicine, although school meals had positive impacts on test scores as long as teachers were well trained. A remedial education program and computer-assisted learning in India both appear to have increased learning. For a comprehensive literature review, see Glewwe and Kremer (2006).

Research has shown that child health affects schooling outcomes. Such research faces serious econometric challenges, yet a few recent papers have used credible methods to quantify the impact of early childhood nutrition on schooling outcomes. A recent study found that providing deworming medicine raises enrollment and daily attendance in Kenya (Miguel and Kremer, 2004). For a recent review, see Glewwe and Miguel (2008).

III. Primary Education in Sri Lanka

This section reviews the education system and student academic performance in Sri Lanka, focusing on primary schools and the test performance of grade 4 students.

A. Sri Lanka's Education System. Despite its low income ($1,300 per capita in 2007), Sri Lanka has enrolled nearly all primary aged (age 5-10) children in school; the net primary enrolment rate is 96%, and the primary completion rate is 95%. Gender equity also prevails; male and female enrollment rates are equal at all educational levels. These achievements reflect several policies. First, in the 1950s Sri Lanka established an extensive network of free public schools. Second, since the 1970s all students receive free textbooks and uniforms. Third, school enrollment has been compulsory since 1997 for children 6 to 14 years old (although families are rarely penalized for non-enrollment).

Sri Lanka's schools have two unusual features. First, private schools are rare (less than 5% of total enrollment); since the 1960s opening of new private schools has been forbidden, although pre-existing private schools can continue operating. Second, schools typically offer both primary and secondary grades. More specifically, Sri Lanka has four types of schools. Type 1AB offer grades 1-13 and all three curriculum streams (arts, commerce and science). Type 1C schools also offer grades 1-13, but only two streams (arts and commerce). Type 2 offer only grades 1-11, and Type 3 schools offer only grades 1-5 or 1-8. Almost all urban schools are Type 1AB or 1C and thus offer the full cycle (up to grade 13). Many rural schools are also Type 1AB or 1C, yet Type 2 (up to grade 11) are also common. Other rural schools are Type 3 and thus go up to only grade 5 or 8. In the NEREC data (described below), 46.3% of fourth graders attend schools offering grades 1-13, another 33.2% attend schools offering grades 1-11, and 20.5% attend schools offering grades 1-5 or 1-8.[1]

B. Performance of Grade 4 Students. In 2002, Sri Lanka's National Education Research and Evaluation Center (NEREC) collected data from a sample of 20 grade 4 students in each of 939 randomly selected public schools (NEREC, 2004). To measure the learning of students who had completed four years of school, these students were tested in mathematics, English and "first language" in March, 2003, when almost all were starting grade 5.[2] "First language" was Tamil for Tamil students and Sinhala for all other students. Each test had 40 questions, almost all of which were multiple choice.

Table 1 shows mean test scores, by socioeconomic groups. Scores are normalized to have zero mean and a standard deviation of one (see the first row). On average, girls

[1] These percentages are almost exactly equal to those for grade 1 pupils in Sri Lanka's 2003 school census.
[2] Sri Lanka's school year runs from January to December. The sample includes students who repeated grade 4, and thus were in grade 4 in both 2002 and 2003. Note that the primary repetition rate is only 3%.

outperformed boys on all tests (second and third rows). The next nine rows compare Sri Lanka's provinces. Western Province, which contains the two wealthiest districts (Colombo and Gampaha), performed best in all three subjects. Northwestern and Southern Provinces, which border Western Province, had the next highest scores. Northern and Eastern Provinces had the lowest scores, probably due to the impact of 20 years of secessionist conflict on their education systems. The next lowest performer is Uva Province, a relatively poor, underdeveloped province.

Test scores vary widely by ethnicity. The tiny Burgher minority (descendents of European colonists) scored highest, followed by Sinhalese, Muslims (Moors) and Tamils. Tamils' low scores reflect civil unrest in the Northeast, where most Tamils live, and the low incomes of Tamil tea and rubber estate workers in Sri Lanka's central mountains.

Students' scores are highly correlated with mothers' education, as expected. Children with uneducated mothers have the lowest scores, followed by children whose mothers have only primary schooling (1-5 years). Additional mothers' schooling is almost always associated with higher scores.

Given the discussion above, one would expect Type 1AB schools to be the best, and indeed their students scored highest on all three exams. Type 1C schools also offer 13 grades, and their students scored second highest on two of the three tests (math and first language). Surprisingly, student scores in Type 2 schools (up to grade 11) are lower than student scores in Type 3 schools, which are in remote or disadvantaged areas.

Table 1 also examines test scores by household per capita expenditure and student health status, from a subsample of the NEREC data with those variables (see Section IV). Students from wealthier families score higher, as expected. The last three rows suggest a

large role for health and nutrition. Height and weight data were used to calculate stunting (low height-for-age) and wasting (low weight-for-height), expressed as Z-scores, which compare a child's height and weight with those from a reference population of healthy children, whose Z-scores have a zero mean and a standard deviation of one. Low height-for-age indicates slow physical growth due to poor nutrition, diarrhea or other illnesses in the first years of life. Weight-for-height indicates recent malnutrition, diarrhea or other illnesses.[3] Stunted children (height-for-age Z-score < -2) scored about one third of a standard deviation below the average student. Marginally stunted children (Z-score from -2 to -1) scored slightly below average, and children who were not stunted (Z-score > -1) scored above average. This suggests that early childhood nutrition influences academic skills. Yet the relationship between *current* nutrition and academic performance is weak; the test scores of children with weight-for-height Z-scores below -2 ranged from -0.14 to -0.05, and those with higher Z-scores had scores either equal to or slightly above 0.00.

IV. Data and Methodology

This section describes the data available from Sri Lanka and the approach used to estimate the impacts of school quality, socioeconomic factors and child health on learning among grade 4 students in that country.

A. Data. This paper uses three sources of data. The first is the National Education Research and Evaluation Center survey of 16,383 students in 939 randomly selected

[3] A third indicator of child nutritional status is weight for age, which reflects both malnutrition in early childhood and current malnutrition. In order to distinguish between these two types of malnutrition, this paper uses only height for age and weight for height.

public schools (NEREC, 2004).[4] To measure the learning of students who completed grade 4 in December 2002, NEREC administered math, English and first language (Sinhalese or Tamil) tests to fifth graders near the beginning (March) of the 2003 school year. (Students who repeated grade 4 were tested, but not students who repeated grade 5.) At the same time, NEREC also administered questionnaires to students, parents, teachers, section heads, and principals.

The second source is the data collected by Sri Lanka's National Education Commission in the summer of 2003 from a random sub-sample of the NEREC students: 2,653 students in 140 schools (NEC, 2004). The NEC collected three types of data. First, it used a household questionnaire to collect child and household data, including parents' reports on their child's health. Second, school questionnaires were completed for each school, focusing on grade 4 teachers (including classroom observation). Third, in mid-2003 medical staff recorded health and nutrition data for each child. The data from the NEREC and NEC questionnaires are summarized in Appendix Tables A.1 and A.2.

The third data source is the Sri Lanka Integrated Survey (SLIS), which sampled 7,500 households in all provinces from October 1999 to September 2000. It collected a wide variety of data using household, community and price questionnaires.

B. Key Characteristics of Education in Sri Lanka. Several aspects of education in Sri Lanka have implications for estimation. First, primary education is virtually universal (the SLIS data show a 97.0% enrollment rate for children age 6-10), and this holds for all income groups (the rate for the poorest 20% of the population is 94.7%).

[4] NEREC originally planned to sample 1880 students from each of Sri Lanka's nine regions. In each region, about 100 schools were sampled, and 20 students were randomly sampled from each school. Only 94 schools with 20 students are needed for 1880 students, but a few schools were added since only 10 students were sampled if schools had less than 20 fourth graders.

Thus delayed entry into primary school is rare; if a substantial fraction of children enter grade 1 at age 7 or older, instead of age 5 or 6, the net enrollment rate would not be 97%. Therefore selection bias from delayed enrollment or non-enrollment in primary school is very unlikely.

Another important aspect is low grade repetition, which reflects an automatic promotion policy. The primary repetition rate is 3% (World Bank, 2005). Almost all fifth graders enroll on time and never repeat; 93% of the pupils in the NEC sample were born in the 12 month period (February 1993 to January 1994) corresponding to on-time enrollment and no repetition. Thus repetition cannot cause serious selection bias.

Finally, Sri Lanka has a low primary dropout rate. Only 1.4% of pupils who start grade 1 fail to finish grade 5, the last year of primary school (World Bank, 2005). Overall, lack of delayed enrollment, repetition and dropping out imply that both attrition and selection bias are unlikely; a sample of fifth grade pupils is a random sample of all Sri Lankan children who were nine years old at the start of the school year. (Sri Lankan pupils start grade 1 if they are five years old when the school year begins.)

Another estimation concern is whether parents can choose from several nearby schools and, if so, how frequently they do. Such choice is feasible; 66% of the NEC households report being within one kilometer of the nearest school, and 86% report being within two kilometers.[5] Yet most children attend the nearest school. The NEC data show that between 56%, and 81%, of Sri Lankan fourth graders attend the nearest school (25% of the sample is missing the variable indicating attendance at the nearest school). In contrast, only 15% report not attending the nearest school and doing so for school

[5] These numbers imply that, for a given household, as long as there are other households within 1-2 kilometers in two or more different directions, there are likely to be at least two schools within 2-3 kilometers of that household.

quality concerns. A far more common way for parents to address school quality worries is by enrolling their children in private tutoring ("tuition") classes that operate outside of school hours. The NEC data show that 74% of grade 4 students attend such classes.

A related issue is whether parents alter the quality of their children's schools. This appears unlikely. Teachers are assigned at the national level. The NEC data suggest that parents do not influence their children's schools. When asked "how often do you participate in school activities related to your child?" 81% responded "only if the school requires it". A more drastic way to alter school quality, moving to find a better school, is rare. About 72% of children live in their place of birth (SLIS data). Only 29% of adults report living away from their birthplace, and the main reasons for moving are marriage, land availability and work. Finally, parents rarely send their children to boarding schools; 94% of children in the NEC sample lived with both parents.

Overall, neither selection nor attrition bias is likely in Sri Lanka, and school quality is unlikely to be endogenous due to parental actions. Moreover, the few studies that check for such bias when estimating student learning typically have found little or no evidence of it (e.g. Glewwe and Jacoby, 1994, and Glewwe et al., 1995).

C. Analytical Framework. Estimating the impact of education policies on learning requires a clear framework to guide, and interpret, the estimates. Assume that parents maximize life-cycle utility, which depends on goods and services in each time period, child health in each time period, and each child's educational attainment and socioeconomic success. The constraints are production functions for academic skills (learning) and child health, the impacts of years in school and skills on children's future incomes, a life-cycle budget constraint, and (possibly) credit constraints.

The learning production function, a structural relationship, is:[6]

$$A = a_{pf}(\mathbf{C}, FS, MS, \mathbf{Q}; S, \mathbf{H}, \mathbf{EI}) \qquad (1)$$

where A is skills acquired ("achievement"), "pf" denotes production function**, C** is a vector of fixed child characteristics (mainly "innate ability" and motivation/preferences), FS and MS are fathers' and mothers' schooling, **Q** ("quality") is a vector of school, teacher and principal characteristics, S is the child's years in school, **H** is a vector of child health variables, and **EI** is all education "inputs" under parental control (time children spend studying at home, purchased education materials, time in tuition classes, etc.).

Consider which variables are endogenous and exogenous in the sense that parents control them.[7] The child characteristics in **C**, innate ability and motivation/tastes for education, are exogenous, as is parental schooling. Grade 4 students are young, so the **Q** variables (school, teacher or principal characteristics that affect learning) are largely time invariant. They are also arguably exogenous; most pupils attend the closest school and parents do little to alter school quality.

In most developing countries years of schooling (S) is endogenous since primary school children often start late, repeat and/or drop out. Yet these are all rare for Sri Lankan primary students, so S is exogenous. Indeed, S has no variation since all sampled children were in grade 4 in 2002, so it is dropped from the analysis (and can be dropped from (1)).

[6] For recent discussions of education production functions for developed and developing countries, see Glewwe (2002), Todd and Wolpin (2003), Glewwe and Kremer (2006), and Hanushek (2008).

[7] Note that this distinction is *not* the same as that between exogeneity and endogeneity for econometric estimation; the latter is concerned with whether a variable is correlated with the error term in an econometric model, which is discussed in more detail in the next subsection. In this subsection, this distinction is made to clarify the distinction between the production function for cognitive skills and the reduced form equation for cognitive skills (the latter includes only exogenous variables).

The last two sets of variables are endogenous. Child health (**H**) can directly affect learning (see Glewwe and Miguel, 2008, for a recent review). Child health problems include poor nutrition in early childhood, malnutrition while in school, parasitic infections, vision and hearing problems, and micronutrient deficiencies. Educational inputs (**EI**), which include daily attendance, enrollment in tuition (tutoring) classes, and purchased textbooks and other educational materials, are also clearly endogenous.

Several variables that affect learning are *excluded* from equation (1) because their effects are only *indirect*; they change A only by changing S, **H** and **EI**. They are school and health care prices ($\mathbf{P_S}$ and $\mathbf{P_H}$), dwelling and local environment conditions that affect child health (**DLE**), household wealth (W), household productive assets that may affect children's time allocation (**PA**), and parental "tastes" for education (T). Schooling prices ($\mathbf{P_S}$) include fees, school supply prices, tuition class fees, and travel time to school (which may affect daily attendance). Health care prices ($\mathbf{P_H}$) include prices for health care services and distances to healthcare facilities. Dwelling and local environment variables include drinking water source, type of toilet, and local prevalence of infectious diseases.

Household wealth (W) indirectly affects student learning through purchases of educational inputs. In theory, it can be endogenous: working children (who probably study less) raise household wealth. Yet Sri Lankan primary school age children rarely work. Only 8% of children in the NEC data worked on family farms or businesses when school was in session, and only 0.5% worked over six hours per week. Wage work is even rarer; only 2% report such work when school is in session, and only 0.2% work over six hours per week.

Sri Lankan households' main productive asset (**PA**) is land. Even after controlling for household wealth, parents with land may expect their children to work on it, reducing

both time in school and time studying at home. Yet since few Sri Lankan children work long hours when in school, the impact of productive assets on learning is likely to be small.

Parents' choices regarding child health (**H**) and educational inputs (**EI**) based on **C**, FS, MS, **Q**, $\mathbf{P_S}$, $\mathbf{P_H}$, **DLE**, W, **PA** and T can be expressed as:[8]

$$\mathbf{H} = h(\mathbf{C}, FS, MS, \mathbf{Q}, \mathbf{P_S}, \mathbf{P_H}, \mathbf{DLE}, W, \mathbf{PA}, T) \quad (2)$$

$$\mathbf{EI} = ei(\mathbf{C}, FS, MS, \mathbf{Q}, \mathbf{P_S}, \mathbf{P_H}, \mathbf{DLE}, W, \mathbf{PA}, T) \quad (3)$$

Inserting (2) and (3) into (1) gives the *reduced form* equation for A:

$$A = a_{rf}(\mathbf{C}, FS, MS, \mathbf{Q}, \mathbf{P_S}, \mathbf{P_H}, \mathbf{DLE}, W, \mathbf{PA}, T) \quad (4)$$

Equation (4) is a causal relationship, but not a production function because it reflects household preferences and includes prices as arguments. The "rf" (reduced form) subscript distinguishes it from the production function in equation (1).

Policymakers' primarily concern is the impact of education policies on years of schooling (S) and academic achievement (A). Such policies include raising teacher quality, which affects **Q**, and changing school costs ($\mathbf{P_S}$). Equation (4) shows how such changes affect A. Policy choices require comparison of the costs of such changes to their benefits, measured by increases in A. Costs should also include costs borne by households, so changes in **EI**, as given in (3), and in household leisure must be included in the cost.

To clarify the difference between the production function in (1) and the reduced form relationship in (4), consider changing one element of **Q**, call it Q_i. Equation (1)

[8] In a more general setting, where years of schooling (S) varies and does so in part due to household choices, that variable will also be a function of the explanatory variables in equations (2) and (3), and substituting it out of equation (1) will still yield equation (4).

shows how changing Q_i affects A holding constant all other variables that *directly* affect learning, which is the *partial* derivative of A with respect to Q_i. In contrast, (4) shows the impact on A *after allowing **H** and **EI** to change* in response to changes in Q_i, which is the *total* derivative of A with respect to Q_i. For example, parents may respond to higher teacher quality by reducing education inputs. These two impacts of Q on A (partial and total derivatives) can differ; researchers should indicate which relationship they are estimating. This paper estimates both.

When examining a policy's impact, should policymakers use equation (1) or (4)? The latter is useful because it shows what actually happens to A if **Q** changes. In contrast, the former does not show this; it ignores changes in **H** and **EI** due to changes in **Q**. Also, (4) shows what happens after changing $\mathbf{P_S}$ and $\mathbf{P_H}$, but (1) cannot since $\mathbf{P_S}$ and $\mathbf{P_H}$ are excluded since they do not directly affect A. Yet the structural impact in (1) is useful: it may better capture overall welfare effects. Intuitively, if increasing **Q** causes parents to reduce educational inputs **EI**, they probably use the money saved to buy more consumer goods. The reduced form impact in (4) reflects the lower A from the drop in **EI**, but ignores higher household welfare from increased purchase of consumer goods. In contrast, the structural impact in (1) ignores the effect of **Q** on both **EI** and consumer goods, and since these effects have opposite impacts on household welfare they tend to cancel out. Thus welfare changes from increasing **Q** tend to be underestimated by the reduced form relationship in (4), but this bias is absent from estimated changes in A in equation (1). See Glewwe et al. (2004) for details.

D. Applying the Framework to Sri Lanka. The objective of this paper is to estimate equations (1) and (4) and use these estimates to draw causal inferences regarding

the determinants of learning in Sri Lanka. These equations can be estimated if one has accurate data on every variable in them. Table 2 shows the variables from the NEC and NEREC surveys. Some variables in (1) and (4) are in neither survey, and others may be measured with error. Both problems lead to bias. This subsection explains the approach used to minimize bias. While we cannot guarantee that our estimates are unbiased, the unusually rich data should minimize omitted variable bias and thus provide more accurate estimates than previous studies have provided. Even so, the results presented in Sections V and VI should be regarded as suggestive, rather than definitive.

To begin, consider the exogenous child variables, **C**, in (1). While they are exogenous in the sense that they are not chosen by households, they are endogenous in the (econometric) sense that they are correlated with unobserved variables. That is, much of the explanatory power of observed child variables such as sex, age, ethnicity and birth order in that equation reflects their correlation with innate ability, tastes and motivation. The latter are very difficult to measure, so these variables are included to "control for" them. First-born children may have higher ability, perhaps due to better maternal nutrition before they are born.[9] Girls may have more innate reading talent, and boys may have more math talent, so a sex variable helps control for ability (OECD, 2003). Age can also indicate ability; older children have had more time to develop their innate ability.[10] Another indicator of ability, and perhaps of tastes and motivation, is parents' education. Parents' ability, tastes and motivation presumably affected their schooling, and these are, in part, inherited by their children. Thus parental schooling reflects all three.

[9] Later born children may receive less prenatal nutrition if their mothers recently gave birth to their older sibling(s); see King (2003).

[10] The idea here is that there is a fixed genetic endowment of innate ability, but it expresses itself in terms of abstract thinking ability over time as the child grows, so that ability in terms of being able to learn in school depends not only on the genetic endowment but also on child age.

Parental schooling (FS and MS) also enters (1) directly. Thus its estimated impact in (4) reflects both direct effects and child ability, taste and motivation effects. Yet parents' education, while exogenous in the sense that it is not a choice variable, may be imprecisely measured. Fortunately, the NEC and NEREC surveys both have this variable, so one measurement can be used to instrument the other.

The NEREC and NEC data have many school, teacher, and principal variables (**Q**). School data include school type (see subsection III.A), student-teacher ratio, whether textbooks and teacher's guides arrived before the school year started, whether student desks, blackboards, computers and toilets are considered adequate, electricity, access to drinking water, and whether the school is for boys or girls only.

The NEC surveyed teachers who taught the sampled students in grade 4. Most schools had several grade 4 teachers, who cannot be linked to specific students. Thus grade 4 teacher characteristics are school averages. They include sex, general education, teacher training, years of teaching experience, primary school teaching experience, years at present school, days absent (reported by principal), in-service training sessions, visits from in-service advisors (school inspectors), divisional directors and education directors, parent-teacher meetings held, involvement in teaching students after school, adequacy of equipment and materials received, and availability (for students) of textbooks, exercise books, workbooks, pencils and other materials. Lastly, in 2003 trained observers visited classrooms to record teachers' preparation, pedagogical methods, use of English, use of learning materials, interactions with students, evaluation methods, and overall enthusiasm.

Principals have similar variables: gender, general education, teacher education, years of teaching experience, years of experience as a principal, experience as principal

in current school, frequency of supervising teachers and inspecting lesson plans, staff meetings on education matters, whether the school is in a "school family" (explained below), parent awareness programs, and attendance at school family meetings, parent-teacher meetings, and educational reform programs at district, zone and division levels.

The NEREC principal, section head and teacher questionnaires collected similar data. Yet many NEREC variables had inconsistent or missing values, perhaps because school personnel filled out these questionnaires without assistance. In contrast, the NEC used trained enumerators to interview school personnel, yielding data with fewer problems. Unless otherwise noted, school and teacher variables are from the NEC data.

A final point regarding school and teacher variables is that one way to reduce omitted variable bias is to use school fixed effects estimation. This amounts to adding a dummy variable for each school, which accounts for variation in both observed and unobserved school characteristics. While this greatly reduces bias due to omitted school and teacher variables, it comes at the cost of removing all school and teacher variables from the regression, so that one can estimate the impacts only of family and student level variables. The next section presents estimates both with and without school fixed effects.

The NEC collected detailed child health (**H**) data. The household questionnaire solicited (from parents) child information on: illness in the past month, school absence in the past year due to illness, any illness ever of more than two weeks, bouts of malaria (how many times in lifetime, in last year, and in last three months), worms in stools (how many times in last three months and in last year), use of de-worming medicine in past year, and the presence of vision problems, hearing problems, and physical or mental disabilities. Data were also collected on children's diets and health habits.

The NEC employed trained medical personnel to conduct physical measurements of 2459 (out the 2653) pupils. The data include height, weight, Bitot's spot in eyes (to check Vitamin A deficiency), goiter (iodine deficiency), visual acuity (with glasses on, using Snellen chart),[11] hemoglobin (iron) level in blood (finger prick), and pinworm, roundworm, whipworm and hookworm (fecal samples).

The data indicate that several health problems are too rare to explain variation in student learning. Just eight students had Bitot spot. Very few had moderate roundworm (11 students), whipworm (10) or hookworm (5) infections; none had heavy infections. Only five had pinworms. This low incidence of helminths reflects the fact that 96% of parents report giving their children deworming medicine. Goiters (3% of students) and malaria (only 2% of parents report their child had malaria in the past year) are also rare.

In contrast, anemia is common; 11.2% of children fall below the WHO standard (11.5 grams/deciliter), but only 0.1% have severe anemia (below 8.0 grams/deciliter). Stunting (height-for-age Z-score < -2) affects 16% of the sampled students, and 19% are wasted (weight-for-height Z-score < -2). Yet these variables measure nutrition problems with error; height and weight vary even among well-nourished children. This adds random measurement error to height-for-age and weight-for-height Z-scores, leading to underestimated impacts. Consistent estimation requires instrumental variables; possible instruments are the household's water source, type of toilet, and current eating habits.

Lastly, consider vision and hearing. Vision was measured by medical personnel, and changes very slowly, which suggests little measurement error. Yet hearing is from parental reports, which could have errors. There are no credible instruments for hearing. Yet hearing problems are rare; the parents of only 34 children report a problem, so while

[11] There are no data on which students wear eyeglasses.

the lack of an instrument may lead to attenuation bias for the impact of hearing problems, it is unlikely to have a large effect on the estimated impacts of other variables.

The last variables in (1) are parent-provided educational inputs (**EI**). The NEREC and NEC data include: 1. How often different household members help the child with schoolwork; 2. Hours per week the child spends studying, attending tuition classes, and working; 3. Access to textbooks, exercise books and workbooks, by subject; 4. Children's books at home; 5. Whether parents obtain library books for the child; 6. School attendance (school records); 7. Language spoken at home; and 8. Parent provided "educational trips".

The NEC education input data may have measurement errors. Fortunately, the NEREC parent and child questionnaires also (imperfectly) measured most of them. If these errors are random and uncorrelated across surveys (NEREC questionnaires were filled out by parents and children in March 2003, while trained interviewers filled out the NEC questionnaire in the summer of 2003), the NEREC data can be used to instrument the NEC data. More specifically, education inputs from the NEC data were instrumented as follows. Hours per week studying and in tuition classes in the NEC data were instrumented by a dummy variable in the NEC indicating that the child attends tuition classes, a similar variable in the NEREC data, and two variables (see below) indicating parents' tastes for education. Children's books at home and preschool attendance in the NEC data were both instrumented by similar NEREC variables. Finally, exercise books were in the NEC data instrumented by two NEREC variables: frequency (reported by the child) of teacher use of exercise books and blackboards.

Turn next to equation (4); **H** and **EI** in (1) are replaced by $\mathbf{P_S}$, $\mathbf{P_H}$, W, **DLE**, **PA** and T. Sri Lanka's public schools are free and provide free textbooks and uniforms.

Workbook and exercise book prices vary little by region, so the only school price ($\mathbf{P_S}$) variables are tuition class fees, distance to the nearest primary school, and distance (from school) to the nearest public library. The NEC data on pupils' hours in, and payments for, tuition classes were used to calculate school average tuition class "prices". The NEC survey asked households the distance to the nearest primary school; this is a price since longer distances raise the opportunity cost of a day in school. Finally, the NEC school questionnaire indicates the distance from each school to the nearest public library.

Now consider health prices ($\mathbf{P_H}$). The NEC school questionnaire has distances to the nearest hospitals and clinics. The SLIS collected local prices of medical services (registration fee, blood test, urine analysis, stool analysis, malaria test and TB test). Mean prices were calculated for Sri Lanka's 25 districts.[12]

Household wealth (W) is approximated by per capita expenditures from the NEC data.[13] Parents were asked for monthly expenditures on food and on 14 non-food items. They also reported monthly household income, in one of seven ranges, which is used to instrument per capita expenditures to reduce attenuation (measurement error) bias.

For **DLE** variables, dummy variables were created for toilet type and source of drinking water. A dummy variable indicates electric lighting, which presumably helps students study at night. Regrettably, no data exist regarding local disease prevalence.

Land is Sri Lanka's main productive asset (**PA**); 27% of NEC households report owning at least one acre. Few report owning other productive assets, such as boats or vehicles, so land is the only productive asset used.

[12] The SLIS included no households from Mullaitivu or Kilinochchi districts; prices were assigned from the districts with the longest borders along these districts.

[13] Household expenditure is closely related to household wealth, especially if households can smooth consumption. See Dercon (2004) for a recent assessment of the extent of consumption smoothing in developing countries.

The last variable in (4) is parental tastes for education (T). Two variables are used. The first, "hope", is parents' report of the highest degree they want for their child. The second, "opinion", is an index of parents' attitudes on education based on their agreement with eight statements such as "It is a wise act to invest in education".

V. Empirical Results

This section presents estimates of equations (1) and (4). The first subsection focuses on child and household variables, controlling for school characteristics using fixed effects. The second adds school variables. The sample size drops from 2653 to less than 2450 because of missing data (mostly mother's age, use of libraries, and children's books at home). IV estimates reduce the sample to slightly under 2400.

A. School Fixed Effects. Columns 1-3 of Table 3 present OLS estimates, with school fixed effects, of equation (1): production functions for math, English and first language skills.[14] The first four variables control for child innate ability and motivation (**C**). Girls outperform boys in each subject. Girls may have more reading talent than boys, but this cannot explain the math score; perhaps girls are more motivated for all subjects. Age has a significantly positive impact – presumably students' intellectual abilities increase with age. Firstborn children perform relatively well, perhaps reflecting higher ability due to biological factors and/or greater attention from parents in the first years of life (relative to later-born children). Finally, mother's age raises test scores;

[14] To see whether these estimates are biased by endogenous school choice within communities, all estimates in Tables 3 and 4 were rerun using community (education zone) fixed effects; the results are very similar. In another check for bias due to children not attending the nearest school, we re-estimated Tables 3, 4, 5 and 6, adding two dummy variables, one indicating children who were not attending the nearest school and the other indicating children with missing data on whether they attended the nearest school; the results did not change, and the dummy variables were never significant at the 5% level. Also, dropping all children not going to the nearest school from the sample had very little impact on the results.

early childbearing may have negative biological impacts on children's ability (Pevalin, 2003), but social factors may also play a role. A quadratic mother's age term (not shown here) had an insignificantly coefficient, revealing no negative impact of late childbearing.

Next are three ethnic dummy variables. (Sinhalese is the omitted category; a fourth ethnic dummy, "other", was never significant and was dropped.) Table 1 showed large ethnic differences in test scores. If the NEC and NEREC data include all variables in equation (1), these dummy variables should be insignificant. For English, no ethnic variable is significant, but in first language Tamils and Moors do worse, even after one controls for the language spoken at home, and Moors have lower math scores. Overall, most ethnic differences in Table 1 appear to be captured by other variables in Table 3.

The results suggest that both mothers' (MS) and fathers' (FS) schooling have large, statistically significant impacts on test scores. For each test, father's education has a larger estimated impact, a surprising result since mothers presumably spend more time with their children; perhaps fathers have more say regarding children's education. Father's education may also reflect family income, which may be spent on unobserved educational inputs. Yet adding per capita expenditure as a regressor (not shown) does not change the father's education coefficient (nor any other). (The expenditure variable was significant at the 5%, but not the 1%, level, revealing only weak evidence of omitted educational inputs.)

The next three variables measure child health status (**H**), and a fourth indicates that data are missing for child height (in which case height-for-age is replaced by its mean).[15] Children who are not stunted (high height-for-age), and thus had better

[15] Preliminary regressions included worm egg counts and visual acuity. Egg counts were rarely significant, reflecting Sri Lanka's low incidence of helminth infections. Visual acuity was never significant, probably because only 1% of the sampled pupils had serious vision problems (Snellen ratio < 6/12 for both eyes). See Wisniewski (2010) for a recent analysis of child health and educational outcomes in Sri Lanka.

nutrition in their first years of life, scored higher on all three tests; a one standard deviation increase raises each score by about 0.1 standard deviations. In contrast, weight-for-height, an indicator of current nutritional status, has a much smaller and statistically insignificant impact. Moreover, the estimated impact of weight-for-height is small; a one standard deviation increase raises test scores by only 0.01 to 0.03 standard deviations. Overall, weight-for-height can be excluded from subsequent regressions.

Turning to other health variables, the few children with hearing problems (as reported by parents) have significantly lower test scores, 0.4 to 0.6 standard deviations less. Children who have ever had a serious (> 2 weeks) illness also had significantly lower scores on all three tests. Lastly, the goiter, malaria and hemoglobin variables had no explanatory power and so are excluded from all regressions.

Finally, consider educational inputs (**EI**). Hours in tuition classes has a strong and significantly positive effect on all test scores, as does hours studying on math and first language scores. Hours working had a negative but insignificant effect, probably reflecting Sri Lanka's low rate of child labor, so it was excluded from all regressions.

Mothers' time helping their children with schoolwork has a positive, statistically significant impact on all test scores, but fathers' time has a (weakly) significant impact only on first language. Interaction terms between parents' schooling and time helping children were insignificant. The weak impact of fathers' time may reflect low variation: 60% of mothers, but only 19% of fathers, report helping their children with schoolwork.

Daily attendance has a strong positive impact on all tests, as expected, as do children's books at home and borrowing library books. "Educational trips" (to historic

and cultural sites) also have positive and statistically significant effects. Finally, exercise books and preschool attendance have significantly positive effects.

The R^2 coefficients indicate that these regressions "explain" 23-27% of within-school variation (variation conditional on school fixed effects) of test scores. Since the test scores probably contain substantial measurement errors, the amount of "true" variation these regressions explain is probably much higher.

Many explanatory variables in Table 3 may be measured with error, causing attenuation bias. Columns 4-6 of Table 3 report estimates (with school fixed effects) that attempt to reduce bias by instrumenting seven variables: mother's and father's education, hours in tuition classes, hours studying, children's books at home, preschool attendance, and exercise books, using the instruments discussed in subsection IV.D.[16]

The instrumental variable (IV) estimates pass several specification tests. First, overidentification tests do not reject the hypothesis that the mathematics and first language production function residuals are uncorrelated with the instruments, though it was rejected at the 5% (but not the 1%) level for the English test. Second, checking for weak instruments, the (excluded) instruments have high predictive power for all but one of the instrumented variables, with F-tests from 6.64 (preschool) to 98.12 (father's years of education). The sole exception is hours studying; its F-test was 3.21. Third, Hausman tests comparing the fixed effects results in columns (1) – (3) with IV fixed effects results in columns (4) – (6) decisively reject the null hypothesis of equal parameters (p-values of 0.0000 for each subject). Fourth, six other potentially endogenous variables (height-for-

[16] Recall that instruments are used only to avoid attenuation bias due to possible measurement error in the observed variables. In particular, we do not claim that our instruments address the potential problem of omitted variable bias. As already explained (subsection IV.D), our main approach for minimizing omitted variable bias is to use a large number of explanatory variables (and to use school fixed effects to avoid bias due to omitted school and teacher variables), but we recognize that some bias may remain in our results.

age, father helps child with schoolwork, mother helps child with schoolwork, use of library books, educational trips and serious illness) passed the (joint) Hausman test; their coefficients were unaffected by IV estimation.[17]

Most uninstrumented variables have impacts similar to those in columns (1) - (3) of Table 3, with four exceptions. First, the first-born coefficient is smaller and loses significance in the math regression. Second, the effects of mother's age decline and lose significance for math and first language. Third, the ethnicity variables have smaller impacts and lose statistical significance. Finally, the effects of mothers helping children, library books and educational trips all fall and lose significance.

For the instrumented variables, the impacts of parental education are somewhat larger, though in two of three cases mother's education loses significance due to lower precision. The impact of hours in tuition classes is 4-5 times higher and still significant, but hours studying loses significance due to very high standard errors, perhaps reflecting weak instruments. The impacts of children's books are 3-4 times higher and significant (although marginally for math). The exercise book impacts increase 2-3 fold (and remain significant), but the preschool effect is imprecisely estimated and thus insignificant.

Overall, IV results suggest that measurement errors generate serious attenuation bias in OLS estimates of the impacts of tuition classes, children's books at home and exercise books. These estimates are large; raising time in tuition classes from 1-3 to 4-6 hours per week increases test scores by 0.27 to 0.38 standard deviations, and exercise books increase test scores by 0.24 to 1.13 standard deviations.

[17] The Hausman test checks whether additional variables are endogenous, conditional on the first five being specified as endogenous (Davidson and MacKinnon, 1993, pp.241-242). Additional IVs were weight-for-age Z-score, parent is a library member, education trip expenditures, water source is tubewell, variables indicating how regularly the child eats meals, distance to nearest health clinic, missing school frequently in last year due to illness, parents help children with schoolwork (NEREC), and whether parents are alive.

Recall that reduced form impacts of variables of interest may differ from their production function impacts. Also, variables with only indirect effects on learning are excluded from the production function, yet their reduced form (indirect) impacts may be of interest. Table 4 presents such estimates, i.e. estimates of equation (4); the health (**H**) and educational input (**EI**) variables in equation (1) are replaced by wealth (W), dwelling characteristics (**DLE**), productive assets (**PA**) and parental tastes for education (T).[18]

Exogenous child characteristics (**C**) and parental education (FS and MS) appear in both the production function and the reduced form. The main changes in the OLS results are that the impacts of child age, sex, first-born status and maternal age at birth are smaller. This suggests that parents help "less able" children, compensating for their lower innate ability. Also, mother's education has larger effects; which suggests that better educated mothers provide more education inputs and have healthier children.

Regarding variables with only indirect effects, agricultural land has a positive but statistically insignificant impact, indicating little role for child labor. Electric lighting has a large, statistically significant impact, raising scores by 0.21 to 0.26 standard deviations; presumably it helps children study at night. Reduced form estimates support this; electricity raises hours studying, but this impact is imprecisely estimated (t-statistic of 1.60). Household expenditure per capita is also significant, but with a smaller impact than electricity; a one standard deviation increase raises scores by 0.07 to 0.08 standard deviations.

[18] Tests for the validity of the instrumental variables are mostly supportive. The overidentification test is not significant at the 5% level for the first language test and is barely significant at that level (p-value of 0.048) for the math test; however, the null hypothesis that the instruments are not correlated with the error term is rejected at the 1% level for the English test (p-value of 0.002). F-tests for weak instruments ranged from 4.88 (opinion) to 351.69 (hope). Hausman tests that compare the uninstrumented results in columns (1) – (3) to the instrument results in columns (4) – (6) decisively reject the (joint) null hypothesis that the coefficients on the instrumented variables are the same.

Two variables indicate parents' tastes for education. The one measuring hopes for their child's education is highly significant, while the other (general opinion on education) is less significant, and insignificant for math. Finally, children whose drinking water is from a river or stream have significantly lower math scores, and children in households with "pit" latrine toilets do worse in English; these estimated effects probably reflect lower child health.

Columns (4)-(6) of Table 4 examine whether the OLS results change when per capita expenditures, parental education and parental tastes for education are instrumented to reduce attenuation bias. The impact of per capita expenditures is too imprecisely estimated to conclude anything. The impacts of parents' education and parental tastes increase, suggesting attenuation bias in the OLS estimates.[19] Other results change little, except that electricity has weaker effects.

B. School and Teacher Impacts. Table 5 replaces the school fixed effects in Table 3 with school and teacher characteristics from the NEC data. Columns 1-3 present OLS estimates, and columns 4-6 present IV estimates, instrumenting the same variables (with the same instruments) as in Table 3. The NEC data have many school and teacher variables, but with just 140 schools the number of school variables one can use is limited. Variables without explanatory power for any test are excluded. The child and household variable impacts are similar to those in Table 3, so the focus here is on school variables. Yet one should keep in mind that, despite detailed school and teacher variables, it is still

[19] For the parental taste variables, not only attenuation bias but also simultaneity bias is possible; if students do well in school, parents may raise their opinions about the value of education. If this occurs, the instruments for these variables (which are second measurements) will be correlated with unobserved factors that increase test scores and so can yield inconsistent results. Thus, even though the estimated impacts of parental taste variables are plausible, this estimation problem could lead to overestimation of their impacts.

possible that the following results suffer from omitted variable bias; the rich set of school and teacher characteristics used can reduce such bias, but they cannot eliminate it.

The only school physical facility or equipment variable with any significant impact is desks. About 39% of principals report having insufficient desks. Sufficient desks appears to increase all three test scores, but only the positive impact of 0.15 standard deviations on math scores is statistically significant.

About 83% of Sri Lankan pupils attend schools associated with a "school family", a cluster of schools that collaborate and share resources. Teachers in a "family" meet to discuss teaching methods, share solutions to problems and exchange reading material, while principals discuss school organization and administrative issues. The OLS results in Table 5 indicate that joining a school family raises all test scores by about 0.2 standard deviations, but this impact is halved and insignificant when IV estimation is used.

Consider next the single-sex school variables. Even after controlling for students' gender, boys enrolled in all-boy schools (14 of the 140 schools, 12 of which are in urban areas) do significantly worse on all tests, with impacts from -0.16 to -0.33. In contrast, girls in the eight all-girl schools do much better in English, an impact of 0.46. IV estimates show no impact of all-girl schools on English scores, although the negative impacts of all-boy schools remain statistically significant. These results reflect some unobserved aspects of all boy-schools. Perhaps boys' behavior worsens without girls in the classroom, but this is speculative.

The last three variables pertain to teachers and principles. More experienced teachers appear to increase students' scores on all three tests, but after instrumenting this impact declines and loses significance. Similarly, teacher-parent meetings appear to

increase all three test scores, but the estimated effects decline and lose significance after instrumenting. Finally, the coefficient on principals' years of experience (as principals) is positive and statistically significant effect on English, but only for IV estimates.[20]

In summary, two school and teacher characteristics appear to have significantly positive impacts on learning: student desks (math scores only) and principal years of experience (English only). One variable reduced all three scores: all-boy schools. OLS regressions explain much of the variance in test scores: 37 to 43 percent. Since test scores probably have random errors the "true" variation explained is probably much higher.

Table 6 shows the reduced form impacts of school variables. In principle, parents' responses to variation in school characteristics can yield different results in Tables 5 and 6. Examining the IV estimates for math scores, the positive coefficient for desks is somewhat smaller and insignificant, while the coefficient for school family increases and becomes significant. The negative influence of all-boy schools is larger and remains significant. The effect of parent-teacher meetings rises and acquires significance, while the principal's experience variable loses significance.[21] Comparing Tables 5 and 6, some school variables seem to substitute for parental inputs while others are complements. More specifically, parents appear to reduce educational inputs when schools have more desks or more experienced principals, while schools belonging to a school family and parent-teacher meetings seem to persuade parents to raise effort for their children's education.

[20] A somewhat speculative explanation for this result is that well off communities, which use English in everyday life, are more attractive places for principals to work, and more experienced principals are able to get transferred to those communities. If so, the direction of causality is from better English skills to more experienced principals.

[21] One could argue that the single sex school variables are endogenous, since parents choose such schools for their children; estimates that exclude those variables yield similar results for the other school variables.

C. Is Omitted Variable Bias a Serious Problem? Tables 7 and 8 examine the sensitivity of the IV results in Tables 5 and 6 to omitted variable bias. Columns 1-3 of Table 7 reproduce the Table 5 IV estimates of the impacts of school variables. Suppose no data exist for parent-provided educational inputs (**EI**). If parents provide more inputs in response to low quality schools, estimates from regression analysis will underestimate the impact of school quality variables. Omitting **EI** variables yields the results in columns 4-6 of Table 7. The impact of the school family variable increases and becomes (marginally) significant, as do the all-girl school variable (English only) and parent-teacher meetings. Overall, this suggests that higher quality schools generate more, not less, parentally provided educational inputs.

Table 8 repeats this exercise for the IV estimates in Table 6 of the (reduced form) impact of school variables on learning, omitting the two parental taste for education variables. The impact of all-boy schools falls by half, and the impact of parent-teacher meetings drops by more than half and loses some statistical significance. Admittedly, the intuition behind this result is unclear. Yet, overall, Tables 7 and 8 suggest substantial omitted variable bias when estimating the impact of school characteristics on learning without measures of parental attitudes or detailed data on educational inputs.

VI. Policy Implications

These findings suggest several policy initiatives to improve learning outcomes in Sri Lanka. First, grouping schools into school families appears to raise school quality, perhaps by providing opportunities for teachers and principals from different schools to

learn from each others' experiences. Currently, school family networks in Sri Lanka are arranged informally. An official policy to set up school families could increase learning.

Second, teacher interactions with parents seem to improve learning. More specifically, parent-teacher meetings may persuade parents to do more for their children's schooling (this variable was insignificant in the production function estimates but significant in the reduced form estimates). As explained in subsection IV.B, most parents do little to change the quality of their local school. One policy worth exploring is to get parents more directly involved in raising school quality, and more specifically in holding principals and teachers accountable for their children's performance.

Higher student attendance also increases learning. This unsurprising finding highlights the need for policies that raise attendance. Currently, Sri Lanka offers several incentives for children to enroll, such as free tuition, textbooks, and uniforms. Subsidized transport and mid-day meals in poor areas also encourage daily attendance. Yet daily attendance is often low, especially in poor areas. Cash transfers conditional on daily attendance, a successful policy in several Latin American countries (Damon and Glewwe, 2009), should be considered in areas with low student attendance.

Students who have exercise books and attend schools with enough desks appear to learn more (although the effect of the latter variable is somewhat smaller and insignificant in the reduced form estimates, which may reflect a small reduction in parental inputs in response to the provision of desks). This suggests that the government should equip all schools with basic learning equipment, such as pupil desks and chairs, and ensure that all children have basic writing materials.

Children attending schools with experienced principals have higher scores, at least in English. Principals' management skills and leadership are probably important factors affecting school performance. Sri Lanka has a training center that provides off-site training for principals. Yet no program provides on-site support for principals, which may be even more effective. Policymakers should seriously consider providing on-site training to principals, especially less experienced principals.

Child health also contributes to learning. Sri Lanka already has basic school health programs; health workers visit schools regularly to test children for several illnesses, and poor children receive free mid-day meals. Expanding school health programs could increase learning. Yet the strong impacts of height-for-age suggest a need for nutrition programs directed toward infants and very young children. Two programs currently exist: 1. The Thriposha program provides foodstuffs to pregnant and lactating women, to infants between 6-11 months old, and to older children whose growth falters (as certified by a medical health officer); and 2. The Samurdhi poverty reduction program transfers income to poor families, especially those with malnourished children. The impacts of these and other nutrition programs should be rigorously evaluated; those that are effective should be expanded.

Children enrolled in private tuition classes seem to learn more. While one could argue that this may mostly reflect unobserved child motivation, which leads to increased enrollment in these classes as well as increased learning, for children who are 10 or 11 years old the decision is primarily made by parents, and parental motivation is controlled for, at least in part, by the variables that measure parental actions (e.g. time spent helping children with schoolwork). These classes have not only direct costs but also opportunity

costs, as they crowd out extra-curricular activities. They could create perverse incentives for teachers, who may reduce classroom teaching effort to increase the demand for their tuition classes. Further research on this phenomenon is needed to understand its costs and benefits.

VII. Conclusion

This paper has used unusually rich data from Sri Lanka to investigate the determinants of reading and math skills among fourth grade students. Several conclusions stand out. First, most of the differences in test scores across ethnic groups reflect differences in school and (observed) family characteristics. Second, parents' education plays a large role, but the mechanisms are unclear, especially for father's education. Third, consistent with results from Pakistan (Alderman, et al., 2001) and the Philippines (Glewwe, et al., 2001), early childhood nutrition, measured by height-for-age, appears to have a sizeable impact on learning. Hearing problems seem to have strong negative effects, but this applies to only 1-2% of students. Other health conditions, such as iron deficiencies and current nutritional status (measured by weight-for-height), had little explanatory power. Fourth, the estimated effect of hours in tuition classes is large and significant. This suggests that, despite Sri Lanka's efforts to equalize access to education, better off students can "buy" a higher quality education. Fifth, electric lighting at home appears to help students, presumably by increasing opportunities to study at night.

There are also useful results concerning school and teacher characteristics. Principals' and teachers' years of experience, grouping schools into "school families",

and parent-teacher meetings all appear to increase learning. For boys, the estimated impact of attending an all-boy school is negative, though the reasons why are unclear.

While these results provide useful policy guidance, many unanswered questions remain. First, much more thinking is needed on the role of tuition classes. In essence, these classes constitute a partial privatization of education in Sri Lanka. Second, much remains to be learned about which school (and teacher) characteristics and policies are most effective in promoting learning. Given persistent econometric problems, a series of randomized interventions would probably provide the best evidence on the impacts of particular policies. Third, more information is needed on the role of child health, and on what policies (either in schools or in communities) best reduce children's health problems. While Sri Lanka's educational accomplishments are envied by many other developing countries, much room remains for further progress.

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Table 1: Standardized NEREC Test Scores by Geographic and Socioeconomic Groups

		Math		English		First Language	
	n	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
All Students	16,383	0	1	0	1	0	1
Boys	8,299	-.09	1.05	-.12	.99	-.14	1.03
Girls	8,084	.09	.94	.12	.99	.15	.95
Region							
Western	1,842	.29	.88	.44	1.00	.33	.88
Central	1,816	-.12	1.00	-.08	.96	-.11	1.01
Southern	1,808	.08	1.01	.01	1.04	.04	1.05
Eastern	1,814	-.39	1.03	-.34	.91	-.37	1.02
Northern	1,857	-.40	1.03	-.34	.91	-.35	.97
North-Central	1,828	.09	.93	-.09	.91	-.02	.92
North-Western	1,820	.12	.93	-.04	.93	.10	.93
Sabaragamuwa	1,793	.02	1.02	-.05	.98	.02	1.00
Uva	1,805	-.14	1.03	-.19	.94	-.17	1.05
Sinhalese	10,999	.16	.95	.09	1.01	.15	.97
Tamil	3,561	-.52	1.03	-.36	.90	-.49	1.00
Moor/Malay	1,715	-.18	.95	.01	.96	-.18	.91
Burgher	17	.46	.89	.68	.82	.32	.85
Mother's Educ.							
None	1,029	-.69	1.01	-.63	.73	-.73	1.00
Grade 1-5	3,970	-.42	1.00	-.43	.81	-.45	.99
Grade 6-10	6,036	-.05	.97	.13	.90	-.05	.95
O level	3,452	.37	.82	.37	.98	.39	.82
A level	1,667	.60	.76	.79	1.00	.65	.76
Post-grad	229	.62	.77	.93	1.01	.66	.72
Father's Educ.							
None	803	-.71	1.01	-.66	.69	-.73	.98
Grade 1-5	4461	-.38	1.01	-.41	.82	-.41	1.00
Grade 6-10	6150	.04	.96	-.12	.91	-.04	.95
O level	3226	.38	.83	.42	.93	.41	.84
A level	1436	.59	.75	.79	1.00	.62	.76
Post-grad	307	.64	.79	.95	1.04	.67	.76
School Type							
Grades 1-13, 3 subj	2,673	.43	.82	.60	1.02	.46	.82
Grades 1-13, 2 subj	4,909	.03	.97	-.07	.93	.03	.97
Grades 1-11	5,448	-.25	1.01	-.31	.86	-.28	1.00
Grades 1-5, 1-8	3,353	-.03	1.04	.06	1.05	-.02	1.03

		Math		English		First Language	
	n	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Exp. Quintile							
1	534	-.39	1.04	-.41	.86	-.41	1.04
2	526	-.22	1.02	-.33	.85	-.26	1.00
3	534	-.06	.98	-.13	.91	-.10	.98
4	526	.08	.94	.11	.96	.12	.93
5	533	.53	.76	.68	1.00	.58	.72
HAZ < -2	405	-.28	1.03	-.36	.89	-.32	1.06
-2 > HAZ < -1	1154	-.10	1.01	-.10	.96	-.12	1.01
HAZ > -1	1094	.21	.94	.23	1.03	.24	.91
WHZ < -2	348	-.05	1.03	-.14	1.00	-.09	1.01
-2 > WHZ < -1	1668	.00	.99	.02	.99	.01	1.00
WHZ > -1	637	.03	1.00	.02	1.01	.01	.98

Table 2: Description of Explanatory Variables

Variable	Description	n	Mean	Std. Dev
Child Characteristics **(C)**				
Sex	Dummy variable: 1=boy, 0=girl	2653	.55	.50
Age (months)	Child age at time of household interview (grade 5)	2649	293.9	13.8
First-born	Dummy variable indicating child is first born	2653	.40	.49
Mother age	Age of mother at time child was born	2584	26.96	5.98
Sinhalese	Dummy variable indicating child is Sinhalese	2653	.65 7	.47
Tamil	Dummy variable indicating child is Tamil	2653	.20	.40
Moor	Dummy variable, child is Moor or Malay (Muslim)	2653	.13	.34
Burgher	Dummy variable indicating child is Burgher/other	2653	.00	.04
Household Characteristics **(**FS, MS, Y, **PA**, T)				
Mother yr ed	Mother's years of education	2653	8.99	3.61
Father yr ed	father's years of education	2653	8.80	3.67
HH expenditure	Log of household monthly expenditures per capita	2653	7.21	.60
Log of acres	Log of agricultural acres owned by household	2653	1.18	2.11
Drinks from river	Dummy variable indicating child drinks from a river or stream	2634	.02	.12
Pit latrine	Dummy variable indicating pit latrine	2537	.17	.38
Electricity	Dummy variable indicating dwelling has electricity	2653	.72	.45
Hope	Indicator of highest expectation parent has for child, 1=other or no special expectation, 2= complete primary 3=below GCE O/L, 4=Pass GCE O/L, 5=Pass GCE A/L, 6= Technical/vocational, 7=First degree, 8=Other professional (e.g. law, accounting, medicine, engineering), 9=Postgraduate degree	2635	5.13	2.26
Opinion	parents opinion of the value of education	2609	27.03	3.03
Medunone	mother has no education, 1=yes, 0=otherwise	2653	.05	.23
medu15	highest education achieved by mother was grade 1-5, 1=yes, 0=otherwise	2653	.22	.42
medu610	highest education achieved by mother was grade 6-10, 1=yes, 0=otherwise	2653	.36	.48
Meduol	highest education achieved by mother was OL level, 1=yes, 0=otherwise	2653	.22	.41
Medual	highest education achieved by mother was AL level, 1=yes, 0=otherwise	2653	.13	.34
medupost	highest education achieved by mother was degree or post graduate degree, 1=yes, 0=otherwise	2653	.02	.13
dedunone	father has no education, 1=yes, 0=otherwise	2653	.04	.19
dedu15	highest education achieved by father was grade 1-5, 1=yes, 0=otherwise	2653	.26	.44
dedu610	highest education achieved by father was grade 6-	2653	.35	.48

	10, 1=yes, 0=otherwise			
deduol	highest education achieved by father was OL level, 1=yes, 0=otherwise	2653	.21	.41
dedual	highest education achieved by father was AL level, 1=yes, 0=otherwise	2653	.11	.31
dedupost	highest education achieved by father was degree or post graduate degree, 1=yes, 0=otherwise	2653	.03	.17
hhinc	Indicator for household income in Rs: 1=<5,000, 2=5,001-7,000, 3=7,001-10,000, 4=10,001-15,000, 5=15,001-25,000, 6=25,001-50,000, 7=>50,001	2612	2.56	1.45
nerechope	Indicator of highest expectation parent has for child, 1=other or no special expectation, 2= complete primary 3=below GCE O/L, 4=Pass GCE O/L, 5=Pass GCE A/L, 6= Technical/vocational, 7=First degree, 8=Other professional (e.g. law, accounting, medicine, engineering), 9=Postgraduate degree (NEREC survey)	2601	2.44	1.66
nerecopin	parents opinion of the value of education (NEREC survey)	2623	27.55	4.75
***Child Health* (H)**				
Height/age Z-sc	Height for age Z-score	2653	-1.12	.89
Weight/age Z-sc	Weight for age Z-score	2653	-1.48	.81
Weight/height Z-sc	Weight for height Z-score	2653	-1.23	.82
Severe ill	Dummy for child has ever had a serious illness that lasted more than 2 weeks	2625	.15	.36
Hearing prob.	Dummy variable Indicating parents' report of whether child has any problem with hearing	2627	.01	.12
***Educational Inputs Chosen by the Parents* (EI)**				
Hours tuit. class	hours spent in tuition class (1=0 hours, 2=up to 3 hours per week, 3=3-6 hours per week, 4=>6 hours per week)	2643	2.59	1.19
Hours study	hours spent studying at home (1=0 hours, 2=up to 3 hours per week, 3=3-6 hours per week, 4=>6 hours per week)	2643	3.27	.89
Father help	0=dad does not help child with homework, 1=dad helps sometimes, 2=dad helps regularly	2653	.79	.74
Mother help	0=mom does not help child with homework, 1=mom helps sometimes, 2=mom helps regularly	2653	1.35	.84
Days attended	number of days child was present in school in 2002	2637	163.02	29.08
Children's	How many books child has to read at home other	2599	1.95	.96

books	than school text books			
Library books	Dummy for parents are members of the library and get the child library books	2578	.09	.28
Educ. trips	Dummy for parents have taken child on trips with educational benefits (e.g. to cultural, historic or geographic sites) during the last year	2653	.40	.49
Exercise book	Dummy for child owns a math exercise book	2653	.81	.40
Exercise book	Dummy for child owns a English exercise book	2653	.80	.40
Exercise book	Dummy for child owns a First Language exercise book	2653	.77	.42
Preschool	Dummy for child attended preschool (NEC)	2628	.89	.31
Engl. at home	Dummy for parents say they speak English always	2634	.12	.32
Sin/Tam at home	Dummy for the language that the test was taken is the same that the parents report speaking always at home	2634	.97	.17
Ptuition	Indicator for parents stated they try and send their child to tuition classes, 1=yes, 0=no (NEREC)	2653	.73	.44
Stuition	Indicator for child stated that they attend tuition classes, 1=yes, 0=no (NEREC)	2458	.66	.47
Pbook	Indicator for number of books available for the child to read at home, 1= zero books, 2= less than 10 books, 3=10-20 books, 4=21=30 books, 5=31-40 books, 6=more than 40 books (NEREC)	2653	2.17	1.07
Nursery	Indicator for child states they attended nursery school, 1=yes, 0=no (NEREC)	2541	.77	.42
Tuseexer	Indicator for students stating that their teacher frequently uses the exercise book when teaching, 1=yes, 0=no (NEREC)	2653	.35	.48
Tuseblack	Indicator for students stating that their teacher frequently uses the black board when teaching, 1=yes, 0=no (NEREC)	2653	.64	.48
***School and Teacher Characteristics* (Q)**				
Desks	Dummy variable indicating school has adequate student desks	2653	.58	.49
School family	Dummy variable indicating whether school is member of school family	2653	.83	.37
Boys school	Dummy for school is a boy's school	2653	.11	.32
Girls school	Dummy for school is a girl's school	2653	.07	.25
Teach yrs exp	total years of service as a primary teacher	2615	12.81	6.18
Par-teach mtg	Number of parent-teacher meetings held by teacher	2573	3.92	2.11
Princ yrs exp	Principal's total years of service as a principal	2633	9.08	5.99

Table 3: Estimates of Test Score Production Functions Using School Fixed Effects

	OLS with Fixed Effects			Instrumental Variable with Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	Math	English	First Lang.	Math	English	First Lang.
Sex	-0.134***	-0.227***	-0.257***	-0.124**	-0.233***	-0.253***
	(0.037)	(0.038)	(0.040)	(0.049)	(0.050)	(0.052)
Age (months)	0.005***	0.005***	0.003**	0.005***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
First-born	0.107***	0.256***	0.179***	0.033	0.225***	0.136***
	(0.032)	(0.035)	(0.034)	(0.050)	(0.046)	(0.049)
Mother's age	0.010***	0.014***	0.010***	0.005	0.009***	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Tamil	-0.206	0.044	-0.349**	-0.078	0.224	-0.192
	(0.162)	(0.123)	(0.136)	(0.215)	(0.162)	(0.160)
Moor	-0.303*	-0.002	-0.276**	-0.196	0.233	-0.047
	(0.159)	(0.196)	(0.138)	(0.200)	(0.240)	(0.140)
Burgher	0.394	0.097	0.374	0.084	0.089	0.456
	(0.600)	(0.745)	(0.384)	(0.455)	(0.646)	(0.478)
Father yrs ed	0.039***	0.048***	0.034***	0.043***	0.057***	0.025*
	(0.006)	(0.007)	(0.006)	(0.012)	(0.013)	(0.013)
Mother yrs ed	0.013**	0.015***	0.017***	0.020	0.015	0.035**
	(0.006)	(0.005)	(0.006)	(0.015)	(0.016)	(0.016)
Height/age Z-sc	0.086***	0.109***	0.106***	0.088***	0.096***	0.099***
	(0.019)	(0.020)	(0.018)	(0.022)	(0.024)	(0.021)
Haz dummy	-0.144**	-0.112*	-0.156**	-0.069	-0.002	-0.091
	(0.073)	(0.064)	(0.065)	(0.089)	(0.079)	(0.079)
Weight/height Z-sc	0.027	0.018	0.011	0.025	0.005	-0.007
	(0.020)	(0.021)	(0.018)	(0.024)	(0.024)	(0.021)
Hearing prob.	-0.636***	-0.377**	-0.405**	-0.571***	-0.351**	-0.376**
	(0.165)	(0.161)	(0.172)	(0.135)	(0.150)	(0.169)
Severe ill	-0.121**	-0.081**	-0.138***	-0.094	-0.048	-0.149**
	(0.050)	(0.039)	(0.047)	(0.061)	(0.056)	(0.058)
Hours tuit. class	0.075***	0.076***	0.088***	0.370***	0.265**	0.334***
	(0.019)	(0.017)	(0.017)	(0.093)	(0.103)	(0.087)
Hours study	0.054**	0.021	0.064***	-0.105	-0.009	0.018
	(0.022)	(0.022)	(0.019)	(0.191)	(0.205)	(0.199)
Father help	0.025	0.010	0.041*	-0.005	-0.054*	-0.011
	(0.022)	(0.025)	(0.023)	(0.029)	(0.030)	(0.030)
Mother help	0.071***	0.094***	0.064***	0.016	0.035	-0.013
	(0.022)	(0.023)	(0.022)	(0.027)	(0.030)	(0.027)
Days attended	0.005***	0.005***	0.006***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Children's books	0.055***	0.133***	0.095***	0.149	0.517***	0.303***
	(0.020)	(0.022)	(0.018)	(0.097)	(0.111)	(0.086)
Library books	0.162***	0.284***	0.150***	0.044	0.055	-0.027
	(0.052)	(0.053)	(0.052)	(0.073)	(0.084)	(0.078)
Educ. trips	0.094***	0.083**	0.071**	0.033	-0.023	-0.014
	(0.035)	(0.037)	(0.034)	(0.046)	(0.051)	(0.047)

Exercise book	0.432***	0.242***	0.344***	1.127***	0.746***	1.085***
	(0.042)	(0.046)	(0.043)	(0.190)	(0.209)	(0.215)
Preschool	0.192***	0.096	0.203***	0.306	-0.423	0.234
	(0.072)	(0.069)	(0.070)	(0.418)	(0.429)	(0.423)
Engl. at home		0.148**			-0.081	
		(0.061)			(0.077)	
Sin/Tam at hm			0.282*			0.338*
			(0.150)			(0.181)
Constant	-3.862***	-3.831***	-3.597***			
	(0.454)	(0.429)	(0.469)			
Observations	2428	2424	2424	2397	2393	2393
R-squared	0.231	0.265	0.273			

Robust standard errors, clustered at the school level, in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.
Instrumented variables (columns 4-6): Father yrs ed, Mother yrs ed, Hours tuit class, Hours study, Children's books, Exercise book, Preschool.
Instruments: Dadedu15, Dadedu610, Dadeduol, Dadedual, Dadedupost, Mommedu15, Momedu610, Momeduol, Momedual, Momedupost, Ptuition, Stuition, Hope, Opinion, Electric, Pbook, Tuseexer, Tuseblack, Nursery.

Table 4: Estimates of Test Score Reduced Form Equations with School Fixed Effects

	OLS with Fixed Effects			Instrumental Variable w/ Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	Math	English	First Lang.	Math	English	First Lang.
Sex	-0.168***	-0.280***	-0.297***	-0.132***	-0.221***	-0.244***
	(0.041)	(0.043)	(0.044)	(0.048)	(0.058)	(0.051)
Age (months)	0.003**	0.003**	0.001	0.005***	0.005***	0.003
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
First-born	0.170***	0.298***	0.240***	0.140***	0.218***	0.210***
	(0.034)	(0.036)	(0.035)	(0.039)	(0.048)	(0.041)
Mother's age	0.012***	0.015***	0.014***	0.010**	0.007	0.011***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(0.004)
Tamil	-0.288*	-0.000	-0.393**	-0.198	0.019	-0.318*
	(0.160)	(0.128)	(0.159)	(0.156)	(0.197)	(0.171)
Moor	-0.306*	0.025	-0.275*	-0.269	0.254	-0.246
	(0.159)	(0.205)	(0.154)	(0.191)	(0.267)	(0.171)
Burgher	0.062	-0.246	-0.084	-0.237	-0.603*	-0.486***
	(0.388)	(0.499)	(0.208)	(0.403)	(0.354)	(0.183)
Father yrs ed	0.038***	0.052***	0.036***	0.058***	0.074***	0.051***
	(0.006)	(0.007)	(0.006)	(0.012)	(0.013)	(0.011)
Mother yrs ed	0.019***	0.020***	0.024***	0.039**	0.020	0.049**
	(0.006)	(0.006)	(0.006)	(0.017)	(0.021)	(0.019)
Engl. at home		0.155**			-0.058	
		(0.064)			(0.102)	
Sin/Tam at hm			0.231			0.261
			(0.158)			(0.170)
Log of acres	0.009	0.011	0.012	0.009	0.002	0.016
	(0.010)	(0.008)	(0.008)	(0.011)	(0.012)	(0.010)
Electricity	0.248***	0.209***	0.261***	0.186***	0.064	0.207***
	(0.050)	(0.048)	(0.050)	(0.056)	(0.064)	(0.060)
HH expenditure	0.111***	0.139***	0.116***	-0.047	0.063	-0.115
	(0.033)	(0.037)	(0.034)	(0.091)	(0.119)	(0.097)
Hope	0.052***	0.043***	0.044***	0.180**	0.176*	0.213***
	(0.010)	(0.011)	(0.009)	(0.078)	(0.094)	(0.075)
Opinion	0.004	0.014*	0.015*	0.032	0.236**	0.052
	(0.007)	(0.007)	(0.008)	(0.080)	(0.104)	(0.080)
Drinks from river	-0.375**	-0.113	-0.149	-0.379*	-0.182	-0.183
	(0.185)	(0.126)	(0.170)	(0.219)	(0.192)	(0.222)
Pit latrine	-0.007	-0.147***	-0.052	0.003	-0.118*	-0.034
	(0.062)	(0.051)	(0.059)	(0.069)	(0.071)	(0.068)
Constant	-2.876***	-3.384***	-2.696***			
	(0.505)	(0.433)	(0.535)			
Observations	2454	2450	2450	2373	2369	2369
R-squared	0.124	0.187	0.166			

Robust standard errors, clustered at the school level, in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Instrumented (columns 4-6): Father yrs ed, Mothers yrs ed, HH expenditure, Hope, Opinion.

Instruments: Dadedu15, Dadedu610, Dadeduol, Dadedual, Dadedupost, Momedu15, Momedu610, Momeduol, Momedual, Momedupost, Hhinc, Nerechope, Nerecopin.

Table 5: Estimates of Test Score Production Functions with School Characteristics

	OLS			Instrumental Variables		
	(1)	(2)	(3)	(4)	(5)	(6)
	Math	English	First Lang.	Math	English	First Lang.
Sex	-0.135***	-0.236***	-0.268***	-0.184***	-0.322***	-0.320***
	(0.038)	(0.039)	(0.044)	(0.049)	(0.056)	(0.053)
Age (months)	0.006***	0.005***	0.005***	0.007***	0.004***	0.006***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
First-born	0.129***	0.308***	0.189***	0.069	0.242***	0.129***
	(0.036)	(0.039)	(0.038)	(0.047)	(0.052)	(0.045)
Mother's age	0.015***	0.020***	0.016***	0.008**	0.012***	0.009**
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)
Tamil	-0.291***	-0.079	-0.237***	-0.423***	-0.006	-0.343***
	(0.072)	(0.092)	(0.072)	(0.116)	(0.139)	(0.115)
Moor	-0.283***	0.012	-0.223***	-0.355***	-0.031	-0.296**
	(0.101)	(0.110)	(0.081)	(0.126)	(0.159)	(0.126)
Burgher	0.657	0.502	0.640**	0.236	0.525	0.421
	(0.546)	(0.527)	(0.247)	(0.462)	(0.530)	(0.342)
Father yrs ed	0.046***	0.058***	0.046***	0.046***	0.063***	0.039***
	(0.007)	(0.008)	(0.006)	(0.013)	(0.014)	(0.012)
Mother yrs ed	0.016***	0.016***	0.021***	0.022	0.004	0.028*
	(0.006)	(0.006)	(0.006)	(0.017)	(0.017)	(0.017)
Height/age Z-sc	0.102***	0.133***	0.120***	0.092***	0.109***	0.103***
	(0.021)	(0.023)	(0.019)	(0.026)	(0.027)	(0.023)
Haz dummy	-0.057	-0.003	-0.055	-0.001	0.096	-0.000
	(0.084)	(0.083)	(0.076)	(0.105)	(0.105)	(0.091)
Hearing prob.	-0.592***	-0.320*	-0.340*	-0.492***	-0.236	-0.255
	(0.179)	(0.168)	(0.173)	(0.162)	(0.163)	(0.172)
Severe ill	-0.100**	-0.049	-0.094*	-0.052	0.004	-0.072
	(0.049)	(0.043)	(0.048)	(0.066)	(0.061)	(0.060)
Hours tuit class	0.098***	0.074***	0.109***	0.396***	0.323***	0.396***
	(0.019)	(0.020)	(0.019)	(0.088)	(0.090)	(0.086)
Hours study	0.066***	0.014	0.068***	-0.351*	-0.346	-0.264
	(0.021)	(0.023)	(0.020)	(0.201)	(0.222)	(0.191)
Father help	0.024	-0.015	0.023	-0.004	-0.093**	-0.022
	(0.024)	(0.031)	(0.025)	(0.034)	(0.040)	(0.033)
Mother help	0.078***	0.113***	0.072***	0.014	0.049	-0.003
	(0.025)	(0.026)	(0.024)	(0.032)	(0.035)	(0.029)
Days attended	0.005***	0.004***	0.005***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Children's books	0.068**	0.133***	0.113***	0.166	0.585***	0.278***
	(0.026)	(0.032)	(0.021)	(0.101)	(0.103)	(0.091)
Library books	0.146***	0.303***	0.135**	0.055	0.055	-0.001
	(0.052)	(0.059)	(0.052)	(0.082)	(0.100)	(0.085)
Educ. trips	0.152***	0.129***	0.112***	0.110*	0.009	0.046
	(0.041)	(0.048)	(0.040)	(0.056)	(0.061)	(0.055)
Exercise book	0.367***	0.199***	0.246***	0.763***	0.423**	0.676***
	(0.050)	(0.049)	(0.050)	(0.192)	(0.199)	(0.192)
Preschool	0.148**	0.056	0.153**	-0.006	-0.309	0.047
	(0.067)	(0.063)	(0.069)	(0.319)	(0.334)	(0.295)

Engl. at home		0.190***			-0.101	
		(0.067)			(0.088)	
Sin/Tam at hm			0.338**			0.287
			(0.165)			(0.219)
Desks	0.147**	0.070	0.084	0.130*	0.044	0.069
	(0.058)	(0.059)	(0.057)	(0.074)	(0.076)	(0.072)
School family	0.220***	0.205***	0.197***	0.101	0.066	0.101
	(0.067)	(0.071)	(0.069)	(0.107)	(0.114)	(0.101)
Boys school	-0.262***	-0.155*	-0.131	-0.330***	-0.230**	-0.193**
	(0.085)	(0.078)	(0.085)	(0.106)	(0.091)	(0.096)
Girls school	0.101	0.462***	0.145	-0.033	0.128	-0.030
	(0.107)	(0.127)	(0.094)	(0.171)	(0.186)	(0.155)
Teacher yrs exp	0.009**	0.010**	0.007*	0.003	0.007	0.001
	(0.004)	(0.005)	(0.004)	(0.006)	(0.007)	(0.006)
Par-teach mtg	0.032***	0.045***	0.030**	0.018	0.030	0.017
	(0.011)	(0.015)	(0.012)	(0.017)	(0.020)	(0.017)
Princ yrs exp	0.005	0.007	0.004	0.008	0.013**	0.007
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Constant	-5.065***	-4.631***	-4.895***	-4.324***	-3.863***	-4.587***
	(0.457)	(0.440)	(0.516)	(1.034)	(1.167)	(0.925)
Observations	2305	2301	2301	2275	2271	2271
R-squared	0.37	0.43	0.42	0.14	0.18	0.21

Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%
Instrumented (columns 4-6): Father yrs ed, Mother yrs ed, Hours tuit class, Hours study, Children's books, Exercise book, Preschool.
Instruments: Dadedu15, Dadedu610, Dadeduol, Dadedual, Dadedupost, Momedu15, Momedu610, Momeduol, Momedual, Momedupost, Ptuition, Stuition, Hope, Opinion, Electric, Pbook, Tuseexer, Tuseblack, Nursery.

Table 6: Estimates of Test Score Reduced Form Equations with School Characteristics

	OLS			Instrument Variable		
	(1)	(2)	(3)	(4)	(5)	(6)
	Math	English	First Lang.	Math	English	First Lang.
Sex	-0.166***	-0.272***	-0.293***	-0.106*	-0.211***	-0.233***
	(0.043)	(0.043)	(0.047)	(0.057)	(0.065)	(0.056)
Age (months)	0.003**	0.002*	0.001	0.007***	0.006**	0.005**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)
First-born	0.213***	0.360***	0.268***	0.162***	0.265***	0.224***
	(0.039)	(0.041)	(0.040)	(0.049)	(0.058)	(0.047)
Mother's age	0.017***	0.022***	0.020***	0.013***	0.017***	0.015***
	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)	(0.004)
Tamil	-0.217***	-0.055	-0.181**	-0.443***	-0.317*	-0.446***
	(0.082)	(0.098)	(0.078)	(0.149)	(0.173)	(0.143)
Moor	-0.342***	-0.109	-0.288***	-0.646***	-0.518**	-0.626***
	(0.097)	(0.106)	(0.088)	(0.206)	(0.245)	(0.201)
Burgher	0.456*	0.289	0.299***	0.176	0.225	-0.049
	(0.239)	(0.311)	(0.083)	(0.336)	(0.375)	(0.152)
Father yrs ed	0.050***	0.060***	0.050***	0.053***	0.068***	0.049***
	(0.007)	(0.008)	(0.007)	(0.015)	(0.016)	(0.014)
Mother yrs ed	0.028***	0.025***	0.033***	0.055***	0.044*	0.057***
	(0.006)	(0.006)	(0.007)	(0.018)	(0.023)	(0.018)
Engl. at home		0.222***			-0.051	
		(0.069)			(0.124)	
Sin/Tam at hm			0.379**			0.132
			(0.170)			(0.237)
Log of acres	0.007	-0.002	0.004	-0.012	-0.036**	-0.012
	(0.012)	(0.008)	(0.011)	(0.013)	(0.016)	(0.014)
Electricity home	0.300***	0.330***	0.299***	0.228***	0.223***	0.226***
	(0.058)	(0.059)	(0.058)	(0.068)	(0.084)	(0.069)
Hope	0.048***	0.045***	0.045***	0.079	0.026	0.126
	(0.012)	(0.012)	(0.011)	(0.108)	(0.131)	(0.096)
Opinion	0.001	0.012	0.010	0.192***	0.302***	0.182**
	(0.008)	(0.008)	(0.008)	(0.073)	(0.089)	(0.073)
HH expenditure	0.131***	0.165***	0.145***	-0.130	0.087	-0.152
	(0.038)	(0.039)	(0.039)	(0.151)	(0.183)	(0.142)
Drinks from river	-0.411***	-0.251	-0.260**	-0.441**	-0.291	-0.359**
	(0.132)	(0.161)	(0.111)	(0.174)	(0.182)	(0.150)
Pit latrine	-0.111*	-0.124**	-0.153**	0.001	0.084	-0.039
	(0.063)	(0.061)	(0.062)	(0.103)	(0.133)	(0.099)
Desks	0.087	0.025	0.016	0.111	0.044	0.043
	(0.064)	(0.058)	(0.064)	(0.088)	(0.110)	(0.085)
School family	0.160**	0.170**	0.150*	0.246**	0.265*	0.247**
	(0.079)	(0.073)	(0.077)	(0.109)	(0.136)	(0.112)
Boys school	-0.251**	-0.140*	-0.138	-0.472***	-0.464**	-0.320**
	(0.102)	(0.077)	(0.091)	(0.166)	(0.211)	(0.153)
Girls school	0.079	0.460***	0.130	0.068	0.353	0.150
	(0.089)	(0.126)	(0.083)	(0.193)	(0.261)	(0.166)
Teach yrs exp	0.007	0.009*	0.006	0.017**	0.023**	0.016*

	(0.005)	(0.005)	(0.005)	(0.008)	(0.010)	(0.008)
Par-teach mtg	0.032**	0.048***	0.032**	0.066**	0.086**	0.070***
	(0.012)	(0.014)	(0.012)	(0.028)	(0.037)	(0.026)
Pr yrs exp	-0.001	0.001	-0.002	-0.005	-0.003	-0.007
	(0.005)	(0.005)	(0.005)	(0.008)	(0.009)	(0.007)
Constant	-3.657***	-4.325***	-3.857***	-8.470***	-12.913***	-7.817***
	(0.566)	(0.489)	(0.629)	(2.094)	(2.601)	(2.084)
Observations	2329	2325	2325	2252	2248	2248
R-squared	0.29	0.39	0.34			0.04

Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%
Instrumented (columns 4-6): Father yrs ed, Father yrs ed, HH expenditure , Hope, Opinion.
Instruments: Dadedu15, Dadedu610, Dadeduol, Dadedual, Dadedupost, Momedu15, Momedu610, Momeduol, Momedual, Momedupost, Hhinc, Erechope, Nerecopin

Table 7: Production Function, Instrument Variable Regression with School Variables

	Table 5 Results			Table 5, dropping educational inputs		
	(1)	(2)	(3)	(7)	(8)	(9)
	Math	English	First Lang.	Math	English	First Lang.
Desks	0.130*	0.044	0.069	0.125**	0.068	0.059
	(0.074)	(0.076)	(0.072)	(0.062)	(0.063)	(0.063)
School family	0.101	0.066	0.101	0.147**	0.143*	0.130*
	(0.107)	(0.114)	(0.101)	(0.071)	(0.074)	(0.074)
Boys school	-0.330***	-0.230**	-0.193**	-0.312***	-0.198**	-0.190**
	(0.106)	(0.091)	(0.096)	(0.100)	(0.078)	(0.089)
Girls school	-0.033	0.128	-0.030	0.037	0.418***	0.099
	(0.171)	(0.186)	(0.155)	(0.101)	(0.131)	(0.093)
Teach yrs exp	0.003	0.007	0.001	0.009**	0.010*	0.007
	(0.006)	(0.007)	(0.006)	(0.004)	(0.005)	(0.004)
Par-teach mtg	0.018	0.030	0.017	0.026**	0.040**	0.024*
	(0.017)	(0.020)	(0.017)	(0.012)	(0.016)	(0.012)
Pr yrs exp	0.008	0.013**	0.007	-0.002	-0.000	-0.003
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
Constant	-4.324***	-3.863***	-4.587***	-3.353***	-3.723***	-3.194***
	(1.034)	(1.167)	(0.925)	(0.445)	(0.421)	(0.516)
Observations	2275	2271	2271	2430	2426	2426
R-squared	0.14	0.18	0.21	0.24	0.33	0.28

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Reduced Form, Instrument Variable Regression with School Variables

	Table 6 Results			Table 6, dropping taste for education		
	(1)	(2)	(3)	(4)	(5)	(6)
	Math	English	First Lang.	Math	English	First Lang.
Desks	0.111	0.044	0.043	0.082	0.016	0.014
	(0.088)	(0.110)	(0.085)	(0.062)	(0.060)	(0.062)
School family	0.246**	0.265*	0.247**	0.128*	0.109	0.112
	(0.109)	(0.136)	(0.112)	(0.071)	(0.068)	(0.071)
Boys school	-0.472***	-0.464**	-0.320**	-0.296***	-0.202***	-0.175*
	(0.166)	(0.211)	(0.153)	(0.102)	(0.076)	(0.093)
Girls school	0.068	0.353	0.150	-0.006	0.336***	0.053
	(0.193)	(0.261)	(0.166)	(0.100)	(0.128)	(0.091)
Teach yrs exp	0.017**	0.023**	0.016*	0.006	0.008	0.005
	(0.008)	(0.010)	(0.008)	(0.005)	(0.005)	(0.005)
Par-teach mtg	0.066**	0.086**	0.070***	0.020*	0.031**	0.018
	(0.028)	(0.037)	(0.026)	(0.012)	(0.015)	(0.012)
Pr yrs exp	-0.005	-0.003	-0.007	-0.002	-0.000	-0.004
	(0.008)	(0.009)	(0.007)	(0.005)	(0.005)	(0.005)
Constant	-8.470***	-12.913***	-7.817***	-3.776***	-5.066***	-3.762***
	(2.094)	(2.601)	(2.084)	(0.622)	(0.562)	(0.697)
Observations	2252	2248	2248	2337	2333	2333
R-squared			0.04	0.25	0.35	0.30

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table A.1 Information Collected in NEREC Questionnaires

I. Child Questionnaire (completed by child at school)

Age, sex, number of older brothers and sisters, and younger brothers and sisters
Lives with one or both parents, or somewhere else
Languages spoken at home
School days without breakfast, and without meal after school
Availability of desk and/or chair at school
Means of transport to travel to school, and travel time required
Grade first entered current school, and whether attended preschool
Access to different types of textbooks and workbooks
Person at home who assists with schoolwork
Whether attends private tuition (tutoring) classes, and attitudes on those classes
Days absent from school, and reasons for absences
Watching TV and listening to radio, and if so favorite programs
Availability of newspapers at home
Whether teacher uses various books and/or visual aids in class
Attitudes toward school subjects and other aspects of school

II. Parent Questionnaire (completed by having parent come to the school)

Relationship to the child (father, mother, other types of relatives, nonrelative
Age (of respondent)
Parents of child are still alive, and current marital status of parents
Father and mother live with child, or somewhere else
Race and religion of both parents
Number of male and female children in family, and how many now in school
Where child lives while attending school
Type of dwelling, and whether child has bedroom, room for toys/books, garden
Dwelling has water, electricity, toilets, telephone, various durable goods
Education of mother, father, and older children, and occupation of each parent
Sources and amount (by 6 categories) of family income
School expenses of different types, and who pays for those expenses
Whether something interfered with child's education in 2002.
Languages used at home
Child's after school activities
Availability of newspapers in the household, and types of newspapers
Number of books in household, and whether use is made of libraries
TV programs watched by child, and total hours per day child watches TV
Other activities of child (e.g. cultural, religious, vacation)
Discussions with child's teacher, with child; child participates in school activities
Who helps child with schoolwork, hours per day child does school work at home
Participation by child in tuition classes, including cost and hours per week
Any discussions on education with child's friends' parents
Educational aspirations for child, and opinions on child's education

III. Teacher Questionnaire

Age (10 year ranges) and sex
Type of living quarters, distance and travel time from living quarters to school
Class and grade of teacher training, highest educational and professional degrees
Years experience as teacher, as primary teacher, and as teacher in current school
Days trained in teaching of math, English and local language, by training institute
Possession of teacher handbook, skill list, class book and workbook, by subject
Main sources of knowledge about teaching and learning of grade 4 students
Grades taught in 2002
Class size and prevalence of student absences, for grade 4 in 2002
Adequacy of 11 types of equipment (chairs, desks, blackboard, cupboard, etc.)
Receipt of money for "Quality Inputs" in 2002, and how many is spent
Opinion of teaching environment (space, ventilation, noise, etc.)
Who monitors teaching, and how often, and benefits provided by monitors
Fraction of students reaching "required level" in math, English and local language
How often leave is taken
Frequency of using various teaching methods, & when began to prepare for 2002
Number of students in special categories (dropout, repeat, orphan, disabled, etc.)
Fraction of students who do not eat breakfast, do not have exercise books, pencils
Opinions about grade 4 syllabus, by subject (math, English, local language)
Opinions about grade 4 "class books", by subject (math, English, local language)
Opinions about grade 4 suggested activities, by subject
Opinions on "list of essential learning skills", & on how often to evaluate students

IV. Sectional Head Questionnaire

Sex, and current position/post held
Years of experience as deputy principal and sectional head
Highest educational and professional degrees
Facilities to conduct duties (room, storage area)
Sufficiency of teacher handbooks, textbooks, and workbooks, by subject
Were 10 procedures followed in grade 4 in 2002 (recordkeeping, discussions, etc.)
Opinion of grade 4 teachers' performance in 2002 in 13 different categories/tasks
Opinion of grade 4 teachers' monitoring of students performance (9 activities)
Opinion of grade 4 teachers' ability/activities in influencing student learning
Opinion on teacher evaluation methods
Agreement with 12 statements on improvements in the school and on monitoring

V. Principal Questionnaire

"Council", age, and type of school
Total number of students and number of grade 4 students and classes, all in 2002
Age (10 year ranges), sex and general education level of principal
Principal's educational schooling and special training

Principal's position (permanent or temporary), "grade" & education service grade
Years of experience as principal, overall and in this school
Whether principal lives in this school
Number of grade 4 teachers, by sex and level of vocational/educational training
Frequency with which grade 4 teachers take leave
Frequency that grade 4 teachers participate in voluntary training
Number of classes and classrooms, by grade, and numbers of other types of rooms
Opinion on sufficiency of sports grounds, playground, and school garden
Sufficiency of 12 types a facitlies/equipment (e.g. water, electricity, telephones)
Adequacy of toilets
Distances traveled by students and teachers to come to school
Distance from school of 7 types of public amenities (clinic, post office, bus, etc.)
Frequency of bad behavior and thefts at school, and assessment of school security
Sources of financial support
Participation of principal in 7 activities (teaching, supervision, meet parents, etc.)
Opinion/Satisfaction regarding 10 general issues

Table A.2 Information Collected in NEC Questionnaires

I. Household Questionnaire (administered by interviewer at the child's home)

Child's age, sex, whether lives at home, and contact with home of not living there
Basic information on all household members (eg. age, sex, education, occupation)
Whether parents are alive, and whether they live with the child
Dwelling amenities for child (room, area for books/toys, garden, play area)
Method child uses to go to school, and times he/she leaves home & returns home
Hours per week in 11 after school activities (studying, working, playing, etc.)
Frequency that child reads newspapers
Books at home that child can read, and child's access to library books
Types of radio and television programs that child listens to or watches
Cultural activities that family takes the child to (7 types)
Parental contact with teachers and participation in school activities
Who helps the child with schoolwork done at home, and how frequently.
Participation in tuition (private tutoring classes), by academic subject
Contact between child's parents and the parents of child's friends
Parental expectations for child's education, and why parents value education
Reasons child has missed school in past year
Agreement with 17 statements regarding education and the child's school
Absence from school in past year due to health problems
Has child ever had a serious illness (one that lasted more than 2 weeks)
Illnesses during the past month (diarrhea, cold, asthma, fever)
Number of child bouts of malaria (ever, last 3 months)
Number of times that child has had worms (ever, last 3 months, last year)
Whether child has vision, hearing or other disability/problem.
Adequacy of child's diet, and events that lead to household food shortages
Detailed list of foods eaten by child in the previous day
Child health habits (drink boiled water, use of latrine, hours of sleep)
Dwelling information (type, number of rooms, water source, toilet, energy source)
Consumer durable (20 items) & productive assets (11 items) owned by household
Distance from dwelling to nearest, and most often used, of 7 amenities
Household monthly expenditures on food and 13 non-food items
Household income in past year, by source of income, and self-perceived status
Detailed expenditure on health and education items, for child and for others
Credit and savings history in past 5 years, and current savings
Whether household had a negative income shock, and what effect it had
Have any children dropped out of school
Household participation in community organizations/societies
Languages spoken at home, and family activities and discussion topics
Newspapers read, and books owned or borrowed, by family members
Methods used to discipline and reward the child

II. School Questionnaire (administered at the child's school)

Location and type of school
Where students come from, and whether any reside at the school
Distance from school to closest of 14 amenities (clinic, market, govt. office)
Student enrollment by grade and sex
Number of teachers, by sex and educational background
Number of grade 4 teachers, by training
Leave (absences) taken by grade 4 teachers ni 2004, by type of leave
Adequacy of supplies of 15 kinds of items (desks, blackboards, cupboards, etc.)
Availability of larger items in 2002 (reading room, garden, first aid box, etc.)
Whether textbooks were received on time in 2002, and if not how late
Existence of protective wall for school, and adequacy of toilets for children
Sex, educational background, and type of appointment of school principal
Years of experience of school principal
Where principal lives, and distance and travel time to school
Leave (absences) taken by principal in 2002
Frequency with which principal supervises "key stage 2 teachers"
Frequency of school staff meetings to discuss education issues
Questions on "school family" activities
Number of PTA meetings and school developing society meetings held in 2002
Number of times principal attended education reform programs in 2002
Parental awareness programs held in 2002, and reasons for them
Special projects undertaken in 2002 by school development society
Sex, educational background, and type of appointment of all grade 4 teachers
Years of service and marital status of all grade 4 teachers
Where each grade 4 teacher lives, and distance and travel time to school
In service training and school inspectors visits for all grade 4 teachers
Questions on "school family" activities for all grade 4 teachers
Hours grade 4 teachers teach students "after hours", why and which subjects
Methods teacher uses to inform parents of children's progress
Adequacy of equipment and materials of grade 4 teachers in 2002
Adequacy of grade 4 student textbooks, class books, workbooks & pens in 2002
Child's sex, language spoken at home and attendance of pre-school
Child's favorite play activities, favorite school subjects, and activities after school
Childs scores on "grade 4 learning competencies" (language, numeracy, environ.)
Student prizes/awards, and bad behavior
Student attendance in 2002 (from school records), and date of birth
Classroom observation of grade 4 teachers (11 categories)