WHEN THE LIGHTS GO ON: HOUSEHOLD ELECTRIFICATION AND EDUCATIONAL OUTCOMES IN RURAL INDIA

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ABSTRACT

This study uses econometric analysis to examine the relationship between household electrification and educational outcomes in rural India. Using the Annual Status of Education Report (ASER) from 2009-2011, this study finds that students whose households are electrified are more likely to complete grade-appropriate tests successfully as compared to their counterparts whose households are not electrified. The findings, which are consistent with prior research on this topic, suggest that additional investment in India's energy sector can yield improved educational outcomes.

The research and writing of this thesis is dedicated to everyone who helped along the way. Many thanks to Chris Toppe and my thesis team for the brainstorming and support. I would especially like to thank Barbara Schone, Adam Thomas, Ruth Hill Vargas, and Andrew Zeitlin for their guidance on my research and quantitative analysis. I am indebted to Michael Barker for his invaluable assistance and patience as I navigated STATA. Finally, a huge thank you to my family and friends for all of their support and love.

Many thanks,
Mona Dave

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Introduction

For development to be sustainable, governments must invest in both human capital and infrastructure modernization. With varying success, India has employed this strategy in the context of its efforts to maintain economic growth and reduce poverty. However, rampant corruption, broken incentive structures, and a massive population have made the improvement of government service delivery difficult. In rural areas, where over two-thirds of the population lives, according to the India Government census of 2011, this is a particular challenge.

To create opportunities for social advancement, India has placed significant resources into enhancing its human capital stock and infrastructure capabilities, which include its primary school education system and its electrification system. Although these sectors may seem unrelated, in reality empirical research indicates a close relationship between the two. The UN Foundation argues, “the lack of modern energy services stifles income-generating activities and hampers the provision of basic services such as health care and education” (UN Foundation). Specifically, access to electricity within a household has the potential for improving educational outcomes, because it extends studying hours into the evening and nighttime, it often speeds up household chores and tasks thereby creating more opportunities to study, and it closes the digital divide by making access to information and communication technology (ICT) more readily available (Kanagawa and Nakata 2008).

In line with the Millennium Development Goals, India seeks to provide basic education to all children by 2015. According to the 2011 Government of India census, literacy rates nationwide increased to 74.0% from 64.8% over the last ten years and in rural areas increased to 68.9% from 58.7%. However, despite these gains and numerous government programs to raise student enrollment rates and improve educational outcomes, India continues to lag behind the global adult literacy rate of approximately 84% estimated by the UNESCO Institute for Statistics (UIS).

Similarly, India has set a goal of 2017 for extending electricity to all households as stated in its 12th Economic Development Plan. In this regard, the 2011 Indian Government census indicates that 67.2 percent of all Indian households use electricity as their main sources of lighting. Specifically, 55.3 percent of rural households and 92.7 percent of urban households are electrified. The data indicates that populations experiencing low literacy rates also have limited access to electrification, raising questions about the relationship between these two conditions. A significant body of empirical analysis conducted primarily by development agencies and practitioners concludes that access to electricity is positively correlated with educational outcomes. Using past research as a guide, this study explores the effect of rural electrification on educational outcomes. Specifically, this study examines the relationship between having a household electricity connection and educational outcomes in reading and arithmetic across rural India. To conduct this study, I use the Annual Status of Education Report (ASER) dataset facilitated by Pratham, an India-based non-governmental organization.

As India and other developing nations struggle to reduce poverty and stimulate economic growth, it is pertinent that they have a sound understanding of the relationship between socio-economic conditions facing their populations and development. For example, evidence from this thesis can contribute to policymaking and future research on improving educational outcomes through investment in infrastructure and technology not commonly regarded as a component of education development policy.

Background

State of Education in India

Important determinants of educational opportunity and outcomes include household characteristics pertaining to asset ownership, parental levels of education, and financial costs of schooling. In addition, government policies to bolster enrollment, improve schooling quality, and ensure sustained learning also greatly influence a child's educational outcomes.

With approximately 30 percent of its population under age 15 (Indian Government Census 2011), India's hope of providing free and compulsory education to its citizenry has proven difficult. To fulfill this goal, which dates back to the country's independence, India's leaders have instituted multiple government schemes. In 2001, the government began its Midday Meal Scheme, which incentivizes school enrollment, particularly for poorer communities, by serving a midday meal to all children attending government schools. Started in 2004, the *Sarva Shiksha Abhiyan*, is an important initiative to realize universal education by 2010, which has since been extended. The program funds supply side needs, such as the upgrade of school facilities and reduction of student-teacher ratio, as well as demand side factors, such as free textbooks and other materials for students from disadvantaged groups. In 2009, the government passed the Right of Children to Free and Compulsory Education (RTE) Act, which enacts into law the right of every child "to full time elementary education of satisfactory and equitable quality in a formal school" (Department of School Education and Literacy). Through each of these schemes, the government has stated its intention to improve educational services and facilities and given civil society specific policies and benchmarks to reference when advocating for the same.

While none of these schemes is perfect and each varies in its effectiveness, India has successfully increased enrollment rates since 2001. According to UNICEF's Situation of Children in India report, net enrollment in 2007 was 95.5 percent, up 10.4 percentage points from 2001. Strides in girls' primary school enrollment are particularly noteworthy – jumping from 77 percent in 2001 to 93.6 in 2007. These findings are consistent with the 2011 Annual Status of Education Report (ASER) results, which find that only 3.3 percent of children between six and 14 years of age are out of school as compared to 6.6 percent in 2006. Also, completion rates for primary school increased by approximately 22 percentage points between 1991 and 2006; specifically from 63.8 percent in 1991 to 72.4 percent in 2001 to 85.7 percent in 2006 (UNICEF Situation of Children in India 2011).

While enrollment and completion rates are important aspects of educational achievement, attendance and quality of educational services are key indicators for success. In this regard, India has a great deal of room for improvement. Compared to children from OECD countries that attend school for six to eight hours a day for between 160-200 days a year, children in India generally attend schools for three hours a day for 140 days of the year (Banerjee and Duflo 2011). National primary school attendance rates are dismal and equaled only 70.9 percent of enrolled students when ASER conducted its 2011 survey, which is down from 73.4 percent in 2007. State specific attendance rates in 2011 vary and are as low as 50 percent in Bihar, 52.3 percent in Manipur, 54.5 percent in Madhya Pradesh and 57.3 in Uttar Pradesh. Each of these figures represents a decline in attendance rates since 2007.

An even harder factor to assess is the level of student achievement, which is, in part, a reflection of an education system's quality. National Council of Educational Research and Training (NCERT) conducted national standardized testing among Standard 5 students in two rounds: 2002-2003 and 2006-2007. The institution found that average scores were 46.5 percent in mathematics, 58.6 in language, and 50.3 in environmental studies during the first round and increased by 2 percent, 1.7 percent, and 1.9 percent, respectively, in the second round. (NCERT 2006) Similarly, ASER 2011 found that student achievement is suboptimal. Nationwide, only 48.2 percent of Standard 5 children are able to read a short passage equivalent to a Standard 2 level and only 61 percent of the same children are able to complete a two-digit subtraction problem. State-specific results vary with most states facing a decline in student achievement from 2010 and a few states experiencing an improvement in student achievement levels.

These results indicate that despite India's success in enrolling children in primary school, it is not successfully teaching them. Low levels of learning can be attributed to a number of factors, including teacher absenteeism, an inadequate number of schools and classrooms, and a shortage of resources for meeting the needs of a diverse population that, particularly in rural areas, is spread out. ASER found that nationwide on the day that it conducted its survey, 87 percent of teachers were present and in over 10 states, 90 percent or more appointed teachers were present. Banerjee and Duflo (2011) find that even when teachers are present they are often reading the newspaper, drinking tea, or talking with colleagues instead of teaching, which they do for less than half the time they are supposed to.

Furthermore, there are a variety of societal cleavages along which inequality persists, including gender, caste, religion, and geography. Inequity in the opportunities available to Indian children is not necessarily attributable to differences in educational expenditures, but is likely related to deeply ingrained discriminatory practices or economic realities. (Asadullah and Yalonetzky 2008). For example, Kingdon (2007) found that gender bias occurs primarily as a result of household discrimination as opposed to structural discrimination within the education system. Dougherty and Herd (2008) found that nearly two-thirds of all out-of-school children come from the five poorest states – Bihar, Uttar Pradesh, West Bengal, Madhya Pradesh, and Rajasthan. In rural areas, ASER 2011 found that one in four students attend a primary school where the language of instruction is different from that which they speak at home. Additionally, in a number of rural schools, ASER found that students from multiple grades occupy the same classroom, which is a result of classroom and/or teacher shortage.

A schooling quality divide also exists along rural and urban lines and is most stark when considering literacy rates, which are 85 percent in urban areas of India and 68.9 percent in rural areas. (Indian Government Census 2011). As a result, rural areas with poorly performing government schools are experiencing a growth in private schools, which tout better student and teacher performance after controlling for family and school characteristics. (Muralidharan and Kremer 2006).

Kingdon and Uni (2001) find that secondary and higher levels of education yield significantly higher wage returns than primary and lower levels of education in India. However, each hurdle to achieving quality universal education described above has consequences for higher levels of education, productivity, and workplace entry. Often, keeping children, especially girls, in school upon their completion of primary school is a challenge. According to World Bank statistics, enrollment rates for secondary school were 63 percent in 2010. This rate of attrition can be attributed to family circumstances and customs, limited access to secondary schooling, which varies across and within states, and poor facilities within schools.

LITERATURE REVIEW

Education is an important component of economic growth and poverty alleviation. In particular, education improves productivity of labor thereby increasing economic opportunities and wages, but also has societal benefits, like lowering fertility rates and improving health indicators, particularly when girls are educated. Recognizing that education is an important component of human capital, developing nations worldwide, including India, are striving to provide universal basic education to their children. Concurrently, theorists posit that the provision of public services and infrastructure, such as electricity, have a significant role in improving educational outcomes as well as quality of life. Recent empirical analysis conducted primarily by development agencies and practitioners concludes that access to electricity is positively correlated with educational outcomes.

This section provides a review of the literature pertaining to the relationship between education and economic growth, the state of electrification in India, and the social benefits of electrification.

Education and Economic Growth

Economists and social scientists have debated the contribution of education on economic growth for decades. A significant body of empirical research from the 1980s and 1990s indicates that education is positively correlated with economic growth despite discrepancies in the measurement of education across countries (Barro, 2002, Johnes, 2006, Krueger and Lindahl, 2001, Mankiw et al, 1992). In particular, both initial levels as well as changes in educational attainment are positively linked to economic growth (Krueger and Lindahl, 2001, Gemmell, 1996, Topel, 1999). Education, like other forms of human capital stock, has diminishing returns; therefore, the rate of return to educational investment is greatest in low- and middle-income countries (Psacharopolous and Patrinos, 2002). Psacharopolous and Patrinos (2002) observe that the private rate of return on educational investment in India is associated with a wage increase of 2.6% for each additional year of primary schooling, 17.6% for each additional year of secondary schooling, and 18.2% for each additional year of higher education.

Enrollment alone is not sufficient for economic growth, which is also dependent upon the quality of educational outcomes, which includes primary school completion and the retention of numeracy and literacy (Boissiere, 2004). As the number of primary schools worldwide proliferates, but resources available for teaching and materials remain limited, this question of quantity versus quality of education persists. Recent literature highlights the importance of quality, sustained educational outcomes for economic growth (Hanushek and Woessmann, 2007, Psacharopoulos and Patrinos, 2002, Tilak, 2007). Improved economic growth rates can have significant impact on poverty reduction in developing countries and as countries become more developed, the demand for a more educated workforce increases (Murphy and Welch, 1994). In low-income developing countries, primary basic education is most important for growth (Gemmell, 1996) and serves as a foundation upon which a more prosperous society is built.

Using two measurements of education, enrollment rate and average years of education, Self and Grabowski (2004) examine the impact of education at various levels on growth and use "Granger causality"[1] to test the causal relationship between these variables. The authors found "that primary education is not just strongly correlated with growth, but it has a strong causal impact on growth as well" (p. 52). These results are consistent across male and female students. At the secondary level, the results are less convincing. While enrollment rates show a causal impact on growth, average years of education at secondary levels do not. When observing

[1] Granger causality is a statistical method to test whether a given time series can predict another in the future or in the past.

females alone, the authors find a causal impact of secondary education on growth using both measurements of education. At the tertiary level, there is no causal link between either measurement of education and growth for the general population. However, for women and only using average years of education, there is a causal link between tertiary education and growth. Since tertiary enrollment rates for females were unavailable and the proportion of Indians participating in this level of education is limited, such causal results should be regarded with caution.

Beyond its private returns of improving individual labor productivity, education can have social returns that benefit society at large. As per Psacharopoulos and Patrinos (2002), spillover benefits of education are difficult to identify and measure and empirical evidence is “scarce and inconclusive” (p. 3). On the other hand, Krueger and Lindahl (2001) conclude that the challenges of accurate data collection and measurement error result in the ambiguous effect of education’s positive externalities. Despite contestation of this point on empirical grounds, researchers argue that the children of educated mothers have lower mortality rates and better health indicators, which results in spillover benefits for subsequent generations. As such, decreased fertility rates and increased participation of women in labor markets and public life can be attributed to education’s positive externalities.

State of Electrification in India

Having access to electricity improves quality of life and facilitates economic growth, including through the expansion of productive daytime hours in households, agriculture, and commerce as well as through the extension of evening hours for study, recreational reading, and entertainment through television and Internet. Electricity can also increase safety during nighttime hours, reduce indoor air pollution by replacing kerosene use, and forge new economic opportunities.

Since India's expansion of rural village electrification began in response to the 1960s famine to encourage electricity use for irrigation and improved agricultural yield, household electrification remained a lower priority (World Bank 2001). In recent years, the Indian Government has undertaken multiple efforts to improve electricity access for its citizens, including through the 2003 Electricity Act, subsequent national policy papers, and the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) initiative started in 2005, which sought to electrify all unelectrified households across India by 2012 (Bhattacharya 2006). Unable to meet its objectives, the RGGVY was extended and now aspires to reach all households by 2017.

In part, the low rate of household electrification is contingent upon connection costs, reliability of electricity supply, and village electrification, which is based off an antiquated government definition that considers a village electrified if at least one home has access to electricity (Bhattacharya 2006). Oda and Tsujita (2010) analyze the disparities in and determinants of rural electrification at the village level in Bihar state, India. Taking into consideration governance systems, livelihood potential, caste composition, and population size, the authors find that only distance from the capital is a significant predictor of whether a village is or is not electrified. Remote villages are less likely to be electrified, because of "cost ineffectiveness" and technical barriers to grid connection. Khandker, Samad, Ali, and Barnes (2010) found that an additional hour of electricity access at the village level is associated with a 2.7 percent increase in household adoption of electricity and a 14.4 percent increase in household electricity consumption. The authors conclude, "electricity access, in conjunction with service reliability, is what matters in improving household welfare in rural India" (p. 20).

Additionally, the provision of electricity is highly politicized, including in terms of which villages receive it and how and where *load shedding*, scheduled power outages, takes place (Wilkinson, 2006, Min, 2010). Such clientelism is characteristic of Indian democracy and other representational democracies, which run the risk of economic inefficiency when delivering goods and services (Besley and Coate, 1998, Robinson and Torvik, 2005, Mani and Mukund, 2007). Using satellite imagery and matching techniques, Min (2010) studied village electrification in Uttar Pradesh, India's most populated state that is also home to the largest proportion of unelectrified villages. The author found that the probability of a village being electrified was "substantially and significantly higher in constituencies represented by the low Caste [Bahujan Samaj Party]" (p. 34).

Even when these hurdles are overcome, "the larger share of benefits from rural electrification is captured by the non-poor" (World Bank 2008, p. xv). In contrast to their poorer counterparts, wealthier households reap greater benefits of electricity as a result of higher consumption and multiple uses beyond household lighting (Khandker et al 2010). To meet the demand for household electrification, some state governments and entrepreneurial citizens have successfully explored alternative energy sources that do not require a connection to government electricity grids. (Banerjee, 2006, Cust et al, 2007, Sharma, 2007). Regardless of the source, access to household electricity remains a central element of the troika on which Indian politics hinge - *bijli, sadak, paani* (electricity, roads, water).

Social Benefits of Electrification

The welfare benefits of household electrification are increasingly documented and include improvements in livelihood, health, and education as well as more productive time use.

Electricity and other sources of modern energy create income generation opportunities and reduce time spent on drudgery and household tasks, which can instead be spent on leisure or educational and informational activities. Access to lighting, including through electrification, also extends study and reading hours and time available for completing household chores, thereby improving educational outcomes worldwide (Cabraal et al, 2005, ESMAP, 2002, World Bank, 2008, Jacobson 2004).

Whether in the household or community, electricity is positively correlated with average school years completed, school enrollment rates, and literacy. In examining the welfare impacts of rural electrification in Bangladesh, Khandker, Barnes, and Samad (2009) found that the number of school years completed by boys and girls improve as a result of household electrification. In villages with electricity, boys and girls of electrified households complete 1.13 and 1.07 additional years of schooling compared to children from unelectrified households (Khandker et al 2009, p. 30). Grid electricity is used primarily for lighting, followed by television watching, and finally for reading and other activities.

Similarly, in another study, Khandker, Barnes, Samad, and Minh (2009) examined commune-level effects of electrification on school enrollment rates in Vietnam. They found that grid-connected communes are statistically significantly better off than non grid-connected communes. In the former, income is 80 percent higher and school enrollment for boys and girls increased 17.1 percent and 14.8 percent, respectively. Also, study results indicated that school enrollment outcomes improved more for girls than boys.

Similarly, Kanagawa and Nakata (2008) argue that individuals with no access to modern energy, including electricity, experience a drastic improvement in their quality of life once access is available. The authors found a positive relationship between electricity consumption per capita and literacy rate in India and argue that electrification in rural households provides adequate lighting for nighttime studying and utilization of television, radio, and information and communication technologies for educational purposes. Using multiple regression analysis and an energy-economic model, the authors examined unelectrified areas of rural Assam state, India to estimate the improvement in educational outcomes and other aspects of socio-economic status. Using a META Net economic modeling system, Kanagawa and Nakata argue that 96.3% of unelectrified households across Assam state can achieve electrification upon distribution of appropriate lighting appliances and materials. As such, they conclude Assam state's literacy rate would increase by approximately 11.9 percentage points, from 63.3% to 74.4%, if electricity access were made available.

Most studies researching the effects of electrification on education utilize average school years completed, school enrollment rates, or literacy as dependent variables. Boissiere (2004) indicates that the quality of literacy and numeracy retention are also important components of educational outcomes. However, studies rarely use such measures of educational outcomes as dependent variables. Expanding upon past research, this study uses nationally administered reading and arithmetic tests to explore the relationship between educational outcomes and electricity consumption in rural India.

DATA

Data Source

This study uses Pratham's Annual Status of Education Report (ASER) surveys from 2009-2011. Pratham, a Mumbai-based non-profit organization that seeks to improve the quality of education for underprivileged children in India, coordinates ASER. The organization began conducting ASER in 2005 in an effort "to get reliable estimates of the status of children's schooling and basic learning (reading and arithmetic level) at the district level and to measure the change in these basic learning and school statistics from [year to] year" (ASER 2011 Report, p. 24). ASER, which means *impact* in a number of Indian languages, is the largest effort to collect data specifically on children's elementary education in India.

On an annual basis and in conjunction with over 700 local organizations and institutions across the country, ASER reaches over 700,000 children in over 15,000 rural villages nationwide. The sample is complied by selecting 600 households per district, which represents 20 households in 30 villages per district. Districts are administrative units within an Indian state or territory and villages are sub-units within districts. Since this study uses three years of ASER data, I assembled a dataset that combines observations from only those districts that appear in all three years.

ASER employs a two-stage sampling design: stage one involves randomly selecting 30 villages from the census village directory and by using a probability proportion to size (PPS) sampling technique to ensure that villages with larger populations have a better chance of being selected as compared to their smaller counterparts. Stage two involves randomly selecting 20 households in each village by dividing villages into quarters and, from the center of each quarter, surveying every fifth house until five are visited. In each household, any child between ages 5-16 is surveyed and tested. An advantage of PPS is that "weighted estimates are exactly the same as the un-weighted estimates at the district level" (ASER 2011 Report, p. 288). As such, this study does not use weights, since children are the unit of analysis in district and year fixed effects analysis.

Measures and Descriptive Statistics

Annually, the ASER survey asks a set of core questions and uses simple tests to evaluate children's abilities in reading and arithmetic. The survey questions cover child-, household-, and village-specific characteristics that aim to assess enrollment in school, parental schooling levels, relative affluence, and village attributes as well as student achievement. To increase the sample size and improve the statistical rigor of this study, I pool ASER data from 2009-2011. Since it is only by chance that a child might be surveyed in more than one year and it is not possible to determine if this is the case, the resulting dataset is repeated cross sections and not a panel.

I restrict the dataset to children in Standards 1, 3, and 5, since this study focuses on the educational achievement of only these students on particular grade-appropriate tests. As such, the total sample size for three years of pooled data amounts to 527,631 observations.[2] However, a large fraction of observations have missing data on the independent or control variables, which may include some children with missing values on multiple variables and some children with no missing values at all. Upon regressing observations without missing values on my independent variable, I find that there is a statistically significant difference between the average value of electricity for children with and without missing observations. This fact raises the possibility that the missing data within the sample is systematic and could bias the results of the study if dropped. As such, I do not drop these observations. Instead, for each variable with missing

[2] There are 1,927,407 observations across all ASER data from 2009-2011 and 1,233,425 observations have missing data.

observations, I create a corresponding indicator variable that represents all missing values for that variable. Next, I recode all missing values to 0. I include the dummy variable and the original variable in regressions to capture the true value of the coefficient on each variable despite the presence of missing data.

a. Independent Variable

Of particular relevance to this study are survey questions asked in regards to electricity connection. Upon observing the respondent's household for wires, electric meters, and/or fittings, ASER marked the questionnaire "yes" or "no" for household electricity connection. Therefore, this variable is an indicator variable. Of the total sample, 67.85 percent are electrified. From year to year, household electrification across the dataset increases slightly.[3] In 2009, 64.37 percent of households had an electricity connection, 68.74 percent in 2010, and 70.67 percent in 2011. If there was indeed an electricity connection in the home, ASER asked "whether the household had electricity any time on the day of [the] visit, not necessarily when… doing the survey" (ASER 2011 Report, p. 33). Among those households that did have an electricity connection, 98.59 percent had electricity on the day of the survey. Reasons for not having electricity flow that day could be a result of *load shedding,* scheduled electricity outages, or electricity not yet having been used that day.

[3] Across all ASER data from 2009-2011, household electricity within the sample increased by three to four percent each year.

b. Dependent Variables

Another set of variables of particular relevance to this study is survey questions related to the administration of reading and arithmetic tests. To assess each child's level of educational achievement, ASER asked a series of simple, pass/fail reading and arithmetic tests. Figure 1 is the four part reading test ASER administered to children, which asked them to 1) identify letters, 2) read a few familiar short words, 3) read four simple linked sentences from a Standard 1 text, each having no more than 4-5 words, and 4) read a short story consisting of seven to 10 sentences from a Standard 2 text. The test is compatible with the vocabulary, sentence construction, and contexts presented in Standard 1 and 2 language textbooks of the state and in the language that the child learns at school. Children are asked to complete each section in order of rigor and highest level section a child is able to successfully complete is recorded by ASER.

For the purposes of this study, I focus on the performance of Standard 1 students' ability to complete part two or more, because I anticipate that upon enrolling in Standard 1 and using a government-issued Standard 1 text, a child should be able to identify letters and read short words. Hence, I create a dependent variable named *lower level reading test* that is coded 1 if a child can read a few familiar short words or more and coded 0 if a child is unable to read shorts words. Likewise, I focus on the performance of Standard 3 students on part four, because a child in Standard 3 should be able to read a government-issued Standard 2 text. As such, I create a dependent variable named *higher level reading test* that is coded 1 if a child can read a short story consisting of seven to 10 sentences from a Standard 2 text and coded 0 if a child is unable to do so.

Figure 1: Reading Test Administered to Students

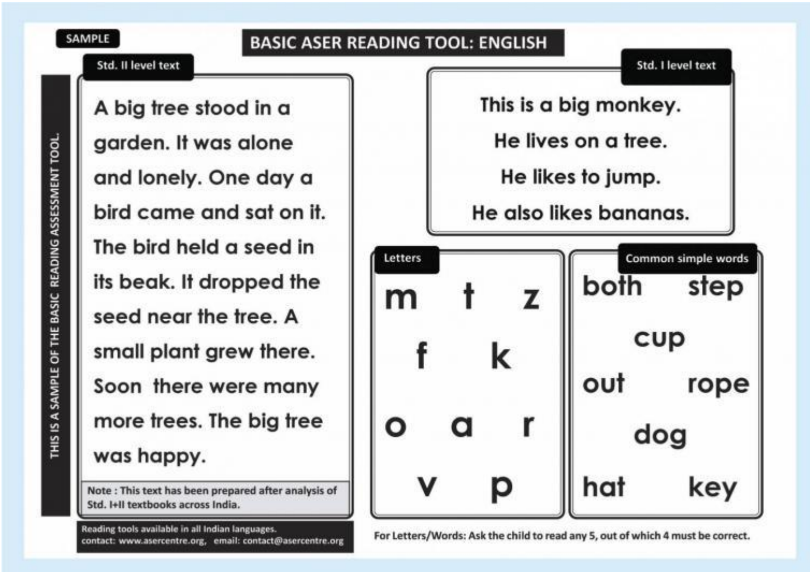

Figure 2 is the four part arithmetic test ASER administered to children, which asked them to 1) identify a randomly selected set of numbers between one and nine, 2) identify a randomly selected set of numbers between 11 and 99, 3) solve a two-digit subtraction problem that involves borrowing, and 4) solve a division problem that involves a one-digit divisor and three-digit dividend. Children are asked to complete each section in order of rigor and the highest level section a child is able to successfully complete is recorded by ASER.

I focus on the performance of Standard 3 students' ability to complete part two of the math test or more, because according to government standards, a child in Standard 3 should be able to identify numbers. Hence, I create a dependent variable named *lower level math test* that is coded 1 if a child can identify two-digit numbers or more and coded 0 if a child is unable to do so. Likewise, I look at the performance of a Standard 5 students' ability to complete simple division problems. As such, I create a dependent variable named *higher level math test* that is coded 1 if a student can successfully complete division problems and coded 0 if they cannot.

Figure 2: Arithmetic Test Administered to Students

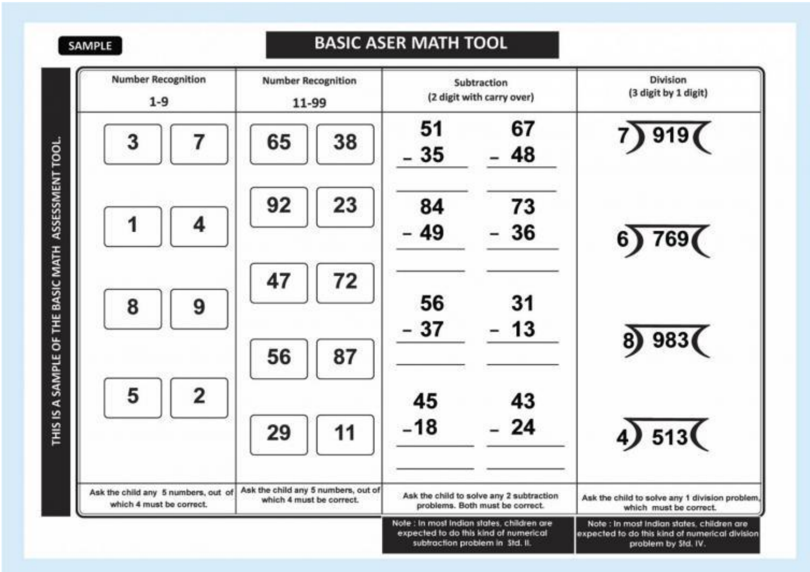

Table 1 illustrates student achievement in reading by grade. The percentages represent the proportion of children that can complete each test. Only 23.55 percent of children in Standard 1 can complete the lower level reading test or more (16.39 percent can read a few short words, 4.16 can read a short paragraph, and 3 percent can read a short story). Another 30.03 percent of Standard 1 children cannot complete any tests and 40.51 percent can only recognize letters. Among Standard 3 children, only 18.39 percent can complete the higher level reading test, which requires reading a story at Standard 2 level. Table 2 illustrates student achievement in arithmetic by grade. Among Standard 3 children, 68.94 percent can complete the lower level math test or more (33.77 percent can identify two digit numbers, 26.28 can complete subtraction problems, and 8.89 can complete division problems). Among Standard 5 children, 34.22 percent are able to complete the higher level math test, which requires them to do division problems.

Table 1: Highest Level of Test Completion by Grade					
Reading					
Standard	Nothing	Letter	Word	Para at Std. 1 level	Story at Std. 2 level
1	30.03	40.51	16.39	4.16	3.00
3	5.44	18.32	28.19	24.88	18.39

Table 2: Highest Level of Test Completion by Grade					
Arithmetic					
Standard	Nothing	Single Digit Numbers	Double Digit Numbers	Subtraction	Division
3	5.20	20.39	33.77	26.28	8.89
5	1.97	8.06	18.93	32.11	34.22

In summary, Table 3 provides descriptive statistics for the independent and dependent variables for this study by grade.

Table 3: Descriptive Statistics for Independent and Dependent Variables by Grade					
Variable	**Non Missing Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Standard 1					
Household Electricity	182,058	.65	.48	0	1
Lower Level Reading Test	183,402	.24	.42	0	1
Standard 3					
Household Electricity	169,369	.68	.47	0	1
Higher Level Reading Test	170,638	.18	.39	0	1
Lower Level Math Test	170,638	.69	.46	0	1
Standard 5					
Household Electricity	172,329	.70	.46	0	1
Higher Level Math Test	173,591	.34	.47	0	1

c. Control Variables

ASER asked respondents a number of questions about children's schooling, parental characteristics, and various household- and village-level attributes that likely influence children's educational outcomes and having a household electricity connection. The literature on this subject provides justification for the importance of using these variables as controls, since they are correlated with both the dependent and independent variables. Table 4 lists and defines the control variables I use in this study and Table 5 provides summary statistics about each control variable. Of particular note, for children whose parents never attended school, I recode missing values to 0 on the variable for highest level of schooling, *father class* and *mother class*. Additionally, the correlation between the key dependent variables and control variables does not exceed 15 percent and the correlation between the key independent and control variables does not exceed 39 percent. Finally, while ASER asked the same set of core questions each year, the dataset labeled and coded variables differently from year to year. Thus, for uniformity, I rename and recode key variables.

Table 4: Variable Definitions for Control Variables

Variable	Definition
Village Electricity	An indicator variable that denotes whether a village is electrified.
Household Type - Pucca	An indicator variable that denotes if the home visited is *pucca*, or made of permanent materials. Construction of a *pucca* dwelling is likely more costly than the construction of other, less permanent dwellings.
Household Toilet	An indicator variable that denotes whether the household has a toilet.
Household Mobile	An indicator variable that denotes whether the household has a mobile phone.
Tuition	An indicator variable that denotes whether the child attends tutoring classes outside of school.
Male Child	An indicator variable that denotes whether the child is male.
Father Class	A variable that records the highest class the father attended.
Mother Class	A variable that records the highest class the mother attended.
Government School	An indicator variable that denotes whether the child attends a government school.

Table 5: Descriptive Statistics for Control Variables					
Variable	**Non Missing Observations**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Village Electricity	519,900	.90	.30	0	1
Household Type - Pucca	526,157	.28	.45	0	1
Household Toilet	516,169	.39	.49	0	1
Household Mobile	517,448	.64	.48	0	1
Tuition	459,692	.18	.39	0	1
Male Child	521,197	.54	.50	0	1
Father Class	473,763	6.10	4.80	0	18
Mother Class	499,582	3.70	4.30	0	18
Government School	527,631	.74	.43	0	1

Strengths and Weaknesses

The ASER survey has multiple strengths, particularly its large sample size, since each year the survey reaches approximately 600,000 children across rural India. Also, that the reading and arithmetic tests are taken at home provides confidence that a child's true educational achievement is recorded. If tests were administered in school, teachers might choose the most intelligent children for testing or more intelligent children might self select into survey participation.

As it pertains to the questionnaire, ASER enumerators observed the home for wires and electrical fittings; however, may not have asked respondents whether they have functioning household electricity. Conducting the survey in this manner may have led to some inaccuracies in reporting. Still, I believe this is not a major concern since missing data in my key independent variable is limited as is missing data in the variable associated with whether the household received electricity that day. The ASER survey does not ask questions specific to caste, religion, and income, which may be important factors in children's educational achievement as well as in the ability of a household to acquire electricity.

Also, ASER acknowledges that margins of error are consistently higher for test outcomes, particularly math tests for Standards 3-5, because of the low incidence of children that attend these grades in the population and large standard errors. Still, I believe that pooling three years of data into one dataset increases my sample size enough to overcome this problem and provides greater statistical power to my model.

Each year ASER chooses a cluster of 10 new villages in each district and returns to that cluster for the next two years in an effort to reflect changes over time. For security reasons, ASER does not code each village similarly from year to year, which makes it impossible to create a panel dataset and conduct village-specific analysis.

METHODOLOGY

Using ASER survey data, this study explores the correlation between household electrification and educational outcomes in rural India. In particular, I look at student achievement on four pass/fail tests – a lower level reading test, a higher level reading test, a lower level math test, and a higher level math test.

The null and alternative hypotheses tested are

> H_0: Household electricity connection is not correlated with educational outcomes in rural India after controlling for village connectivity, gender of the student, type of education received by the student, parental education, and household asset ownership.
>
> H_a: Household electricity connection is correlated with educational outcomes in rural India after controlling for village connectivity, gender of the student, type of education received by the student, parental education, and household asset ownership.

This study uses limited probability models controlling for a variety of observable child-, household-, and village-level characteristics as well as district and time fixed effects. By using district fixed effects, I control for unobserved characteristics that are district-specific and do not change over time. Similarly, by using year fixed effects, I control for time-variant unobservable characteristics that are common across all villages. Each of these methods reduces omitted variable bias.

To conduct this analysis, I use the following fixed effects regression model for each pass/fail test. The complete fixed effects regression model is

$$test = \beta_0 + \beta_1 household\ electricity + \beta_2 village\ electricity + \beta_3 household\ type\ pucca + \beta_4 household\ toilet + \beta_5 household\ mobile + \beta_6 tuition + \beta_7 child\ male + \beta_8 father\ class + \beta_9 mother\ class + \beta_{10} government\ school + \beta_{11} m\_household\ electricity + \beta_{12} m\_village\ electricity + \beta_{13} m\_household\ type\ pucca + \beta_{14} m\_household\ toilet + \beta_{15} m\_household\ mobile + \beta_{16} m\_tuition + \beta_{17} m\_child\ male + \beta_{18} m\_father\ class + \beta_{19} m\_mother\ class + \alpha + \gamma + u$$

The variables that begin with *m_* are missing data indicator variables. The alpha (α) variable represents district fixed effects, the gamma (γ) variable represents year fixed effects, and the final variable (u) represents the error term. Regressions are computed with robust standard errors to control for heteroskedasticity.

REGRESSION RESULTS

As described in earlier sections, I explore the correlation between household electricity connection and educational outcomes. In particular, I look at student achievement on four pass/fail tests – a lower level reading test, a higher level reading test, a lower level math test, and a higher level math test. For each test, I present one table with four linear probably model (LPM) regressions. Regression 1 in each table is the simplest model and looks at the unconditional correlation between having household electricity and a child's ability to pass the test. It is unconditional, because I do not control for any other factors. For each test, this relationship is positive and statistically significant at a 1 percent level. However, this correlation is driven by a number of factors, including the true effect of electricity on education, the impact of village and district characteristics that affect both access to electricity and educational outcomes, and the impact of household and parental characteristics that affect both electricity access and educational achievement.

As such, in Regressions 2, 3, and 4 of each table, I seek to isolate the magnitude of the correlation between electricity connection and test completion by adding these omitted variables. In Regression 2 of each table, I include a control variable for village electricity, which indicates whether the child's village has an electricity connection. As discussed in the literature review, village electrification is an important determinant of household electricity connection. In Tables 6 and 7, the reading test regressions, the coefficients on village electricity are positive, but only statistically significant for the higher level reading test. In Tables 8 and 9, the math test regressions, the coefficients are statistically significant for both, but negative on the lower level math test and positive on the higher level math test. The magnitudes of the statistically significant coefficients on village electrification are similar to the magnitudes of coefficients for household electricity connection. As such, the inclusion of this variable in the linear probability model is important and notable as it pertains to the correlation between household electrification and educational achievement.

Next, in Regression 3, I add gender of the student, type of education received by the student, parental education, and household asset ownership. Finally, in Regression 4, I add district and year fixed effects. I present regression results for each test below.[4]

Lower Level Reading Test

While the inclusion of control variables in Regression 3 of Table 6 decreases the magnitude of the coefficient on household electricity connection, the coefficient remains positive and highly statistically significant. It predicts that a child whose household has an electricity connection is 5.81 percentage points more likely to successfully complete the lower level reading test or more as compared to a child without a household electricity connection, holding constant other variables in the model.

Upon including district and year fixed effects, Regression 4, the magnitude and significance of the coefficient on household electricity connection further decreases, but remains positive and highly statistically significant. At a 1 percent significance level, a child whose household has an electricity connection is 1.80 percentage points more likely to complete the lower level reading test or more successfully as compared to a child without a household electricity connection. This result indicates that some of the correlation was driven by district variation and time trends in educational attainment and electrification, as well as other fixed district and time characteristics that may be correlated with test completion and household

[4] I find that logit estimates are similar to LPM coefficient estimates. Therefore, I present LPM coefficient estimates, since they are more easily interpretable.

Table 6: Regression Results for Lower Level Reading Test

VARIABLES	Regression 1	Regression 2	Regression 3	Regression 4
Household Electricity	0.125***	0.123***	0.0581***	0.0180***
	(0.0019)	(0.0021)	(0.0022)	(0.0026)
Village Electricity		0.0053*	-0.0080***	0.0056
		(0.0030)	(0.0030)	(0.0035)
Household Type – Pucca			-0.0155***	0.0193***
			(0.0024)	(0.0025)
Household Toilet			0.0776***	0.0306***
			(0.0024)	(0.0025)
Household Mobile			-0.0169***	0.0094***
			(0.0021)	(0.0023)
Tuition			0.106***	0.0985***
			(0.0033)	(0.0031)
Child Male			0.0030	0.0044**
			(0.0019)	(0.0019)
Father Class			0.0034***	0.0037***
			(0.0003)	(0.0003)
Mother Class			0.0105***	0.0062***
			(0.0003)	(0.0003)
Government School			-0.0929***	-0.110***
			(0.0024)	(0.0023)
Missing Data Indicators Variables				
m_Household Electricity	0.0619***	0.0612***	0.0356***	0.0109
	(0.0113)	(0.0113)	(0.0122)	(0.0122)
m_Village Electricity		0.0281***	0.0108	0.0193**
		(0.0090)	(0.0088)	(0.0086)
m_Household Type – Pucca			-0.0120	0.0009
			(0.0182)	(0.0177)
m_Household Toilet			0.0186***	0.0021
			(0.0070)	(0.0070)
m_Household Mobile			-0.0177**	-0.0055
			(0.0076)	(0.0075)
m_Tuition			-0.0335***	-0.0296***
			(0.0026)	(0.0028)
m_Child Male			0.0152*	0.0175**
			(0.0086)	(0.0082)
m_Father Class			0.0052	0.0067*
			(0.0033)	(0.0035)
m_Mother Class			0.0473***	0.0261***
			(0.0044)	(0.0043)
Constant	0.155***	0.150***	0.188***	0.230***
	(0.0014)	(0.0026)	(0.0039)	(0.0043)
Observations	183,402	183,402	183,402	183,402
R-squared (within)	0.020	0.020	0.075	0.046
Number of Districts				548

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7: Regression Results for Higher Level Reading Test

VARIABLES	Regression 1	Regression 2	Regression 3	Regression 4
Household Electricity	0.0736***	0.0703***	0.0162***	0.0112***
	(0.0019)	(0.0020)	(0.0022)	(0.0026)
Village Electricity		0.0132***	0.0021	0.0121***
		(0.0030)	(0.0030)	(0.0035)
Household Type – Pucca			0.0188***	0.0198***
			(0.0023)	(0.0024)
Household Toilet			0.0322***	0.0167***
			(0.0022)	(0.0024)
Household Mobile			0.0047**	0.0117***
			(0.0020)	(0.0022)
Tuition			0.0722***	0.0677***
			(0.0029)	(0.0028)
Child Male			0.0016	0.0011
			(0.0018)	(0.0018)
Father Class			0.0052***	0.0047***
			(0.0002)	(0.0002)
Mother Class			0.0070***	0.0056***
			(0.0003)	(0.0003)
Government School			-0.0870***	-0.0974***
			(0.0026)	(0.0024)
Missing Data Indicators Variables				
m_Household Electricity	0.0465***	0.0446***	0.0080	0.0065
	(0.0109)	(0.0109)	(0.0118)	(0.0118)
m_Village Electricity		0.0131	-0.0018	0.0169**
		(0.0084)	(0.0082)	(0.0083)
m_Household Type – Pucca			0.0119	0.0208
			(0.0188)	(0.0182)
m_Household Toilet			0.0231***	0.0127*
			(0.0068)	(0.0067)
m_Household Mobile			0.0117	0.0098
			(0.0074)	(0.0071)
m_Tuition			-0.0185***	-0.0124***
			(0.0027)	(0.0029)
m_Child Male			-0.0053	-0.0159*
			(0.0084)	(0.0085)
m_Father Class			0.0183***	0.0128***
			(0.0031)	(0.0034)
m_Mother Class			0.0273***	0.0227***
			(0.0042)	(0.0042)
Constant	0.134***	0.124***	0.150***	0.175***
	(0.0015)	(0.0026)	(0.0040)	(0.0045)
Observations	170,638	170,638	170,638	170,638
R-squared (within)	0.008	0.008	0.053	0.039
Number of Districts				548

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8: Regression Results for Lower Level Math Test

VARIABLES	Regression 1	Regression 2	Regression 3	Regression 4
Household Electricity	0.147***	0.156***	0.0934***	0.0284***
	(0.0025)	(0.0027)	(0.0030)	(0.0030)
Village Electricity		-0.0343***	-0.0444***	-0.0102**
		(0.0042)	(0.0042)	(0.0041)
Household Type – Pucca			0.0042	0.0171***
			(0.0026)	(0.0028)
Household Toilet			0.0792***	0.0360***
			(0.0026)	(0.0028)
Household Mobile			-0.0075***	0.0262***
			(0.0026)	(0.0026)
Tuition			0.0558***	0.0483***
			(0.0028)	(0.0032)
Child Male			0.0217***	0.0206***
			(0.0022)	(0.0021)
Father Class			0.0038***	0.0044***
			(0.0003)	(0.0003)
Mother Class			0.0100***	0.0055***
			(0.0003)	(0.0003)
Government School			-0.0402***	-0.0776***
			(0.0026)	(0.0028)
Missing Data Indicators Variables				
m_Household Electricity	0.103***	0.108***	0.0984***	0.0488***
	(0.0131)	(0.0131)	(0.0145)	(0.0138)
m_Village Electricity		-0.0161	-0.0285***	-0.0038
		(0.0099)	(0.0097)	(0.0097)
m_Household Type – Pucca			-0.0728***	-0.0036
			(0.0227)	(0.0212)
m_Household Toilet			0.0542***	0.0211***
			(0.0083)	(0.0079)
m_Household Mobile			-0.0353***	-0.0238***
			(0.0089)	(0.0083)
m_Tuition			-0.0811***	-0.0765***
			(0.0035)	(0.0034)
m_Child Male			0.0504***	0.0081
			(0.0102)	(0.0100)
m_Father Class			-0.0287***	-0.0183***
			(0.0042)	(0.0039)
m_Mother Class			0.0240***	-0.0012
			(0.0052)	(0.0049)
Constant	0.589***	0.614***	0.604***	0.703***
	(0.0021)	(0.0037)	(0.0050)	(0.0052)
Observations	170,638	170,638	170,638	170,638
R-squared (within)	0.022	0.022	0.061	0.047
Number of Districts				548

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 9: Regression Results for Higher Level Math Test

VARIABLES	Regression 1	Regression 2	Regression 3	Regression 4
Household Electricity	0.0853***	0.0936***	0.0298***	0.0098***
	(0.0024)	(0.0026)	(0.0028)	(0.0031)
Village Electricity		-0.0362***	-0.0415***	0.0102**
		(0.0043)	(0.0042)	(0.0044)
Household Type – Pucca			0.0192***	0.0230***
			(0.0027)	(0.0027)
Household Toilet			0.0798***	0.0391***
			(0.0027)	(0.0028)
Household Mobile			0.0018	0.0208***
			(0.0026)	(0.0026)
Tuition			0.103***	0.0862***
			(0.0031)	(0.0031)
Child Male			0.0268***	0.0199***
			(0.0022)	(0.0021)
Father Class			0.0067***	0.0055***
			(0.0003)	(0.0003)
Mother Class			0.0059***	0.0066***
			(0.0003)	(0.0003)
Government School			-0.0459***	-0.0784***
			(0.0029)	(0.0029)
Missing Data Indicators Variables				
m_Household Electricity	0.0373***	0.0422***	0.0091	-0.0186
	(0.0133)	(0.0133)	(0.0145)	(0.0140)
m_Village Electricity		-0.0453***	-0.0558***	-0.000
		(0.0100)	(0.0099)	(0.0095)
m_Household Type – Pucca			-0.0729***	0.0083
			(0.0193)	(0.0203)
m_Household Toilet			0.0399***	-0.0006
			(0.0083)	(0.0079)
m_Household Mobile			0.0045	0.0063
			(0.0089)	(0.0084)
m_Tuition			-0.0413***	-0.0262***
			(0.0034)	(0.0035)
m_Child Male			0.0915***	0.0115
			(0.0108)	(0.0100)
m_Father Class			0.0140***	0.0082**
			(0.0041)	(0.0041)
m_Mother Class			0.0402***	0.0281***
			(0.0052)	(0.0049)
Constant	0.282***	0.309***	0.265***	0.327***
	(0.0020)	(0.0039)	(0.0052)	(0.0055)
Observations	173,591	173,591	173,591	173,591
R-squared (within)	0.007	0.007	0.048	0.049
Number of Districts				548

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

electricity connection. The fixed effects model explains 4.6 percent of the variation in a child's ability to successfully complete the lower level reading test or more in this sample.

Higher Level Reading Test

Including control variables to Regression 3 of Table 7 results in a decrease in the household electrification coefficient. At a 1 percent significance level, the coefficient predicts that a child whose household has an electricity connection is 1.62 percentage points more likely to successfully complete the higher level reading test as compared to a child without a household electricity connection.

Once district and year fixed effects are incorporated in Regression 4, the magnitude of the coefficient on household electricity connection further decreases, but remains positive and highly statistically significant. At a 1 percent significance level, a child whose household has an electricity connection is 1.12 percentage points more likely to complete the higher level reading test successfully as compared to a child without a household electricity connection. The fixed effects model explains 3.9 percent of the variation in a child's ability to successfully complete the higher level reading test in this sample.

Lower Level Math Test

Upon including control variables to Regression 3 of Table 8 the magnitude of the household electrification coefficient decreases. At a 1 percent significance level, children from electrified households are 9.34 percentage points more likely to complete the lower level math test or more successfully as compared to children without a household electrification.

However, after district and year fixed effects are incorporated in Regression 4, the magnitude of the coefficient on household electricity connection experiences a sizable decrease, but remains positive and highly statistically significant. At a 1 percent significance level, children from electrified households are 2.84 percentage points more likely to complete the lower level math test or more successfully as compared to children without a household electrification. As such, the inclusion of control variables as well as fixed effects correlated with successful test completion and household electrification refines the coefficient on household electricity. The fixed effects model explains 4.7 percent of the variation in a child's ability to pass the lower level math test or more in this sample.

Higher Level Math Test

The incorporation of control variables to Regression 3 of Table 9 leads to a considerable decrease in the magnitude of the household electrification coefficient. At a 1 percent significance level, the coefficient predicts that a child whose household has an electricity connection is 2.98 percentage points more likely to pass the higher level math test as compared to a child without a household electricity connection.

Upon adding district and year fixed effects in Regression 4, the magnitude of the coefficient on household electricity connection decreases. At a 1 percent significance level, the coefficient predicts that a child whose household has an electricity connection is 0.98 percentage points more likely to pass the higher level math test as compared to a child without a household electricity connection. The fixed effects model explains 4.9 percent of the variation in a child's ability to successfully complete the higher level math test in this sample.

For each of the tests, the extent to which the correlation remains once controlling for other factors - village level electrification first, then household, parental, and student characteristics, and finally fixed district and time characteristics – varies. However, the correlations remain statistically significant and while the magnitudes of the coefficients on household electrification are modest, they reinforce existing literature regarding the correlation between household electricity connection and educational achievement.

As it pertains to some of the control variables, a consistent pattern emerges across the four tests. Enrollment in tuition, which is out of school tutoring classes, and enrollment in a government school each have considerable explanatory power and are likely correlated with both educational achievement and whether a household is electrified. Therefore, the inclusion of these two variables, like the other control variables, is presumably resulting in a more accurate coefficient on household electricity.

Consistently, the coefficient on tuition is positive and highly statistically significant in Regressions 3 and 4 for each test. In the fixed effects regressions, the coefficient predicts that attending tuition is associated with an increased likelihood of completing the lower level reading test or more by 9.85 percentage points, the higher level reading test by 6.77 percentage points, the lower level math test or more by 4.83 percentage points, and the higher level math test by 8.62 percentage points when compared with a child that does not attend tuition.

Similarly, the coefficient on enrollment in a government school is negative and also highly statistically significant in Regressions 3 and 4 for each test. In the fixed effects regressions, the coefficient on this control variable indicates that a child's enrollment in a government school is associated with a decreased likelihood of completing the lower level reading test or more by 11 percentage points, the higher level reading test by 9.74 percentage points, the lower level math test or more by 7.76 percentage points, and the higher level math test by 7.84 percentage points when compared to a child that is not enrolled in a government school.

Missing data

A number of the missing data indicator variables are statistically significant in the fixed effects regressions. However, there is no discernable pattern across tests by which missing data indicator variables are statistically significant, except that the missing data indicator variable for tuition is consistently negative and statistically significant. In Regression 4 of Table 6, coefficients on missing data variables for village electricity, gender, and parental schooling levels are positive and statistically significant at conventional levels. The coefficient on the tuition missing data variable is negative and highly statistically significant. In Regression 4 of Table 7, coefficients on village electricity, household toilet, and parental schooling levels are positive and statistically significant at conventional levels. The coefficients on the missing data indicator variables for tuition and gender are negative and statistically significant. In Regression 4 of Table 8, the coefficients for missing data indicator variables on household electricity and household toilet are positive and the variables on household mobile phone, tuition, and father's schooling levels are negative. All are highly statistically significant. Finally, in Regression 4 of Table 9, the parental schooling missing data variables are positive and the tuition missing data variable is negative. Despite no emergence of a pattern of statistical significance on the coefficients for the missing data indicator variables, the results indicate that missing values are correlated with my variables of interest. Therefore, it is important to control for them.

DISCUSSION AND POLICY IMPLICATIONS

Development economists and researchers have sought to quantify the educational gains of household electrification for years. Commonly used measures of educational outcomes include enrollment and completion rates, literacy levels, and total number of study hours. Data on these measures are more readily available as compared to the measure used in this study – successful completion of pass/fail tests in reading and math. However, measures such as enrollment and time spent studying can be problematic. As discussed earlier, enrollment rates in India, particularly in primary school, are high and do not capture whether a child actually attends school consistently enough to learn. Similarly, data on hours spent studying is often self-reported and could be inflated, particularly in a competitive educational environment such as India. To expand upon past efforts to quantify whether household electrification contributes to educational achievement, this study uses a more selective measure and sample – successful completion of pass/fail tests in reading and math by children in corresponding grades. The narrow approach of this study, which focuses on outcomes that are difficult to impact, may explain the limited magnitude of the final results.

Using fixed effects methods allows me to control for important unobservable factors that are district and year specific and correlated with household electrification and educational outcomes. Some examples of such factors include school and teacher quality, quality of local governance and expenditure, corruption levels, and local economic circumstances. Ultimately, this study finds that having household electricity is correlated with an increased likelihood of successful test completion by approximately one to three percentage points, depending on the test.

To put the results of this study in context, I calculate the percentage change in pass rates for children without electricity if their homes are electrified using the formula for calculating a percentage change. Specifically, I make the assumption that the difference in the current pass rate for children without electricity and the probable pass rate if their homes are electrified is the coefficient on household electricity connection in the fixed effects regressions. Therefore, I divide the coefficient for each test by the current pass rate of that test for children without electricity to calculate the probable increase in test passage. The percentage change in the probability of passing each test is 6.66 percent on the lower level reading test or more, 4.66 percent for the higher level reading test, 10.70 percent for the lower level math test or more, and 3.98 percent for the higher level math test.

These figures can be added to the current pass rates for students from non-electrified houses to provide a sense of their probable pass rates if their houses are electrified. The current pass rates for children without electricity are 23.62 percent on the lower level reading test or more, 31.26 on the higher level reading test, 30.76 on the lower level math test or more, and 24.63 higher level math test. If the households of these children were electrified their probable pass rates would be 30.28 percent on the lower level reading test or more, 35.92 on the higher level reading test, 41.46 on the lower level math test or more, and 28.61 higher level math test. This gain in educational achievement may seem miniscule, however, if scaled to the total Indian population is sizable and could have significant impact on the state of education and learning.

Relatedly, much of the literature on this subject indicates that village electricity is a key determinant of household electricity, which may lead one to believe that most of the correlation between household electricity and education is driven by village electricity. However, the results of this study find that the magnitude of village electrification is similar to that of household electrification. It is noteworthy that both are important when considering their correlation with educational outcomes and may suggest that expanding the grid alone is unlikely to have an impact on educational outcomes, unless an emphasis is placed on ensuring that citizens are able to access affordable electricity within their homes.

Expectedly, household electricity only explains a small amount of the variation in educational outcomes. A number of this study's findings support the literature and trends in this regard. Household wealth, measured by a combination of assets, is positively correlated with test completion, as is parental schooling. The magnitudes on the coefficients of these variables are statistically significant at conventional levels and do not exceed four percentage points. It is not surprising that children of more affluent households and children of more educated parents are likely to have higher educational achievement, on average.

Whether a child attends tuition, which is out of school tutoring classes, or is enrolled in a government school is also likely a reflection of socioeconomic status and wealth. The findings of this study are consistent with the literature in this regard and indicate that participation in out of school tutoring is associated with an increased likelihood of passing all reading and math tests. Attending a government school yields the exact opposite result and is associated with a decreased likelihood of successful test completion. These results are as expected, but disheartening in that they reinforce the conventional wisdom that the Indian government's education system is failing to teach its children effectively and emphasizes the need to improve the quality of government schools. Interestingly, the results of this study find that being a boy is only slightly advantageous in passing the math tests and has no conclusive trend across reading tests.

Like many studies, this study is bound by the variables available in the dataset it uses. As such, it is likely that this study suffers from omitted variable bias, since there are a number of other factors associated with educational achievement that this study does not capture. The R-squared on each of the fixed effects regressions is low and supports this conclusion. This results in a biased estimation of the relationship between my dependent and independent variables. Additionally, while personal and household characteristics play a role in a child's educational achievement, it is possible that families that value electricity may also value education. Therefore, to strengthen this study or similar ones in the future, it is important to control for non household-specific variables, such as school quality and expenditure. The use of repeated cross sections instead of panel data is also a shortcoming of this study. If data for each child were available across multiple years, this study could yield a more accurate representation of the link between household electricity and educational outcomes.

While there is room for improvement in this study, its findings are consistent with previous research that household electricity is positively related to improved educational outcomes. As such, advocates for better primary education could consider access to electricity when promoting the reform of government services. As discussed earlier in the study, income levels, poor-quality housing construction, high costs of connection, and unpredictable electricity supply contribute to a household's prospects of attaining an electricity connection. The latter two determinants are supply side factors that the government can influence upon the exertion of citizen pressure and execution of political will. Issues of corruption and inefficiencies in the sector are additional areas of concern. This study, coupled with literature and research regarding the benefits of household electrification on other social sectors, provides some evidence for continued efforts to electrify all Indian homes.

Conclusion

A variety of factors influence a child's level of educational achievement. Some factors include household characteristics such as relative wealth, parental levels of education, and financial costs associated with schooling as well as school-level characteristics such as the quality of teachers, materials, and facilities. Efforts to research the impact of other factors, including household electrification, on educational outcomes are numerous. This study adds to that body of research by examining the relationship between having a household electricity connection and completion of pass/fail tests in reading and arithmetic.

Using Annual Status of Education Report (ASER) surveys from 2009-2011, this study finds that students whose households are electrified are more likely to complete grade-appropriate tests successfully as compared to their counterparts whose households are not electrified. For a more thorough examination of this relationship, future research should use panel data if available, account specifically for household income levels, and control for non household variables such as school quality and expenditures. This last point is particularly important, because it is possible that families that value electricity may also value education and controlling for factors unrelated to the household would likely yield a more accurate measure of the correlation between household electricity connection and educational outcomes. Still, this study reinforces past research on this topic and finds that household electrification is associated with better performance on reading and math tests in rural India.

The Indian Government's commitment to and investments in education for all and complete rural electrification are laudable. However, significant work to achieve these goals is still required. Advocates should consider the knowledge of a positive correlation between household electricity and educational outcomes when calling for improved government services.

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