Education in Rural Peru: Exploring the Role of Household Electrification in the School Enrollment

Veena S. Kulkarni
Arkansas State University

Douglas F. Barnes
Energy for Development

Citation: Kulkarni, V.S., & Barnes, D.F. (2017). Education in rural Peru: Exploring the role of household electrification in the school enrollment. *Journal of Research in Rural Education, 32*(10), 1-19.

This study employs Peru's National Survey of Rural Household Energy Use data to investigate the correlation between household access to electricity and enrollment of children age 6-18 after taking into account individual-child and household-level characteristics. Results indicate that children residing in households with access to electricity experience a significantly greater amount of reading time than those who do not. Additionally, household electrification substantially improves secondary school enrollment after controlling for household income, educational attainment of head of the household, ethnicity, and region. Findings therefore suggest significant potential benefits of expanding household electrification in enhancing educational attainments of the rural population.

An indisputable hallmark of the post-World War II development process is the educational expansion experienced across the developing world (Hannum & Buchmann, 2005; Lockheed & Verspoor, 1991; Mingat & Winter, 2002; Shavit & Blossfeld, 1993). The literature that analyzes this expansion posits educational outcomes to be a function of a complex interplay between micro (individual-household) and macro (community-structural) level factors (Hannum & Buchmann, 2005; Huisman & Smits, 2009).

A variable that has been gaining some recognition for its positive role in explaining educational outcomes is access to electricity, one of the central modern types of energy. The present study investigates the correlation between household access to electricity and school enrollment of children age 6-18 in rural Peru after taking into account the individual-child and household characteristics that have been deemed relevant. In spite of Peru's emergence as a middle-income country, rural areas suffer from low levels of development in education and electrification. This study is the first attempt to explore the relationship between education and electrification in rural Peru.

All correspondence should be directed to Veena S. Kulkarni, Department of Criminology, Sociology and Geography, Arkansas State University, P.O. Box 2410, State University, AR 72467 (vkulkarni@astate.edu).

The *Journal of Research in Rural Education* is published by the Center on Rural Education and Communities, College of Education, The Pennsylvania State University, University Park, PA 16802. ISSN 1551-0670

Findings from our analyses potentially contribute to our understanding of (a) the strength of the relationship between school enrollment and households' access to electricity, after incorporating the individual-child, household demographic, and economic factors, and (b) the existence and extent of the differential association of household electrification by levels (primary and secondary) of schooling. Furthermore, we expect the study to have policy relevance since access to modern sources of energy as well as to education have been identified as critical in the achievement of the Millennium Development Goals (MDGs) set by the United Nations and accepted by Peru.

Background

There is a prolific body of work demonstrating the independent effect of children's family background on educational attainment. The theoretical framework guiding the majority of this research assumes that the decisions regarding education are made within the household's economic framework by taking into account costs and returns to the household members (Schultz, 1975).

Role of Household and Individual-Child Level Factors in Educational Attainment

The household's economic status is strongly associated with school participation. A notable number of past and contemporary multi- and single-country studies shows a

significant relationship between educational attainments and households' economic position (Behrman & Knowles, 1999; Chernichovsky, 1985; Filmer & Pritchett, 1999a, 1999b, 2001; King & Lillard, 1987).

Other family characteristics that have been found to have an impact on educational outcomes are the household head's education, parental education and occupation, social class (caste), ethnicity, region of residence, and family size and composition. Gender, an individual-child characteristic of a school-age person, has emerged as a very significant factor relating to educational outcomes. A considerable volume of research convincingly demonstrates that educational opportunities for girls and boys are not the same (Hill & King, 1995; Stromquist, 1989). Gender influences school participation and its quality both independently and through its interaction with household and community characteristics (Al-Samarrai & Peasgood, 1998; Andrabi, Das, & Khwaja, 2008; Ashby & Gómez, 1985; Bowman & Anderson, 1980; Glick & Sahn, 2000; Grant & Behrman, 2010; Hannum, 2003; Ilahi, 2001; Jamison & Lockheed, 1987; Lancaster, Maitra, & Ray, 2008; Parish & Willis, 1993; Pritchett, 2004; Stash & Hannum, 2001).

One of the other important individual-child characteristics is the child's engagement in the labor market. Economists view the decision to send children to work for money, rather than to school, is influenced by adult wages and household income (Basu & Van, 1998). Lower adult wages force parents to push their children to engage in child labor to supplement household income.

Role of Infrastructure in Educational Attainment

The infrastructure factors related to education that have been recognized by previous research seem to overly focus on supply-side variables like the existence of schools and distance to school (Behrman & Knowles, 1999; Behrman, Deolalikar, & Soon, 2002; Filmer, 2000; Hannum, 2003; PROBE Team, 1999; Ramachandran, 2003; Sujatha, 2002). The relative neglect of infrastructure facilities at the household level may stem from a variety of sources. First, lack of availability of basic facilities at the school level is conspicuous in developing countries, and the hindrance posed by such a lack of amenities in augmenting educational participation and outcomes is obvious. Second, household-level infrastructure such as existence of electricity, safe drinking water, sanitation, modern cooking fuel, modes of media, and communication is more often than not confounded with the household's economic status. An economically well-off household is more likely to have access to better infrastructure. A notable trend to include a mix of individual-child, household, and infrastructure characteristics when analyzing school participation has emerged, however (Hanushek, 1995). The argument also exists that the specific effect of household characteristics is dependent on the larger context in which the household is situated, suggesting that the interaction between family background and community characteristics can vary across contexts (Huisman & Smits, 2009).

Some recent research has isolated the independent effect of household-level infrastructure facilities, such as access to electrification, on income levels (Khandker, Barnes, & Samad, 2012) and on educational outcomes for household members after controlling for the household's economic status. It has been observed that women living in households with electricity, regardless of economic status, read more than their counterparts who live in dwellings without electricity (World Bank, 2002). A study on Colombia shows that educational attainment of household heads residing in units with electricity is greater relative to those who do not have access to electricity (Velez, Becerra, & Carrasquilla, 1983). Additionally, a growing body of work indicates that household access to electrification enhances quality of life in terms of providing income generation opportunities, reducing poverty, improving children's health outcomes, reducing rates of child labor, and enhancing status of the women and girl children (Cabraal, Barnes, & Agarwal, 2005; Grimm, Hartwig, & Lay, 2013; Grogan & Sadanand, 2013; Ilahi, 2001; Leipziger, Fay, Wodon, & Yepes, 2003).

While the positive role of electrified schools has been documented, studies that examine the correlation of household electrification and educational outcomes are just beginning to emerge (Banerjee, Singh, & Hussain, 2011; Khandker et al., 2012; Khandker, Barnes, & Samad, 2013; Kumar & Rauniyar, 2011; Lipscomb, Mobarak, & Barham, 2013; Samad, Khandker, Asaduzzaman, & Yunus, 2013). A positive correlation between (household) income and household infrastructure is reasonable, but it nevertheless cannot be taken for granted. That is, a higher level of household income does not necessarily mean access to good infrastructural facilities.

Additionally, access to household electrification cannot unequivocally be conceptualized as a household- or community-level infrastructure characteristic. Access to electricity may also be a function of exogenous factors such as the government's electrification program and public subsidization. Thus, it is plausible that rich households may not have access to electricity if they are located in a community where there is no electric grid connection. Conversely, poor households may have access to electricity if they are located in a community with universal access to electrification. Notwithstanding this complex relationship wherein it is possible that households that can afford electricity are not be able to access it, research demonstrates that having access to electricity at the household level contributes positively to educational participation.

Based on a scant body of research that considers the relationship between educational outcomes and household access to electricity, the benefits of household electrification

on educational attainments can be conceptualized as direct and indirect. The direct benefits independent of a household's economic position include availability of greater study time for children and therefore better academic performance leading to greater (a) motivation for children to stay in school and (b) incentives for parents to encourage children to study as opposed to engage in paid and/or unpaid labor activities. Benefits of electrification on time spent on studying and on grade completion were seen in Bangladesh, Bhutan, Brazil, and Nepal, as well as in Sub-Saharan Africa (Banerjee et al., 2011; Bernard, 2012; Khandker et al., 2012; Brenneman & Kerf, 2002; Cabraal et al., 2005; Kapoor, Barnes, & Kulkarni, 2011; Kulkarni & Barnes, 2004; Kumar & Rauniyar, 2011; Lipscomb et al., 2013).

The presence of electricity at home alters children's time allocation among various activities such as paid labor, school-related work, and housework (DeGraff, Bilsborrow, & Herrin, 1993; Ilahi, 2001; Daka & Ballet, 2011). The indirect benefit following the well-documented positive association between income and education (Khandker et al., 2012) implies improved levels of household income leading to greater enrollment rates and better outcomes.

Country Context: Economy, Education, and Electrification

Peru appears to have been part of the economic boom experienced in the previous decade by large Latin American countries such as Brazil (World Bank, 2007), but one can argue that socioeconomic progress appears to be mixed when one considers development indicators other than the rate of economic growth (Aguero & Valdivia, 2010; Economic Commission for Latin America and the Caribbean, 1998; Massey & Capoferro, 2006). Peru's annual per capita rate of growth of GDP rose from 1.4% in 2000 to 5.6% in 2011 and peaked at 7.6% in 2010. The rate of growth of per capita GDP in 2005 and 2006, the period during which data for the present study were collected, was 5.6% and 6.6%. Furthermore, there has been a significant decline in the percentage of the population (rural and urban) living below the national poverty line, dropping from 58.7% in 2004 to 28.7% in 2011.

Inequality levels in Peru have been consistently high. Although the rural poverty rates followed a similar rate of decline of nearly 30% during the same period (83.4% to 56.5%), a rural disadvantage persists. According to 2006 data, the percentage of people living in extreme poverty in rural areas (37.1%) is more than seven times that of the population residing in urban areas (4.9%) (World Bank, 2007). In 2003, the Gini coefficient of 0.42, though lower than the Latin American average of 0.52, was still higher than the average (0.30) for middle-income countries. Peru also has higher rates of child labor (26.8%) than does the Latin American and Caribbean region as a whole (11.2%). Such high rates are possibly correlated with lower school participation (World Bank, 2007).

The rural-urban gap can be seen in the arena of education despite near-universal access to primary schooling and a significant increase in secondary enrollments rates (from 68.8% in 2000 to 77.6% in 2011). While gross enrollment rates for both rural and urban regions are reasonably high, there is a noticeable rural-urban gap in the on-time (school) completion rate. The reasons for this underperformance in rural areas have been identified as fewer school hours, inadequate learning materials, and low teacher quality and motivation (World Bank, 2003).

Reports of the 2007 census indicate that the rural electrification rate is 30% (vs. 91% for urban regions), one of the lowest in Latin America and among middle-income countries globally (World Bank, 2011). Details on Peru's electrification and macro-level findings from the data upon which this study draws are elucidated in the document *Peru: National Survey of Rural Household Energy Use* (Meier, Tuntevate, Barnes, Bogach, & Farchy, 2010; henceforth *Peru National Survey*). The *Peru National Survey* reports that in Peru electricity is one of the primary sources of energy, although not the sole one. Peru's low electrification rates may be a reflection of the commonly observed characteristic of "urban bias" across developing countries. The efforts to expand electrification undertaken in late 1970s tended to focus on urban and semi-urban expanses. In recent years, however, to rectify the widening gap between rural and urban areas, the Peruvian government implemented a project targeted to improving rural electrification (Arraiz & Calero, 2015; Meier et al., 2010).

Furthermore, access to and consumption of electricity appear to be a function of household income, with richer rural households having better access and greater levels of consumption relative to their poor counterparts (Meier et al., 2010). There are also notable inter-regional disparities in the percentage of households, with electrification rate ranging from 71% in the Southern Coastal region to 18% in the Amazon region. Thus, despite the recent spurt in economic growth, rural electrification appears to have a long way to go. This trend is particularly disconcerting considering the observed positive relationship between educational attainment and electrification in the developing world.

The present study, by analyzing the relationship between school enrollments and household electrification in a multivariate framework, supplements the findings presented in the *Peru National Survey* (Meier et al., 2010). It is the first attempt to advance our understanding of the relationship between individual-child, household, access to electricity, and the likelihood of school enrollment in

rural Peru. The questions addressed in this research are as follows.

1. What is the role of household electrification in predicting overall, primary, and secondary school enrollments after taking into account individual-child, household, and access to electricity?
2. How does the association between household electrification and school enrollments vary between primary and secondary levels of schooling?

Data and Methods

Data

The data employed in this study come from the *Peru National Survey* (Meier et al., 2010). The data were collected by Peru's National Institute of Statistics and Information Technology in collaboration with the World Bank's Energy Sector Management Assistance Program (ESMAP) in 2005-2006. The data set is unique in its information on access to electricity and on education, income, other socioeconomic characteristics, and household demographics. The sample is representative of the seven major regions (Coastal North, Central, and South regions; Andean North, Central and South regions; and Amazon). The sample size for the survey comprises 6,690 rural households that either have electricity or do not have electricity. The sample size is large enough to provide reliable estimates at the regional level.

Our unit of analysis, following the standard practice adopted for similar research (Banerjee et al., 2011, Khandker et al., 2013), is children instead of households. The advantage of employing children as a unit of analysis is that it helps capture within-household variation, which is particularly important to assess differences by individual-child characteristics. Additionally, household as a unit of analysis is more appropriate when using child schooling as a proxy to assess the household's wellbeing, considering that children's educational attainment is regarded as both an investment and a consumption good (Birdsall, 1982). Also, given that nearly one fifth of Peru's population is in the age 10-19 range, and the average number of children per woman is 2.4 (United Nations International Children's Emergency Fund, 2013), it is very likely that there is more than one school-going child in each household. As our unit of analysis is children age 6-18, we base our analysis on households that have children age 6-18.

Dependent variables. Our dependent variable is a binary variable measuring whether the child is enrolled or not enrolled in school. We recognize that while grade completion is arguably a better measure of educational attainment (Burke & Beegle, 2004), our data source limits us to analysis of enrollment as an outcome. It may be noted that enrollment has been used as one—and often the only—measure in the substantial body of research on educational participation. The probable reasons for the wide acceptance of enrollment as a measure are that it is one of the best flow measures, and it is easily available. Enrollment in the present analysis is measured by whether a child of school-going age is enrolled in school. It is therefore an empirical indicator that captures a child's actual behavior and is different from the concept of "compulsory schooling."

To account for the well-documented significance of the universalization of primary education (relative to higher levels of education) and special programs in the direction of the achievement of universal primary education in the majority of developing countries (Lockheed & Verspoor, 1991), we consider enrollment at primary and secondary levels in addition to overall school enrollment. The dependent variables thus are whether the child is enrolled or not enrolled at age (a) 6-18, (b) 6-11, and (c) 12-18.

Independent variables. Based on the literature reviewed previously, we include the following set of independent variables.

Individual-child. We conceptualize educational attainments as being associated with a child's age and sex. Further, to account for the nonlinear nature of age, we include square of age.

Household. Household characteristics relate to demographic characteristics of the household head—namely, age and educational attainment. While we use a categorical measurement of educational attainment of the household head in descriptive statistics, we measure it as a scale in the multivariate analysis. Given considerable inter-ethnic and inter-regional variation with regard to educational and other socioeconomic development in Peru (Cueto, Guerrero, León, Seguin, & Muñoz, 2009; Meier et al., 2010), we include ethnicity of the head of the household and region as independent variables. We use annual household consumption expenditure as a proxy for household income as is often done in case of developing countries (Grosh & Glewwe, 2000). To adjust for skewness, we use a logarithmic transformation of the annual household consumption expenditure. An additional measure of economic status is ownership of property as indicated by whether the present residence is owned, rented, or yielded. The category "yield" implies that the property has been leased out for the purpose of residence by an institution and not by an individual.

In addition to the central independent variable, household access to electricity, we include an infrastructure variable: type of sanitation facility. We theorize household's access to electricity and type of sanitation facility as a combination of household-level and community-level infrastructure characteristics because access to electricity

in developing countries is the function of the availability of electricity connection in the community as well as a household's willingness and ability to acquire access to it. Although we recognize that access (to electricity) does not always imply availability, owing to lack of information on availability, we rely on access as a proxy for availability. In a similar vein, using a public network sanitation system is a reflection of both the existence of the closed below-surface sewage system in the community and a household's financial ability and willingness to be part of the system.

The methodology that we adopt to predict enrollment rates, given the binary nature of the variables, is logistic regression. In the interest of easier interpretation, we present the odds ratio. We also present marginal effects and predicted probabilities of enrollment. The logit function that we estimate is of the following form.

$$Y = \gamma \text{ Individual-child} + \varphi \text{ Household} + \delta \text{ Infrastructure} + \varepsilon$$

The three dependent variables are measured as:

1 = enrolled at ages 6-11 or 12-18 or 6-18
0 = otherwise

Access to electricity comprises our key independent variable and is part of "infrastructure." The other infrastructure variable is sanitation.

The catalog of the description of the independent variables is provided in Appendix A. To address our two research questions, we follow a two-fold analytic strategy. First, we present descriptive bivariate correlations between (a) the dependent and the independent variables and (b) the central independent variable (access to electrification) and the dependent variables and other independent variables. Furthermore, we explore whether there is indeed a statistically significant difference in the mean amount of time that children in the households with and without electricity spend reading and studying. Second, using multivariate analyses we estimate odds ratio, marginal effects, and predicted probabilities to examine the role of household electrification in predicting enrollment for children age 6-11, 12-18, and 6-18 after accounting for individual-child, household, and infrastructure variables. The odds ratio helps assess whether change in likelihood of enrollment is significantly correlated with the change in access to electrification after accounting for individual-child, household demographic, economic, and other infrastructure variables. The marginal effects measure probabilities of enrollment when the independent variables change by one unit from the mean for continuous variables or change from 0 to 1 in the case of discrete variables. Predicted probabilities compare the probabilities of enrollment when there is access to electricity to a scenario when there is no access to electricity keeping all other independent variables constant.

The descriptive and regression analyses are weighted. The weights are estimated, taking into account both the probability of being included in the sample and adjustment for non-response. In the case of descriptive analyses, we conduct appropriate tests (t-test, chi-square, or test of proportions) to examine the statistical significance of the association between dependent and independent variables. Further, as we employ children as the unit of the analysis, we use robust variance estimators clustered at household level to correct for possible non-independence of observations. As mentioned previously, since it is likely that there is more than one child in a household, employing robust standard errors mitigates the limitation posed by likely correlation among the respondents and the consequent bias in the estimates. The summary statistics of the dependent and independent variables is provided in Appendix B.

Findings

Descriptive Analysis

Children in households with access to electricity read/study for statistically significantly greater amounts of time as compared to children without access to electricity (Figure 1). Children in households with no access to electricity study for 51.6 minutes per day as opposed to children in households with access to electricity who study 65.4 minutes per day.

Table 1 portrays correlations between access to electricity and enrollment separately for the three age groups and enrollment rates disaggregated by sex. The associations for age 6-18 and 12-18 are statistically significant. The enrollment rates decline substantially for secondary-age children, female and male alike. Enrollment is greater in households with access to electricity as compared to those without electricity. The gap, however, is not significant for children age 6-11 because over 90% of children attend school.

The enrollment gap between households with electricity and without electricity is wider for children age 12-18 when compared to children age 6-18 and 6-11. For children age 12-18, households with electricity show an enrollment rate of 83.1% as compared to households without electricity, for which the enrollment rate of is 68.9%. The differential is marginally wider for female children than male children.

The bivariate relationship between dependent and independent variables for the three age groups (6-18, 6-11, and 12-18) depicts age of child, education, ethnicity of the

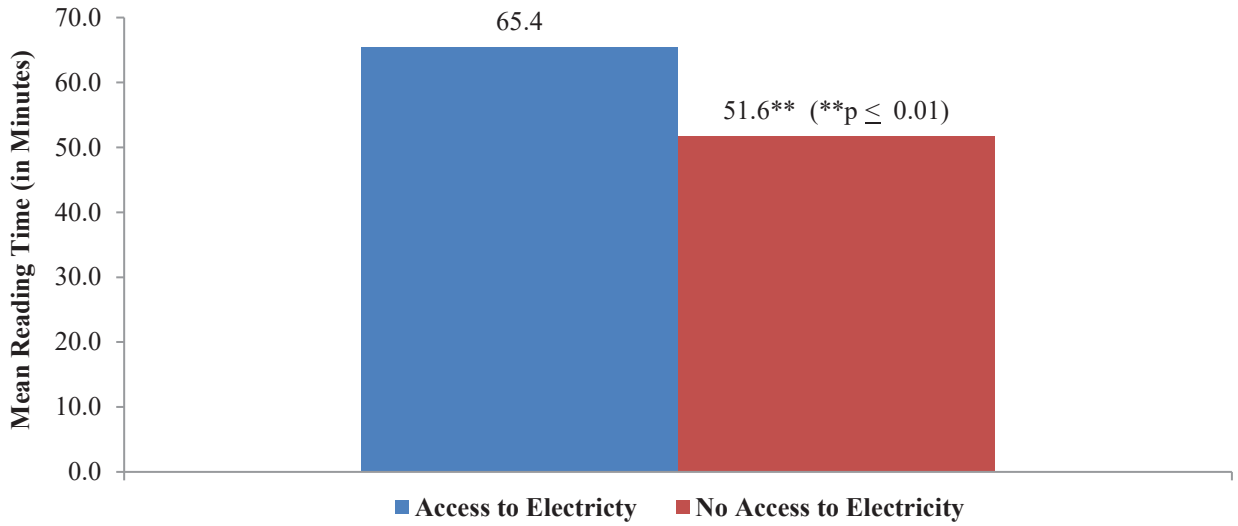

Figure 1. Mean reading time (in minutes) for enrolled children age 6-18 by household access to electricity.

Table 1

Percentage Enrolled by Access to Electricity and Gender for Children Age 6-18, 6-11, and 12-18

	All (1)	Access to Electricity (2)	No Access to Electricity (3)
All			
Age 6-18	83.1	88.0	80.4
Age 6-11	92.2	93.1	91.8
Age 12-18	74.1	83.1	68.9
Female			
Age 6-18	82.6	87.6	79.5
Age 6-11	92.0	93.4	91.2
Age 12-18	72.2	81.2	66.6
Male			
Age 6-18	83.6	88.5	81.1
Age 6-11	92.3	92.8	92.3
Age 12-18	75.6	84.8	70.6

household head, and region of residence as statistically significant across the two groups, enrolled vs. non-enrolled (Table 2).

With respect to ethnic affiliation, the intergroup variations are significant, and Native Amazonic children are most disadvantaged. The disadvantage is accentuated in age group 12-18, with 38.4% of Native Amazonic (age 12-18) children being non-enrolled. The statistics pertaining to economic indicators, type of residence, and annual household consumption expenditure are statistically significant and point to a positive direction between economic status and enrollment rate. In the case of household consumption expenditure, the gap is particularly pronounced for the age group 12-18. The annual household consumption expenditure for children age 12-18 who are enrolled is 5.2 (in '000s of soles, the Peruvian currency), the corresponding figure for non-enrolled children age 12-18 is 4.3 (in '000s of soles).

In the case of the central independent variable of interest, access to electricity, for the age group 6-18, 12% of children living in households with electricity are not enrolled while nearly one fifth (19.6%) of children living in households with no electrification are non-enrolled. For secondary-school-age children (12-18), the gap is even greater with parallel percentages being 17 and 31.

Table 3 presents bivariate associations between access to electrification with the dependent variable and other independent variables. All the associations are statistically

Table 2

Means (Standard Deviation) and Percentage Distribution of Independent Variables by Enrollment Status for Children Age 6-18, 6-11, and 12-18

Variable	Age 6-18		Age 6-11		Age 12-18	
	Enrolled	Non-enrolled	Enrolled	Non-enrolled	Enrolled	Non-enrolled
	(1)	(2)	(3)	(4)	(5)	(6)
Individual-Child Characteristics						
Age (in years)	11.1 (3.4)	14.1 (3.7)	8.6 (1.6)	8.2 (1.8)	14.3 (1.9)	15.8 (1.9)
Sex						
Female (Reference)	82.6	17.4	92.0	8.0	82.6	17.4
Male	83.6	16.4	92.3	7.7	83.6	16.4
Household Demographic and Economic Characteristics						
Age of household head	44.6 (11.2)	46.5 (12.2)	42.4 (11.4)	43.1 (12.5)	47.2 (10.5)	47.5 (11.9)
Household head's education (as a scale)						
No education	77.0	23.0	88.6	11.5	67.5	32.5
Primary incomplete	92.6	7.4	100.0	0.0	87.5	12.5
Primary complete	79.2	20.8	91.3	8.7	67.6	32.4
Secondary incomplete	82.2	17.8	90.1	9.9	74.3	25.7
Secondary complete	91.7	8.3	96.9	3.2	85.9	14.2
Postsecondary	91.2	8.8	95.5	4.5	86.1	13.9
Household head's ethnicity						
Native Quechua	86.1	13.9	90.9	9.1	81.0	19.0
Native Aymara	93.1	6.9	98.2	1.8	87.9	12.1
Native Amazonic	75.1	24.9	90.7	9.4	61.6	38.4
African Peruvian/Black/Asian	89.3	10.7	100.0	0.0	78.5	21.5
White of European origin	80.2	19.8	99.1	0.9	58.0	42.1
Meztizo (Reference)	80.7	19.3	92.5	7.5	69.3	30.7
Region of residence						
Northern Coastal	79.8	20.2	94.2	5.9	69.4	30.6
Central Coastal	87.2	12.8	94.1	5.9	81.5	18.5
Southern Coastal (Reference)	89.8	10.2	93.4	6.6	86.5	13.5
Northern Mountain	73.8	26.2	91.2	8.8	58.0	42.0
Central Mountain	89.3	10.7	95.2	4.8	83.0	17.0
Central South	86.6	13.4	91.3	8.7	82.1	17.9
Amazon	78.0	22.0	89.0	11.0	65.5	34.5
Type of residence						
Owned (Reference)	93.2	6.8	96.3	3.7	88.0	12.0
Rented	82.7	17.3	91.9	8.1	73.7	26.3
Yield	85.4	14.6	93.6	6.4	76.6	23.4
Annual household consumption expenditure (in '000s of soles)	4.9 (4.9)	4.3 (3.4)	4.7 (4.1)	4.1 (3.0)	5.2 (4.5)	4.3 (3.5)
Household Infrastructure Characteristics						
Access to electricity						
Access	88.0	12.0	91.7	8.3	83.1	17.0
No access (Reference)	80.4	19.6	93.1	6.9	69.0	31.0
Type of sanitation						
Public network (Reference)	89.2	10.8	91.8	8.2	87.0	13.0
Pit toilet	81.8	18.2	91.9	8.1	71.7	28.3
Rudimentary	83.4	16.6	92.6	7.4	74.1	26.0
Unweighted number of observations	7,412	1,424	3,887	299	3,525	1,125

Table 3

Means (Standard Deviation) and Percentage Distribution of Independent Variables by Household Access to Electricity for Children Age 6-18, 6-11, and 12-18

Variable	Age 6-18		Age 6-11		Age 12-18	
	Access to Electricity (1)	No Access to Electricity (2)	Access to Electricity (3)	No Access to Electricity (4)	Access to Electricity (5)	No Access to Electricity (6)
Dependent Variable: Enrollment						
Enrolled	38.5	61.5	36.2	63.8	41.4	58.6
Not enrolled (Reference)	26.0	74.0	31.9	68.1	24.3	75.8
Individual-Child Characteristics						
Age (in years)	11.7 (3.6)	11.6 (3.6)	8.6 (1.7)	8.6 (1.7)	14.7 (2.0)	14.7 (2.0)
Sex						
Female (Reference)	35.0	65.0	37.64	62.36	35.8	64.2
Male	38.0	62.0	34.12	65.88	38.4	61.7
Household Demographic and Economic Characteristics						
Age of household head	45.6 (11.7)	44.5 (11.2)	43.1 (11.9)	42.1 (11.2)	48.0 (10.9)	46.9 (10.8)
Household head's education (as a scale)						
No education	26.1	73.9	27.7	72.3	24.9	75.1
Primary incomplete	13.8	86.2	13.2	86.8	14.3	85.8
Primary complete	30.2	69.9	28.9	71.1	31.3	68.7
Secondary incomplete	31.8	68.2	31.0	69.0	32.6	67.4
Secondary complete	42.9	57.1	41.4	58.6	44.6	55.4
Postsecondary	61.4	42.9	59.2	40.8	36.1	63.9
Household head's ethnicity						
Native Quechua	41.7	58.3	41.5	58.5	41.9	58.1
Native Aymara	54.8	45.2	58.1	41.9	51.4	48.6
Native Amazonic	18.0	82.0	23.6	76.4	13.2	86.6
African Peruvian/Black/Asian	13.4	86.7	14.7	85.3	12.0	88.0
White of European Origin	45.4	54.7	45.9	54.1	44.7	55.3
Meztizo (Reference)	32.3	67.7	30.6	69.4	34.0	66.0
Region of residence						
Northern Coastal	32.7	67.3	30.1	69.9	30.1	69.9
Central Coastal	59.2	40.9	62.3	37.7	62.3	37.7
Southern Coastal (Reference)	75.6	24.4	73.6	26.4	73.6	26.4
Northern Mountain	20.2	79.8	18.9	81.1	18.9	81.1
Central Mountain	46.2	53.8	46.2	53.8	46.2	53.8
Central South	47.1	52.9	47.0	53.0	47.0	53.0
Amazon	18.6	81.4	17.8	82.2	17.8	82.2
Type of residence						
Owned (Reference)	36.5	63.5	35.5	64.5	37.4	62.6
Rented	89.7	10.3	89.9	10.1	89.4	10.7
Yield	27.3	72.7	28.2	71.8	73.7	26.3
Annual household consumption expenditure (in '000s of soles)	5.8 (0.8)	5.6 (0.8)	5.8 (0.8)	5.6 (0.8)	5.9 (0.8)	5.6 (0.8)
Household Infrastructure Characteristics						
Type of sanitation						
Public network (Reference)	88.8	11.2	85.7	14.3	91.5	8.5
Pit toilet	30.9	69.1	30.4	69.6	31.4	68.6
Rudimentary	32.1	67.9	32.9	67.1	31.3	68.7
Unweighted number of observations	3,976	4,849	1,840	2,341	2,136	2,508

significant. There is a greater percentage of enrolled children relative to non-enrolled children age 6-18 and 12-18 who reside in households with electricity as opposed to be living in households without electricity. The percentage of enrolled 6-18 age children living in households with electricity is greater (38.5%) than the percentage (26%) of non-enrolled children dwelling in units with electricity. The corresponding difference for children age 12-18 is 17.1%. There is a slightly greater proportion of female children age 6-18 and 12-18 living in households without electricity relative to their male counterparts.

Similar to the pattern observed for likelihood of enrollment, households with more educated heads are significantly more likely to have access to electricity. For all school-age children (6-18 years), the percentage of households in which heads have no education and there is no electricity is 73.9. In contrast 42.9% of households in which the head of household has post-secondary education are without electricity. The corresponding statistics for age 6-11 are 72.3% and 40.8%; for age 12-18 they are 75.1% and 63.9%.

Bivariate cross-regional distributions point toward significant differentials. As expected, economic measure of annual household consumption expenditure is positively related to access to electricity for all three age groups. A similar positive relationship does not seem to exist with type of property and access to electricity. Owned dwellings are less likely to have electricity than rented and yielded housing. This may be because houses that are owned may be older and without grid connection. Households with access to electricity have higher annual household expenditure compared to those without access to electricity. The pattern exhibited for type of sanitation follows the expected direction for all three age groups. For children age 6-18, 69.1% and 67.9% of households with pit and rudimentary toilets, respectively, do not have electricity. In contrast, the corresponding percentage of children with access to public network sanitation that do not have electricity is only 11.2% (for age 6-18).

In sum, descriptive analyses demonstrate significant correlation of individual-child, household demographic, and economic and infrastructure variables with the dependent variable, likelihood of school enrollment, and with the central independent variable, access to electricity. The individual characteristic of being younger improves the enrollment for children age 6-18 and 12-18. At the household level, the education of household head and the annual household consumption expenditure are substantially positively associated with enrollment and access to electrification for children age 6-18 and 12-18. Education of household head is significantly and positively associated with enrollment rates for all three age groups. There are significant ethnic and regional differentials in enrollment rates and access to electricity. Native Amazonic and Amazon emerge as most disadvantaged ethnic group and region respectively with regard to school enrollment and access to electricity. Multivariate estimates presented in Tables 4 and 5 and in Figures 2 and 3 help to examine whether the relationship between enrollment and household electrification is borne out in multivariate framework after accounting for individual-child, household demographic and economic and infrastructure variables.

Multivariate Analysis

We construct regression models separately for children age 6-18, 6-11, and 12-18. Table 4 presents the odds ratio from logistic regression while Table 5 indicates marginal effect on enrollment with respect to access to electricity. The discussion of results here focuses more on differential association of various (independent) variables with three dependent variables rather than on each dependent variable separately. The following central findings emerge from the regression analyses.

There are two specifications for the three dependent variables. The first specification represents bivariate association, and second one is the complete model with all the independent variables. Estimates pertaining to the independent variable of interest, access to electricity, indicate that household-level availability of electricity is statistically significantly associated with school enrollment for school going age (6-18) children and for children age 12-18. Children in the age group 6-18 are 78% more likely, and those in the age group 12-18 are more than twice more likely, to enroll in the first specifications (see Table 4, columns 1 and 5). The statistical significance of this relationship is sustained in subsequent specification, though the strength declines. In the full model, access to electricity increases the likelihood of enrollment of children age 6-18 and 12-18 by 27% and 47%, respectively (see Table 4, columns 2 and 6). Additionally, results show that gender differences are significant for the 6-18 age group and for middle- and secondary-school-age group 12-18. Male children age 6-18 and 12-18 are 28% and 37% more likely than their female counterparts to be enrolled in school (see Table 4, columns 2 and 6).

Among household-level characteristics, children age 6-18 and 12-18 living in households with older heads are more likely (5% for age 6-18, and 7% for age 12-18) to enroll relative to those with younger head of households. With respect to educational attainments of heads of household, higher education of head of households is associated with better odds of enrollment for children of all school-going ages. Likewise, magnitudes of the relationship between education of heads of household and likelihood of enrollment at an odds ratio of 1.18 (age 6-18), 1.20 (age

Table 4

Odds Ratio (Robust Standard Error) from the Logit Regressions on Likelihood of Enrollment of Children Aged 6-18, 6-11 and 12-18

Variable	Panel A: Age 6-18		Panel B: Age 6-11		Panel C: Age 12-18	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	(1)	(2)	(3)	(4)	(5)	(6)
Access to electricity	1.78**	1.27*	1.21	1.00	2.21**	1.47**
	(0.18)	(0.17)	(0.23	(0.21)	(0.24)	(0.22)
Individual-Child Characteristics						
Age		1.91**		7.41**		0.60
		(0.16)		(3.47)		(0.24)
Age square		0.96**		0.90**		1.00
		(0.003)		(0.02)		(0.01)
Male		1.28**		1.12		1.37**
		(0.11)		(0.17)		(0.14)
Household Demographic and Economic Characteristics						
Age of household head		1.05*		1.02		1.07*
		(0.03)		(0.05)		(0.03)
Square of the age of household head		1.00+		1.00		1.00+
		(0.0002)		(0.001)		(0.0003)
Household's education (as a scale)		1.18**		1.20*		1.17**
		(0.05)		(0.09)		(0.06)
Household head's ethnicity						
Native quechua		1.06		0.59+		1.42+
		(0.18)		(0.16)		(0.26)
Native aymara		2.90**		3.43		2.83*
		(1.12)		(2.63)		(1.22)
Native amazonic		1.31**		1.15		1.48
		(0.35)		(0.58)		(0.44)
African Peruvian/Oriental or Asian		3.11*		—[a]		3.00
		(1.89)				(2.24)
White of European Origin		1.30		10.99*		0.91
		(0.37)		(11.22)		(0.33)
Region of residence						
Northern coastal		0.61*		1.31		0.49**
		(0.13)		(0.50)		(0.12)
Central coastal		0.87		1.22		0.76
		(0.19)		(0.46)		(0.18)
Northern mountain		0.49**		0.93		0.39**
		(0.11)		(0.37)		(0.10)
Central mountain		1.47		2.47*		1.19
		(0.36)		(0.92)		(0.32)
Central south		0.90		1.27		0.80
		(0.24)		(0.49)		(0.23)
Amazon		0.45**		0.69		0.39**
		(0.10)		(0.25)		(0.10)
Type of residence						
Rented		1.45		2.20		1.28
		(0.78)		(1.78)		(0.77)
Yield		1.42+		1.28		1.44+
		(0.28)		(0.39)		(0.30)
Log of expenditure		1.36**		1.15		1.47**
		(0.10)		(0.14)		(0.12)
Household Infrastructure Characteristic						
Type of sanitation						
Pit toilet		0.75		1.44		0.58*
		(0.16)		(0.46)		(0.12)
Rudimentary		0.80		1.47		0.64*
		(0.18)		(0.49)		(0.14)
Observations (Degrees of Freedom)	8,825 (1)	8,823 (22)	4147(1)	4,147 (22)	4,644 (1)	4,643 (22)
Likelihood ratio chi-square	30.89 **	669.61**	1.01	69.57 **	51.03**	449.65 **

Note. Robust standard errors in brackets. ** p < 0.01 ; * p < 0.05; + p < 0.10 (two-tailed)
Reference categories: No access to electricity; Female; Meztizo; Southern Coastal; Owned property; Public network.
[a] As there is no variability in likelihood of enrollment for the ethnicity, "African Peruvian/Black/Asian" for age group 6-11, there is no estimate.

Table 5

Marginal Effect (Robust Standard Error) of Select Variables of Having Access to Electricity on School Enrollment for Children Age 6-18, 6-11, and 12-18

Variable	Age 6-18		Age 6-11		Age 12-8	
	(1)		(2)		(3)	
Access to electricity	0.03	+	0.00		0.06	**
	(0.01)		(0.01)		(0.02)	
Individual-Child Characteristics						
Age	0.07	**	0.12	**	-0.08	
	(0.01)		(0.03)		(0.06)	
Male	0.03	**	0.01		0.05	**
	(0.01)		(0.01)		(0.02)	
Household Demographic and Economic Characteristics						
Age of household head	0.01	*	0.001		0.01	*
	(0.003)		(0.03)		(0.01)	
Household's head's education (as a scale)	0.02	**	0.01	*	0.03	**
	(0.01)		(0.004)		(0.01)	
Log of annual household consumption expenditure	0.03	**	0.01		0.06	**
	(0.01)		(0.01)		(0.01)	
Household Infrastructure Characteristic						
Type of sanitation						
Pit toilet	-0.03		0.02		-0.09	*
	(0.02)		(0.02)		(0.04)	
Rudimentary	-0.02		0.02		-0.07	*
	(0.02)		(0.02)		(0.04)	

Note. ** p < 0.01 ; * p < 0.05; + p < 0.10 (two-tailed)
Reference categories: No access to electricity; Female; Public network

6-11), and 1.17 (age 12-18) are considerable (see Table 4, columns 2, 4, and 6). The association between household economic status and the likelihood of enrollment for children age 6-18 and 12-18 is positive and substantial. However, interaction variables between access to electricity and household economic status for all three age categories do not emerge as significant. The estimates can be made available upon request.

With regard to regional differentials, Amazon is the most disadvantaged region for all school-age (6-18) children and for children age 12-18. In Amazon region, children age 6-18 and children age 12-18 are 55% and 61% are less likely to be enrolled than their peers residing in the Southern Coastal region. The other statistically significantly disadvantaged regions (relative to Southern Coastal) for children age 6-18 and 12-18 are the Northern Coastal and Northern Mountain regions. In the case of primary school-age (6-11) children, residing in the Central Mountain region improves the odds of enrollment by 2.47 times relative to children living in Southern Coastal region (see Table 4, column 4). Estimates pertaining to the other infrastructure variable, type of sanitation, indicate that children age 12-18 inhabiting households with pit toilets and rudimentary toilets are 42% and 36% less likely to enroll relative to children living in units with access to the public sanitation network (see Table 4, column 6).

In addition to changes in the likelihood of enrollment, we estimate changes in the probability of being enrolled when the covariates change by one unit (for continuous variables) or change from 0 to 1 (for discrete variables). These changes in probabilities or marginal effects are presented in Table 5. Marginal effects of access to electricity are statistically significant for children age 6-18 and for children age 12-18. Access to electricity increases chances of enrollment by 3% for all school-age (6-18) children and by 6% for children age 12-18 (see Table 5, column 1). Being a male also increases the chances of enrollment by 3% and 5% for children age 6-18 and 12-18, respectively (see Table 5, columns 1 and 3). Higher levels of education of the household head are associated with greater probability of enrollment for all school-age children, as well as for primary- and secondary-school-age children (see Table 5,

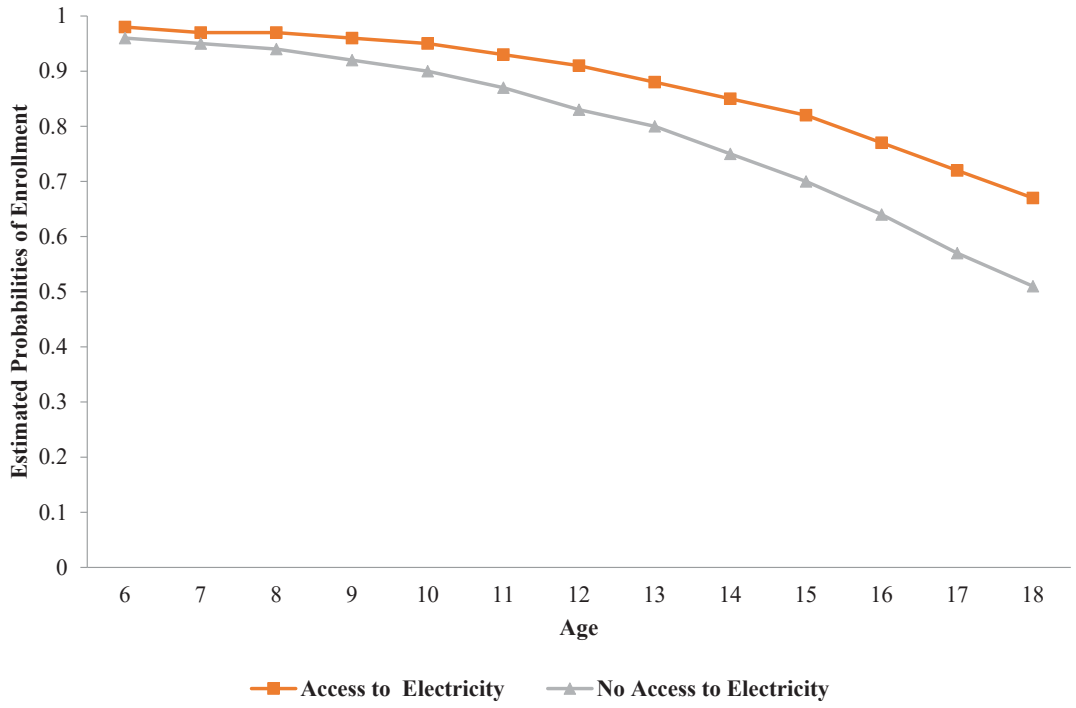

Figure 2. Estimated probabilities of enrollment by age and household access to electricity for children age 6-18.

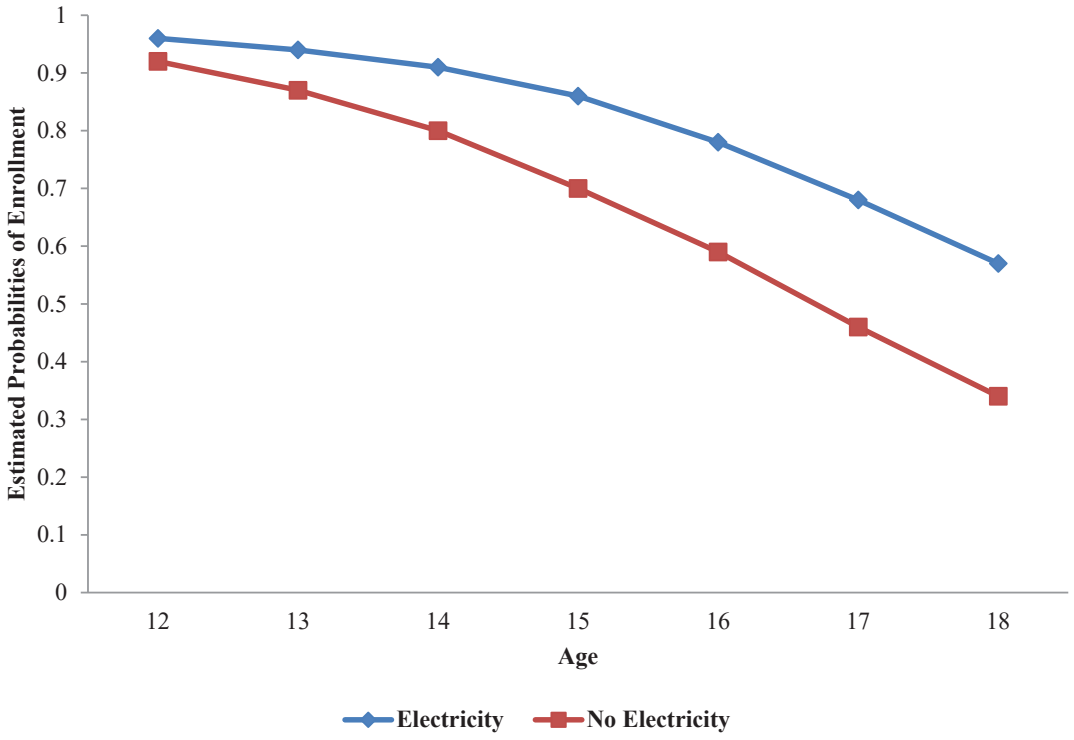

Figure 3. Estimated probabilities of enrollment by age and household access to electricity for children age 12-18.

columns 1, 2, and 3). Residing in an economically well-off household improves enrollment probabilities by 3% for children age 6-18 and by 6% for children age 12-18 (see Table 5, columns 1 and 3). The marginal effect of not having public network type of sanitation is negative for children age 12-18 (see Table 5, column 3).

In the interest of better visual depiction, Figures 2 and 3 display the relationship between estimates in changes in probabilities of enrollment for children age 6-18 and 12-18. The graphs indicate a change in the probability of enrollment with a unit change in age in alternative scenarios of having access to electricity and not having access to electricity after holding all other covariates constant.

As both graphs have a negative slope, probabilities of enrollment expectedly decline with increasing age. The distributions also indicate that as the age of the child advances, the gap between the probabilities of enrollment for children inhabiting households with access to and without access to electricity expands. Figure 3, based on the narrower age group of 12-18, enables us to see more clearly that access to electricity plays a more significant role in predicting secondary school vs. primary school enrollment.

Discussion

The present study examines the role of household electrification in predicting enrollment for school-age children disaggregated by the level of schooling in rural Peru. We employ a unique data set that contains detailed information on household access to electrification as well as on other individual and household-level variables and on the availability of other infrastructure. Our findings complement the macro level patterns observed in the *Peru National Survey* (Meier et al., 2010) and resonate with the patterns seen in the context of the developing world.

Bivariate distributions illustrate a positive association between enrollment and household electrification. A greater proportion of enrolled children resides in electrified households for all school-age children and for children age 12-18. Furthermore, households in which the head has secondary or higher education, typically wealthier and with more access to public network sanitation systems, experience higher enrollment and electrification rates relative to the households in which the heads of household have less than secondary education, are poor, and do not have access to public network sanitation. There are noteworthy inter-ethnic and inter-regional differences. The native Amazonic ethnic group and the region, Amazon are the most disadvantaged. As expected, ethnic and regional comparisons show that low school enrollment converges with low rates of electrification.

Second, bivariate differences are borne out in the multivariate setting for the central independent variable, access to electrification. Greater likelihood of enrollment is predicted for households with better access to electrification in the multivariate framework. The magnitude of the estimate affiliated with electrification after controlling for individual-child, household demographic, and economic variables and the quality of sanitation is quite high. Household access to electricity increases chances of enrollment by 27% for all school-age children and by 47% for children age 12-18. This finding, combined with the positive association between reading/studying time and access to electricity (see Figure 1), suggests electrification aids in improving enrollment by increasing reading/study time. Additionally, non-significance of the interaction between access to electricity and household income for all age categories implies that positive association holds to a similar extent for poor and rich households.

Third, estimates indicate access of electrification is not significant at the primary level but is highly significant for secondary-level enrollment. Plausible explanations are two-fold. First, unlike secondary-level education, there is universal enrollment at the primary level, suggesting that there is very little variability to be explained. Second, secondary school is more demanding in terms of the volume of academic work, which results in a greater need for electricity at home to facilitate studying late in the evening. Moreover, given the pervasiveness of child labor, and that secondary-school-age children (relative to primary-school-age) are more likely to be drawn to work, having electricity at home may encourage them to be diverted from work to school. Post-primary schooling may be constrained by lack of resources to a great extent. This assertion is supported by distribution of the predicted probability seen in Figures 2 and 3. Efficacious schooling would thus require augmenting access to facilities such as electricity at home in addition to more conventional resources such as a good curriculum and quality instruction.

Finally, the variable that emerges as significant across all age categories is education of the head of the household. As education of the head of household increases, the likelihood of enrollment of school-age children residing in that household rises, regardless of whether they are primary- or secondary-school age. Such a pattern is consistent with the generational reproduction of education thesis that is ubiquitous in literature on education in developing countries.

It may be noted that the cross-sectional nature of data makes it not amenable to establishing causality. Additionally, lack of information on timing of the advent of electrification in the educational career of the school-age child, on the reliability of the supply of electricity, and on supply-side factors such quality of school potentially contributes to the overestimation or underestimation of the benefits of access to electrification in improving enrollment. For instance, if a household accesses electricity at a later stage of a child's

educational career, data may contribute to overestimating the role of electrification. In a similar vein, accounting for access to electricity and not for the reliability of its supply may overestimate the function played by access to electricity when the supply is erratic. Also, considering only one measure of educational attainment, namely enrollment, constrains obtaining a comprehensive picture of the role of household electrification. Future studies could consider additional indicators such as test scores and grade level completed, which would contribute to our understanding of the relationship between household electrification and education.

Notwithstanding the limitations of this study, given the robust positive correlation in multivariate analysis between access to electricity and enrollment, and that energy transitions are arguably related to political willingness (Aklin & Urpelainen, 2013), the findings have potential policy relevance. The recognition of this association is especially critical for efficacious policy outcomes since the government of Peru has instituted multi-pronged strategies to improve the quality and equity of education under the auspices of the MDGs and increase rural electricity coverage to 88% by 2020 as part of the National Plan for Rural Electrification (World Bank, 2003, 2011).

The greater role of electrification at the secondary level of education suggests that making electricity accessible in rural areas is correlated with producing a workforce that is able to meet the growing demand for a more highly educated workforce in the ever-increasing globalized workplace. Given the evidence of pent-up demand and willingness to pay a high price for accessing electricity (Meier et al., 2010), the initiatives to expand electrification would be expected to be well received. As Peru embarks on a more inclusive model of development, coupled with the recognition of the significance of electrification in fulfilling the MDGs (Modi, McDade, Lallement, & Saghir, 2005), the government should pay special attention to universalizing rural household electrification.

References

Aguero, J. M., & Valdivia, M. (2010). The permanent effect of recessions on child health: Evidence from Peru. *Estudios Economicos*, *25*(1), 247-274.

Aklin, M., & Urpelainen, J. (2013). Political competition, path dependence, and the strategy of sustainable energy transitions. *American Journal of Political Science*, *57*, 643-658. doi:10.1111/ajps.12002

Al-Samarrai, S., & Peasgood, T. (1998). Educational attainments and household characteristics in Tanzania. *Economics of Education Review*, *17*, 395-417. doi:10.1016/S0272-7757(97)00052-6

Andrabi, T., Das J., & Khwaja, A. I. (2008). A dime a day: The possibilities and limits of private schooling in Pakistan. *Comparative Education Review*, *52*, 329-355. doi:10.1086/588796

Arraiz, I., & Calero, C. (2015). *From candles to light: The impact of rural electrification* (IDB Working Paper Series No. IDB-WP-599). Retrieved from Inter-American Development Bank Web site: https://publications.iadb.org/bitstream/handle/11319/6917/ImpactEvaluationRuralElectrification.pdf

Ashby, J. A., & Gómez, S. (Eds.). (1985). *Women, agriculture, and rural development in Latin America*. Muscle Shoals, AL: International Fertilizer Development Center.

Banerjee, S., Singh, A., & Hussain, S. (2011). *Power and people: The benefits of renewable energy in Nepal*. Washington, DC: World Bank.

Basu, K., & Van, H. P. (1998). The economics of child labor. *American Economic Review*, *88*, 412-427.

Behrman, J. R., Deolalikar, A. B., & Soon, L. (2002). *Promoting effective schooling through education decentralization in Bangladesh, Indonesia, and Philippines* (ERD Working Paper Series No. 23). Retrieved from Asian Development Bank Web site: https://www.adb.org/publications/promoting-effective-schooling-through-education-decentralization-bangladesh-indonesia

Behrman, J. R., & Knowles, J. C. (1999). Household income and child schooling. *World Bank Economic Review*, *13*, 211-256. doi:10.1093/wber/13.2.211

Bernard, T. (2012). Impact analysis of rural electrification projects in Sub-Saharan Africa. *World Bank Research Observer*, *27*, 35-51. doi:10.1093/wbro/lkq008

Birdsall, N. (1982). *Child schooling and the measurement of living standards* (Living Standards Measurement Study Working Paper No. 14). Retrieved from World Bank Web site: http://documents.worldbank.org/curated/en/388661468766816550/pdf/multi-page.pdf

Bowman, M. J., & Anderson, C. A. (1980). The participation of women in education in the third world. *Comparative Education Review*, *24*, 13-32. doi:10.1086/446137

Brenneman, A., & Kerf, M. (2002). *Infrastructure and poverty linkages: A literature review.* Washington, DC: World Bank.

Burke, K., & Beegle, K. (2004). Why children aren't attending school: The case of northwestern Tanzania. *Journal of African Economies*, *13*, 333-355. doi:10.1093/jae/ejh011

Cabraal, A., Barnes, D. F., Agarwal, S. (2005). Productive uses of energy for rural development. *Annual Review of Environment and Resources*, *30*, 117-144. doi:10.1146/annurev.energy.30.050504.144228

Chernichovsky, D. (1985). Socioeconomic and demographic aspects of school enrolment and attendance in rural Botswana. *Economic Development and Cultural Change*, *33*, 319-332. doi:10.1086/451463

Cueto, S., Guerrero, G., León, J., Seguin, E., & Muñoz, I. (2009). *Explaining and overcoming marginalization in education: A Focus on ethnic/language minorities in Peru* (EFA Global Monitoring Report.

Daka, K. R., & Ballet, J. (2011). Children's education and home electrification: A case study in northwestern Madagascar. *Energy Policy*, *39*, 2866-2874. doi:10.1016/j.enpol.2011.02.060

DeGraff, D. S., Bilsborrow, R. E., & Herrin, A. N. (1993). The implications of high fertility for children's time use in the Philippines. *Population and Development Review*, *22*, 265-298.

Economic Commission for Latin America and the Caribbean. (1998). *Economic Survey of Latin America and the Caribbean 1997-1998*. Retrieved from repositorio.cepal.org/bitstream/11362/1042/2/ESLA1997-1998_en.pdf

Filmer, D. (2000). *The structure of social disparities in education: Gender and wealth* (Policy Research Working Paper No. 2268). Retrieved from World Bank Web site: http://documents.worldbank.org/curated/en/617031468739532221/The-structure-of-social-disparities-in-education-gender-and-wealth

Filmer, D., & Pritchett, L. (1999a) The effects of household wealth on educational attainment: Evidence from 35 countries. *Population and Development Review*, *25*, 85-120. doi:10.1111/j.1728-4457.1999.00085.x

Filmer, D., & Pritchett, L. (1999b). Determinants of education enrolment in India: Child, household, village and state effects. *Journal of Educational Planning and Administration*, *13*(2), 135-164.

Filmer, D., & Pritchett, L. (2001). Estimating wealth effects without expenditure data or tears: With an application to educational enrolments in states of India. *Demography*, *38*, 115-132. doi:10.1353/dem.2001.0003

Glick, P., & Sahn, D. E. (2000). Schooling of boys and girls in a west African country: The effects of

parental education, income, and household structure. *Economics of Education Review*, *19*, 63-87. doi:10.1016/S0272-7757(99)00029-1

Grant, M. J., & Behrman, J. R. (2010). Gender gaps in educational attainment in less developed countries. *Population and Development Review*, *36*, 71-89. doi:10.1111/j.1728-4457.2010.00318.x

Grimm, M., Hartwig, R., & Lay, J. (2013). Electricity access and the performance of micro and small enterprises: Evidence from west Africa. *European Journal of Development Research*, *25*, 815-829. doi:10.1057/ejdr.2013.16

Grogan, L., & Sadanand, A. (2013). Rural electrification and employment in poor countries: Evidence from Nicaragua. *World Development*, *43*, 252-265. doi:10.1016/j.worlddev.2012.09.002

Grosh, M., & Glewwe, P. (Eds.). (2000). *Designing household survey questionnaires for developing countries*. Washington, DC: World Bank.

Hannum, E. (2003). Poverty and basic education in rural China: Villages, households, and girls' and boys' enrollment. *Comparative Education Review*, *47*, 141-159.

Hannum, E., & Buchmann, C. (2005). Global educational expansion and socio-economic development: An assessment of findings from the social sciences. *World Development*, *33*, 333-354. doi:10.1016/j.worlddev.2004.10.001

Hanushek, E. A. (1995). Education product functions. In M. Carnoy (Ed.), *International Encyclopedia of Economics of Education* (2nd ed., pp. 277-282). Tarrytown, NY: Pergamon.

Hill, M. A., & King, E. (1995). Women's education and economic well-being. *Feminist Economics*, *1*(2), 21-46. doi:10.1080/714042230

Huisman, J., & Smits, J. (2009). Effects of household- and district-level factors on primary school enrollment in 30 developing countries. *World Development*, *37*, 179-193. doi:10.1016/j.worlddev.2008.01.007

Ilahi, N. (2001). *Children's work and schooling: Does gender matter? Evidence from the Peru LSMS panel data* (Policy Research Report No. 2745). Retrieved from World Bank Web site: http://siteresources.worldbank.org/INTGENDER/Resources/multi0page.pdf

Jamison, D. T., & Lockheed, M. E. (1987). Participation in schooling: Determinants and learning outcomes in Nepal. *Economic Development and Cultural Change*, *35*, 279-306. doi:10.1086/451586

Kapoor, S., Barnes, D. F., & Kulkarni, V. (2011, March). *Impact of modern fuels on education in India*. Paper presented at the annual meeting of the Population Association of America, Washington, DC.

Khandker, S. R., Barnes, D. F., & Samad, H. A. (2012). The welfare impacts of rural electrification in Bangladesh. *Energy Journal*, *33*, 199-218. doi:10.5547/ISSN0195-6574-EJ-Vol33-No1-7

Khandker, S. R., Barnes, D. F., & Samad, H. A. (2013). Welfare impacts of rural electrification: A panel data analysis from Vietnam. *Economic Development and Cultural Change*, *61*, 659-692. doi:10.1086/669262

King, E. M., & Lillard, L. A. (1987). Education policy and schooling attainment in Malaysia and the Philippines. *Economics of Education Review*, *6*, 167-181. doi:10.1016/0272-7757(87)90050-1

Kumar, S., & Rauniyar, G. (2011). *Is electrification welfare improving? Non-experimental evidence from rural Bhutan* (MPRA Paper No. 31482). Retrieved from Munich Personal RePEc Archive Web site: https://mpra.ub.uni-muenchen.de/31482/

Kulkarni, V., & Barnes, D. F. (2004). *The impact of electricity on school participation in rural Nicaragua* (Working Paper). College Park: University of Maryland.

Lancaster, G., Maitra, P., & Ray, R. (2008). Household expenditure patterns and gender bias: Evidence from selected Indian states. *Oxford Development Studies*, *36*, 133-157. doi:10.1080/13600810802037803

Leipziger, D., Fay, M., Wodon, Q., & Yepes, T. (2003). *Achieving the Millennium Development Goals: The role of infrastructure* (Working Paper No. 3163). Retrieved from World Bank Web site: http://documents.worldbank.org/curated/en/339911468761663156/pdf/wps3163.pdf

Lipscomb, M., Mobarak, A. M., & Barham, T. (2013). Development effects of electrification: Evidence from the topographic placement of hydropower plants in Brazil. *American Economic Journal: Applied Economics*, *5*, 200-231. doi:10.1257/app.5.2.200

Lockheed, M. E., & Verspoor, A. M. (1991). *Improving primary education in developing countries*. Washington, DC: Oxford University Press.

Massey, D., & Capoferro, C. (2006). Sálvese quien pueda: Structural adjustment and emigration from Lima. *Annals of the American Academy of Political and Social Science*, *606*(1), 116-127. doi:10.1177/0002716206288105

Meier, P., Tuntivate, V., Barnes, D. F., Bogach, S. V., & Farchy, D. (2010). *Peru: National survey of rural household energy use*. Retrieved from Energy Sector Management Assistance Program Web site: http://esmap.org/node/343

Mingat, A., & Winter, C. (2002). Education for all by 2015. *Finance & Development*, *39*(1), 32-35. Retrieved from http://www.imf.org/external/pubs/ft/fandd/2002/03/mingat.htm

Modi, V., McDade, S., Lallement, D. & Saghir, J. (2005). *Energy services for the Millennium Development*

Goals. Retrieved from United Nations Millennium Project Web site: http://www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf

Parish, W. L., & Willis, R. J. (1993). Daughters, education, and family budgets: Taiwan experiences. *Journal of Human Resources*, *29*, 863-898. doi:10.2307/146296

Pritchett, L. (2004). Access to education. In B. Lomborg (Ed.), *Global crises, global solutions* (pp. 227-235). Cambridge, UK: Cambridge University Press.

PROBE Team. (1999). *Public report on basic education in India*. New Delhi, India: Oxford University Press.

Ramachandran, V. (2003). Backward and forward linkages that strengthen primary education. *Economic and Political Weekly*, *38*, 959-968.

Samad, H. A., Khandker, S. R., Asaduzzaman, M., & Yunus, M. (2013). *The benefits of solar home systems: An analysis from Bangladesh*. Retrieved from World Bank Web site: http://documents.worldbank.org/curated/en/656991467998808205/The-benefits-of-solar-home-systems-an-analysis-from-Bangladesh

Schultz, T. P. (1975). What are appropriate criteria for allocating education resources in Colombia? *24th Latin American Conference on Population Growth and Human Productivity*. Gainsville: University of Florida Press.

Shavit, Y., & Blossfeld, H.-P. (Eds.). (1993). *Persistent inequality: Changing educational attainment in thirteen countries*. Boulder, CO: Westview.

Stash, S., & Hannum, E. (2001). Who goes to school? Educational stratification by gender, caste and ethnicity in Nepal. *Comparative Education Review*, *45*, 354-378. doi:10.1086/447676

Stromquist, N. P. (1989). Determinants of educational participation and achievement of women in the Third World: A review of the evidence and a theoretical critique. *Review of Educational Research*, *59*, 143-183. doi:10.3102/00346543059002143

Sujatha, K. (2002). Education among scheduled tribes. In R. Govinda (Ed.), *India education report: A profile of basic education* (pp. 87-94). New Delhi, India: Oxford University Press.

United Nations International Children's Emergency Fund. (2013). *At a glance: Peru*. Retrieved from https://www.unicef.org/infobycountry/peru.html

Velez, E., Becerra, C., & Carrasquilla, A. (1983). *Rural electrification in Colombia*. Retrieved from U.S. Agency for International Development Web site: http://pdf.usaid.gov/pdf_docs/PNAAT489.pdf

World Bank. (2002). *Rural electrification and development in the Philippines: Measuring the social and economic benefits* (ESMAP Report No. 255/02). Retrieved from http://documents.worldbank.org/curated/en/765461468776759888/Rural-electrification-and-development-in-the-Philippines-measuring-the-social-and-economic-benefits

World Bank. (2003). *Peru: Rural education project* (Report No. 23843-PE). Retrieved from http://documents.worldbank.org/curated/en/567681468758737628/Peru-Rural-Education-Project

World Bank. (2007). *Social safety nets in Peru* (Report No. 42093-PE). Retrieved from http://documents.worldbank.org/curated/en/362151468090299085/pdf/420930SR0P10421sclosed0March0902008.pdf

World Bank. (2011). *Peru: A second rural electrification project* (Report No. 60154-PE). Retrieved from http://documents.worldbank.org/curated/en/550011468325218624/pdf/601540PAD0P1171OFFICIAL0USE0ONLY191.pdf

Appendix A

Description of the Dependent and the Independent Variables

Variable	Description
Dependent Variable	
Whether the child is enrolled or not enrolled?	Enrolled; Not enrolled
	Reference category - Not enrolled
Independent Variables	
Individual-Child Characteristics	
Age	Age of child in absolute values
Age square	Square of the age the child in absolute values
Sex	Female; Male
	Reference category - Female
Household Demographic and Economic Characteristics	
Age of head of the household	Age of head of the household in absolute values
Square of the age of the head of the household	Square of the age of household head in absolute values
Education of the household head (as a scale)	No education; Primary incomplete; Primary complete; Secondary incomplete; Secondary complete; Postsecondary
Ethnicity of the head of the household	Native Quechua; Native Aymara; Native Amazonic; African Peruvian/Black/Asian; White of European origin; Meztizo
	Reference category - Meztizo
Region of residence	Northern Coastal; Central Coastal; Southern Coastal; Northern Mountain
	Central mountain; Central South; Amazon
	Reference category - Southern Coastal
Type of residence	Owned property; Rented property; Yield property
	Reference category - Owned property
Log of annual household consumption expenditure	Logarithm of annual total monthly household consumption expenditure in '000s of soles
Household Infrastructure Characteristics	
Access to electricity	Access; No access
	Reference category - No access
Type of sanitation	Pit toilet; Rudimentary; Public network
	Reference category - Public network

Appendix B

Unweighted Summary Statistics and Sample Sizes (N) for Children Age 6-18, 6-11, and 12-18

	Age 6-18		Age 6-11		Age 12-18	
	Percentage or Mean	N	Percentage or Mean	N	Percentage or Mean	N
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Dependent Variable						
Enrollment						
Enrolled	83.98	8836	92.86	4186	75.81	4650
Not enrolled (Reference)	16.12	8836	7.14	4186	24.19	4650
Independent Variables						
Individual Characteristics						
Age (in years)	11.84 (3.6)	8836	8.60 (1.7)	4186	14.75 (2.0)	4650
Square of the age (in years)	153.12 (86.7)	8836	76.76 (28.5)	4186	221.86 (59.9)	4650
Sex						
Female (Reference)	47.23	8836	48.81	4186	45.81	4650
Male	52.77	8836	51.19	4186	54.19	
Household Demographic and Economic Characteristics						
Age of household head	45.74 (11.7)	8836	43.07 (11.8)	4186	47.64 (11.3)	4650
Household head's education (as a scale)						
No education	8.31	8836	7.57	4186	8.97	4650
Primary incomplete	0.45	8836	0.33	4186	0.56	4650
Primary complete	33.73	8836	33.13	4186	34.26	4650
Secondary incomplete	26.04	8836	25.80	4186	26.26	4650
Secondary complete	11.79	8836	12.18	4186	11.44	4650
Postsecondary	19.68	8836	20.97	4186	18.52	4650
Household head's ethnicity						
Native Quechua	26.44	8836	27.52	4186	25.46	4650
Native Aymara	2.92	8836	3.06	4186	2.80	4650
Native Amazonic	2.67	8836	2.77	4186	2.58	4650
African Peruvian/ Black/Asian	0.78	8836	0.79	4186	0.77	4650
White of European Origin	1.62	8836	1.60	4186	1.63	4650
Meztizo (Reference)	65.57	8836	64.26	4186	66.75	4650
Region of Residence						
Northern Coastal	15.20	8825	13.42	4181	16.80	4644
Central Coastal	12.77	8825	12.08	4181	13.39	4644
Southern Coastal (Reference)	7.23	8825	6.86	4181	7.56	4644
Northern Mountain	15.43	8825	15.12	4181	15.72	4644
Central Mountain	16.32	8825	17.58	4181	15.18	4644
Central South	15.23	8825	15.33	4181	15.14	4644
Amazon	19.82	8825	19.61	4181	16.21	4644
Type of Residence						
Owned (Reference)	2.10	8826	2.70	4181	1.55	4645
Rented	86.65	8826	85.36	4181	87.81	4645
Yield	11.25	8826	11.93	4181	10.64	4645
Annual Household Consumption Expenditure (in '000s of pesos/soles)	5.91 (.82)	8823	5.86 (.83)	4180	5.96 (.81)	4643
Household Infrastructure Characteristics						
Access to electricity						
Access	45.05	8825	44.01	4181	45.99	4644
No access (Reference)	55.00	8825	56.00	4181	54.01	4644
Type of sanitation						
Public network (Reference)	13.29	8826	12.25	4181	14.23	4645
Pit toilet	51.99	8826	52.02	4181	51.97	4644
Rudimentary	34.72	8826	35.73	4181	33.80	4644

Note. The sample sizes vary because of missing values on certain variables. Figures in brackets indicate standard deviation.