IMPACT OF RURAL ELECTRIFICATION ON EDUCATION: A CASE STUDY FROM PERU

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In this paper, I study the impact of rural electrification on education. I find that connecting households to electricity increases studying time by children at home, and interpret this finding as indirect evidence of improvement in education. Using instrumental variables in order to overcome endogeneity problems, my results reveal that providing households with access to electricity leads to children studying an extra 93 minutes per day.

JEL Code: O12, C31, C81

Key words: Rural electrification; infrastructure; education.

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I. Introduction

Impact evaluation of rural electrification programs has received considerable attention in previous literature, not only by academics but also by governments wishing to optimally allocate public resources. In both cases, the conclusion is the same: rural electrification generates substantial and favorable changes in welfare and it can be considered as a crucial prerequisite for economic growth (Khandker et al. 2012, 2013; ADB, 2010; Dinkelman 2008; IEG, 2008; ESMAP 2010, 2003; Cabraal et al. 2005; Martins, 2005; Barnes et al. 2003). The literature recognizes that the benefits of electricity can be divided into two categories: direct and indirect. The former includes improvements in lighting, television viewing, radio listening, and use of refrigeration; while the latter includes better educational outcomes, improved income-generation opportunities, lower fertility rates[1], and better health (by reducing indoor air pollution and the refrigeration of vaccines).

Rural electrification may affect education not only by improving the quality of schools resulting from their use of electricity-dependent equipment but also by increasing time allocation for studying at home (even though the availability of TV may decrease this time, it could also provide educational benefits) (IEG 2008). In this paper, I study the impact of rural electrification on education. I focus my analysis on the effects of connecting rural households to electricity on the time that children spend studying at home. Analyzing a unique survey on the use of energy in Peru conducted in 2013, I find that connecting households to electricity increases the time dedicated to studying by children at home and I interpret this finding as indirect evidence of improvement in education.

The evidence shows that children in electrified households have higher education levels than in those households without electricity. A survey applied in Peru in 2005 revealed that children aged 6 to 18 in households with electricity and who attended school spent an average of 65 minutes per night reading and/or studying, whereas students in households without electricity spend 51 minutes on these activities. The survey found this difference to be statistically significant (ESMAP 2010). In a multicountry survey, IEG (2008), employed standardized demographic and health surveys in 9 countries – Bangladesh, Ghana, Indonesia, Morocco, Nepal, Nicaragua, Peru, Philippines and Senegal – and found that, on average, electricity increases the time that children spend studying at home by more than 70 minutes.

In Peru, through the Law of General Rural Electrification, a package of Rural Electrification Programs began in coordination with regional and local governments, providing villages (populated centers) and rural

[1] See Peters and Vance (2011).

households with access to energy. The Ministry of Energy and Mines (MEM), through the Directorate General of Rural Electrification (DGER), established some prioritization criteria, most importantly lowest coefficients of provincial rural electrification, highest poverty rates, and amounts of subsidies required by connection and density of the population. Many Rural Electrification Programs were implemented between 1993 and 2013 and the last one was scheduled for the period 2008–2017. To date, US$ 278.6 million was invested, 5340 villages were connected to electricity, and the number of rural households with electricity increased from 7.7% in 1993 to 70% in 2013.[2] At the end of 2012, DGER-MEM carried out a study to calculate the social benefits of rural electrification in order to: (i) determine whether public resources were being allocated efficiently, (ii) prioritize funding investments on public projects (to be implemented beginning in 2014), (iii) facilitate the social evaluation of investments on public projects in Peru, and (iv) estimate the direct and indirect benefits of rural electrification. The study lasted from November 2012 to March 2013 (Urrunaga et al. 2013). As part of that study, and in accordance with the requirements of DGER, the Rural Household Energy Use Survey (SRHEU) was conducted in February 2013.

The importance of the accountability in rural electrification programs has increased substantially through more frequent impact evaluation studies. As Ravallion (2008a and 2008b) documented, the methodological sophistication of some of these evaluations has increased substantially; however, he criticizes the dearth of rigorous evaluation research in development policies. In the field of rural electrification, extensive studies have been conducted to assess the impact of electrification by comparing connected and non-connected households within the same region (ESMAP 2003a; Madon and Oey-Gardiner 2002; Massé and Samaranayake 2002; World Bank 2006). Even though these studies have found that electrification provides significant benefits, most have simply shown that there is a correlation between rural electrification and development; however, this correlation could be due to a third variable, such as household income, and thus these studies do not necessarily demonstrate a causal relationship.[3] For the purposes of this paper, the problem of endogeneity that exists in the implementation of rural electrification programs generates flaws in the determination of the direction of causality. In order to control for this problem, I use Instrumental Variables (IV) to determine the net effect of rural electrification, applied to cross-sectional data. A similar technique is used by Khandker et al. (2009, 2012) for education outcome variables.

[2] These projects include the installation of transmission lines of 60, 138 and 220 kV, 2872 km long, small-scale hydro and thermal generation units with 150 MW, 1523 solar panels. The implementation of the Rural Electrification Programs also included the extension of national grid networks and/or isolated electrical systems from which Rural Electric Systems are developed (MEM, Special Report from *Diario El Comercio* [Lima], December 15, 2013, and the National Plan for Rural Electrification 2013-2022).

[3] In the case of other infrastructure (transport, for instance), the literature is also unsatisfactory, failing to address endogeneity issues convincingly (Straub 2013).

Khandker et al. (2009) and Khandker et al. (2012) estimate the benefits of rural electrification in Bangladesh and India, respectively, on various households and individual welfare outcomes (expenditure, income, energy consumption, employment, years of schooling, and time studying) using the 2005 Bangladesh Survey of Rural Households and the 2005 India Human Development Survey of Rural Households. In both cases, Instrumental Variables regression is used.[4] In the former study, they use a household´s location within or beyond 100 feet of an electrical line as an instrument since this influences household´s adoption of grid electricity,[5] but does not directly influence their outcomes. In the latter study, the proportion of households in a community who have electricity is expected to serve as an instrument because peer pressure or the demonstration effect is likely to affect a household´s electrification decision since households tend to follow their neighbors in the village.[6] They find that access to electrification increases weekly boys' and girls´ time studying by more than 6 and 8 minutes/day, respectively, in Bangladesh, and by more than an hour in India (the increase is slightly higher for girls than boys). In this study, I use IV regression. The instrument is the topographic distance between each population center and the nearest medium voltage line, given that this variable is correlated with a household's connection status since the shorter the distance, the greater the likelihood of connection, but is not correlated with children's time studying at home. My results show a positive impact of household electrification on the time children spend studying.

This paper continues as follows: Section II describes the data and presents the econometric method; Section III reports the results; and Section IV presents the conclusions.

II. Data and methodology

In order to identify the effects of households' connection to electricity on education, I use the Survey of Rural Household Energy Use 2013 (SRHEU 2013) conducted by the Ministry of Energy and Mines of Peru (MEM). The survey included 987 electrified and non-electrified households in rural areas in 96 rural population centers[7] in Peru. The sample was probabilistic, stratified at three stages: the levels of provinces, districts, and rural population centers.

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[4] In addition to Propensity Score Matching (PSM) for Bangladesh and Fixed Effects methods for India.

[5] Considering that for those households living within 100 feet of the electricity line or lines that run through a village, connection cost for obtaining electric service is highly subsidized and therefore low (and, by contrast, the connection cost charged by the electric cooperatives for households beyond 100 feet of the line is much higher since they have to bear the full cost of connection),

[6] If neighbours obtain electricity, then a household without electricity can signal lower socioeconomic standing, since households would be expected to avoid obtaining electricity if they could not afford it. It is expected that the higher the percentage of connected households in a village, the greater the likelihood that a household living in that village will connect to electricity, provided it can afford the connection fee and other associated costs. In addition, the proportion of village households with electricity should not directly impact a household´s outcome.

[7] The definition used by MEM for the purpose of the survey is that rural population centers are those with less than 100 dwellings grouped contiguously.

The information collected includes comprehensive data on the socio-demographic characteristics of connected and non-connected households. This data includes household composition (size and each member´s age, sex, and relationship to the head of household), demographics (education levels), economic indicators (assets, income, expenditures), and the way households use energy. Also, for each household member, individual measures of time use (e.g. hours of study at home) were collected. Table 1, columns (1) and (2), provides information on main household-level characteristics.

** INSERT TABLE 1 **

The effects of the provision of electricity to a region can be assessed using the conceptual framework of the theory of change (Bensch et al. 2011) in which the development project is typically represented in a results chain that links the intervention´s input and activities (new electrification interventions in a region and households) to its outputs and impacts (translated into poverty reduction via different channels). Table 1, columns (3) to (6), assesses to what extent the comparability of household characteristics described above translates into heterogeneity between connected and non-connected households. The *p-values* presented in this table show that the tests for difference-in-means between the connected and non-connected households are significant for most of the characteristics.

I focus only on impacts of electricity connection on the time that (primary school) children use for studying at home. I employ this outcome as an intermediate measure to approximate the transmission channel to ultimate educational impacts. Descriptive statistics for this indicator are also provided at the bottom of Table 1. They show that a difference exists between connected and non-connected households at the national level.

Following Bensch et al. (2011), from an impact evaluation perspective, the survey that I use serves to identify the impacts of the treatment of electrification via two principal strategies. The first one is a comparison of household indicators before and after the electrification. For this purpose, the data collected by the MEM serves as a baseline that needs to be complemented by a follow-up survey measuring socio-economic conditions after the electrification intervention. The second strategy is referred to as ex-ante impact assessment: by comparing households already electrified to those not yet electrified, impacts of electrification can be evaluated using cross-sectional methods. The results of this second strategy are presented in this paper.

As mentioned previously, it has to be kept in mind that these kinds of intervention programs are difficult to evaluate, given the endogenity problem that can arise. There is a potential self-selection process due to which comparing outcomes from connected and non-connected households may suffer from substantial biases (Ravallion

2008) because in the case of electrification interventions, the decision to connect is a choice of individual households, which may be taken for unobservable reasons and, at the same time, affect the outcome measured (Peters 2009). For instance, when using such a cross-sectional comparison, the impacts on children's studying time at home are difficult to evaluate. The reason for this is that households with parents with higher levels of education are more likely to raise the funds necessary to connect to the grid (because they have more income and know the importance of children studying at home). This simultaneity time-studying and connection status implies that it is not possible to know if a household has parents with higher levels of education because it is connected, or if it is connected because they have higher levels of education.

Households with electricity have higher levels of benefits compared to those without a connection to electricity. The next question to ask is whether this means that having electricity in a household conclusively contributes to a better education for children in these households. Keeping in mind the endogeneity problem and that grid electricity service is extended first to more developed and densely populated regions (for revenue maximization), and only later reaches more remote and poorer areas (Khandker et al. 2009), I need to find a suitable instrument, that is, a variable that is correlated with electricity connection status but uncorrelated with the household´s outcome variable. Other authors use the Propensity Score Matching (PSM) technique together with the IV method (Bensch et al. 2011; Khandker et al. 2009, 2001) on cross-sectional data. Certainly, both methods have their own advantages and disadvantages. An IV method controls for both observed and unobserved characteristics, while PSM cannot control for unobserved characteristics. But unlike IV or any regression technique, PSM does not assume a functional form, which is certainly an advantage (Khandker et al. 2009). Despite these reasons for using IV regression, I also test whether the OLS or the IV approach is the more appropriate estimation technique for the data at hand, using a Hausman test.

Here I use topographic distance between each population center and the nearest medium voltage line as the instrument for being connected to the electricity network. This measure was generated using Arcgis 10.1 software with the coordinates of the location of transmission lines provided by the Peruvian agency that supervises investment in energy and mines, OSINERGMIN. The Appendix shows the distance measures calculated. I consider this variable to be correlated with household connection status since the smaller the distance, the greater the likelihood of connection, but not correlated with time studying at home by children.

III. Results

In this study, I am interested in estimating the causal effect of rural household electricity connection status on the time spent studying at home by children. Formally, I want to estimate the following equation:

(1) $$Time\ spent\ studying\ by\ children_{ir} = \beta + \alpha\ Household\ connection\ status_{ir} + \theta\ X_{ir} + \varepsilon_{ir}$$

where *Time spent studying by children*$_{ir}$ is the time (in hours) that children dedicate to studying at home i in region r; X is a vector of control variables; the δ_r is a region effect; α is the average treatment effect; and ε_{ipr} is an error term.

To address the endogeneity of household connection status on the time spent studying, I estimate equation (1) by Two Stage Least Squares (2SLS), where the endogenous dummy variable "household connection status" is instrumented by the exogenous variable "topographic distance". Figure 1 plots the conditional probability of a household´s connection to electricity given the distance between the village and the nearest transmission line center. The most important feature of this figure is the negative relationship between the household´s probability of connection to electricity as the topographic (or linear) distance increases. First-stage estimates are reported in Table 2. The point estimates of the coefficient on topographic distance from the sample indicates that the probability of a household´s connection to electricity is around 18 percentage points higher, respectively, for those households located in villages nearest to transmission lines compared to those located far from transmission lines. First-stage effect is very precisely estimated and significantly different from zero.

** INSERT FIGURE 1 **

** INSERT TABLE 2 **

The IV estimator does not recover average treatment effects, unless I am willing to assume a constant treatment effect. Under sensible assumptions, however, it recovers an alternative parameter denoted Local Average Treatment Effect (LATE) (Angrist et al. 1996), which is the average effect of treatment on those individuals whose treatment status is induced to change by the instrument (i.e., by the dummy variable topographic distance). The households are compliers because they obtain a connection to electricity because they live in villages that are located near transmission lines, and would not have been connected otherwise. Thus, the results reported below do not need to be generalized to the population of households that under no circumstances would have been connected to electricity.

My estimates of the impact of households´ connection to electricity are reported in Table 3, with and without controls. In all models, my estimates indicate that acquiring a connection to electricity increases the hours of that children study at home. As a benchmark, I first report reduced-form estimates in columns (3) and (4). The preferred 2SLS estimates in column (6) indicate that connection to electricity significantly increases the time spent studying by children (51.1%).[8] Thus, my instrumental variables results suggest that acquiring a connection to electricity allows children to study 93 more minutes from a baseline of children's studying time. The result of the Haussman test rejects the null hypothesis in these outcomes at 5 percent levels, confirming that IV estimation is the better estimator (consistent) for this sample. I report the OLS results for comparison.

** INSERT TABLE 3 **

IV. Conclusions and discussion

The purpose of this article is to contribute to the economic literature related to impact assessment of rural electrification programs. Using an IV approach to overcome endogeneity concerns, I find a positive association between rural electrification and the number of hours of study by school-age children, suggesting greater opportunities for improvement in school performance.

. According to the findings of this study, electricity leads to a significant increase in the time children spend studying in rural households. For the sake of promoting discussion, the benefits of rural electrification can be approximated in monetary terms if it is assumed that one hour of study by children between 3 and 12 years reduces the possibility of their having to repeat the school year by 1.6 percentage points (Beltrán 2013) and that the cost of an "educative package" required by the Ministry of Education for a multigrade rural school is US$ 642.86 per year[9] (Alvarado and Llempén, 2011). Then, taking into consideration that the benefits of a connection to electricity by households at the national level is 1.55 more hours (or 93 minutes) of study at home, the parameters from Beltran (2013) and Alvarado and Llempén (2011), let me suppose that one more hour of study by a child could save that the government from losing US$ 10.29 (=642.86 x 0.016) per year because of children who have to repeat a year. Thus, in a year, the benefits of rural households connecting to electricity amount to US$ 15.95 (=1.55 x 10.29) on a

[8] Percent change is calculated as 100*Estimate/mean time studying by children.
[9] Exchange rate of S/. 2.8 per US$ 1.0.

national level. Of course, the other benefits of rural electrification, such as, illumination, radio and TV, and refrigeration[10] should be added to this amount.

It is important to recognize that my cross-sectional analysis has potential shortcomings. First, assessed impacts may not be long-term because the patterns observed today may not hold in the future. Second, the survey I use was conducted during school holidays (December to March), biasing the answers about hours of study at home. Thus the database used should serve as a baseline and be followed up in the future for the same households.Even though there are many challenges to be overcome, an expansion of access to electricity in a way that is equitable, both institutionally and financially, can have significant development benefits in rural Peru.

[10] See Urrunaga et al. (2013), in which the costs necessary for the provision of rural electrification were calculated considering benefits of illumination and radio&TV (using consumer excedent and avoided costs methodologies) and of education (using matching techniques),

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Appendix. Calculations of Topographic Distances

Department	Province	District	Population center	Topographic distance (km)
Apurimac	Abancay	Abancay	Atunpata	0.03
Apurimac	Abancay	Abancay	Quisapata	3.72
Apurimac	Abancay	Abancay	Wiracochapata	1.6
Arequipa	Caraveli	Acari	Lucasi	1.4
Arequipa	Caraveli	Acari	Santa Teresa	1.14
Arequipa	Caraveli	Atico	Chorrillos	10.85
Arequipa	Caraveli	Bella Union	San Isidro	0
Arequipa	Caraveli	Lomas	Costa Azul	0.01
Arequipa	Caraveli	Lomas	Santa Sarita	0.01
Arequipa	Caraveli	Yauca	Alto Tupac	0.01
Arequipa	Caraveli	Yauca	Yauca	0.01
Cajamarca	San Marcos	Ichocan	Illuca	6.48
Cajamarca	San Marcos	Ichocan	Llanupacha	0.1
Cajamarca	San Marcos	Ichocan	Paucamarca	3.73
Cajamarca	San Marcos	Ichocan	Paucamayo	3.58
Cajamarca	San Marcos	Ichocan	Poroporito	0.08
Cajamarca	San Marcos	Pedro Galvez	Catagon	0.4
Cajamarca	San Marcos	Pedro Galvez	Pomabamba	2.84
Cajamarca	San Marcos	Pedro Galvez	Rancho Grande	0.04
Cajamarca	San Miguel	Catilluc	Catilluc	0.52
Cajamarca	San Miguel	Catilluc	Catilluc Bajo	0.2
Cuzco	Paucartambo	Caicay	Ccollataro	0.06
Cuzco	Paucartambo	Paucartambo	Phuyucalla	0.02
Huancavelica	Tayacaja	Acraquia	Mucuro	2.3
Huancavelica	Tayacaja	Acraquia	Pamuri	0.04
Huancavelica	Tayacaja	Acraquia	San Cristobal	0.13
Huancavelica	Tayacaja	Acraquia	Tomanya	0.06
Huancavelica	Tayacaja	Salcabamba	Caymo	0.06
Huancavelica	Tayacaja	Salcabamba	Garcia Pampa	1.33
Huanuco	Huamalies	Jacas Grande	Nuevas Flores	0.2
Huanuco	Huamalies	Llata	Buena Vista	5.02
Huanuco	Huamalies	Llata	Libertad	0.46
Huanuco	Huamalies	Llata	Ocshash	0.01
Huanuco	Huamalies	Llata	Sacuatuna	1.34
Ica	Chincha	Chincha Baja	Salinas	0.02
Ica	Chincha	Chincha Baja	Valencia	0.00
Ica	Chincha	Chincha Baja	Vilma Leon	0.01
Ica	Pisco	Independencia	Cabeza De Toro Lateral 6	1.47

Department	Province	District	Population center	Topographic distance (km)
Ica	Pisco	Independencia	Fermin Tanguis	1.47
Ica	Pisco	Independencia	Nuevo Huanuco	1.47
Junin	Satipo	Mazamari	Los Angeles De Eden Alto	0.01
Junin	Satipo	Mazamari	Materiato	1.28
Junin	Satipo	Mazamari	Mirador De Cañete	0.15
Junin	Satipo	Mazamari	San Vicente De Cañete	0.10
Junin	Satipo	Rio Negro	Bajo Huahuari	0.31
Junin	Satipo	Rio Negro	Centro Hauhuari	0.16
Junin	Satipo	Rio Negro	Centro Huahuari	0.16
Junin	Satipo	Rio Negro	Santa Rosa De Panakiari	1.53
Junin	Satipo	Satipo	Alto Capiro	0.25
Loreto	M. Ramon Castilla	Caballococha	Bufeo Cocha	8.72
Loreto	M. Ramon Castilla	Caballococha	Nuevo Palestina	6.03
Loreto	M. Ramon Castilla	Yavari	Fujimori	59.31
Loreto	M. Ramon Castilla	Yavari	Rondinha Zona I	57.53
Loreto	M. Ramon Castilla	Yavari	Santa Rosa	47.15
Pasco	Oxapampa	Oxapampa	Arcuzazu	0.04
Pasco	Oxapampa	Oxapampa	El Abra	0.50
Pasco	Oxapampa	Oxapampa	Quillazu	0.40
Piura	Sullana	Lancones	El Cortezo	0.30
Piura	Sullana	Lancones	Pampas Quemadas	3.20
Piura	Sullana	Lancones	Sausal	5.00
Piura	Sullana	Sullana	Cieneguillo Norte	1.92
Piura	Sullana	Sullana	Las Lomas	1.21
Piura	Sullana	Sullana	Las Mercedes	0.04
Piura	Sullana	Sullana	San Juan De Los Ranchos	16.48
Piura	Sullana	Sullana	Santa Rosa	3.30
Piura	Sullana	Sullana	Tres Compuertas	0.04
Puno	Huancane	Cojata	Bellapampa	4.82
Puno	Huancane	Cojata	Tomapirhua	2.41
Puno	Huancane	Huancane	Bellapampa	4.82
Puno	Huancane	Huancane	Chacacruz	0.01
Puno	Huancane	Huancane	Taurahuta	0.03
Puno	Huancane	Huatasani	Catarani	6.68
Puno	Huancane	Huatasani	Ccancco	1.28

Department	Province	District	Population center	Topographic distance (km)
Puno	Huancane	Huatasani	Curupampa	6.10
Puno	Huancane	Huatasani	Huatapata	1.28
Puno	Huancane	Huatasani	Llinquipata	0.46
Puno	Huancane	Huatasani	Quencha Milliraya	0.05
Puno	Huancane	Huatasani	San Calvario Pongoni	1.63
Puno	Huancane	Huatasani	Tintapata	1.07
San Martin	Rioja	Nueva Cajamarca	Angaiza	0.20
San Martin	Rioja	Nueva Cajamarca	La Primavera	1.45
San Martin	Rioja	Nueva Cajamarca	Palestina	0.12
San Martin	Rioja	Nueva Cajamarca	Vista Alegre	0.03
San Martin	Rioja	Pardo Miguel	El Afluente	10.19
San Martin	Rioja	Pardo Miguel	San Juan Del Mayo	2.95
Ucayali	Coronel Portillo	Yarinacocha	11 De Agosto	1.00
Ucayali	Coronel Portillo	Yarinacocha	Aahh La Capirona	0.06
Ucayali	Coronel Portillo	Yarinacocha	Aahh Monterrico	0.06
Ucayali	Coronel Portillo	Yarinacocha	Jose Olaya	0.23
Ucayali	Coronel Portillo	Yarinacocha	Las Damas De Milagro	0.06
Ucayali	Coronel Portillo	Yarinacocha	San Francisco	0.23
Ucayali	Coronel Portillo	Yarinacocha	San Jose	0.00
Ucayali	Coronel Portillo	Yarinacocha	San Juan	0.01
Ucayali	Coronel Portillo	Yarinacocha	San Lorenzo	0.30
Ucayali	Coronel Portillo	Yarinacocha	Santa Rosa	0.10
Ucayali	Padre Abad	Curimana	Arenal Grande	17.55
Ucayali	Padre Abad	Curimana	Arenalillo	17.55
Ucayali	Padre Abad	Curimana	Sol Naciente	4.00

Source: OSINERGMIN

Table 1. Summary statistics

	Mean (1)	St. Dev. (2)	Non-C (3)	C (4)	Difference (5)	*p-value* (6)
Household characteristics						
Household has electricity (1=Yes, 0=No)	0.337	0.473				
Homeownership (1=Yes, 0=No)	0.853	0.354	0.8593	0.8408	0.0185	0.0000
			(0.3479)	(0.3664)		
Household has connection to water network (1=Yes, 0=No)	0.400	0.490	0.3149	0.5676	-0.0320	0.0000
			(0.4649)	(0.4962)		
Household has connection to sanitation network (1=Yes, 0=No)	0.091	0.288	0.0382	0.1952	-0.1569	0.0000
			(0.1919)	(0.3969)		
Household has concrete, wood or corrugated roof (1=Yes, 0=No)	0.633	0.482	0.5719	0.7538	-0.1819	0.0000
			(0.4952)	(0.4315)		
Household has concrete wall (1=Yes, 0=No)	0.082	0.275	0.0459	0.1532	-0.1073	0.0000
			(0.2094)	(0.3607)		
Household has concrete or hardwood floor (1=Yes, 0=No)	0.323	0.468	0.2982	0.3724	-0.0742	0.0184
			(0.4578)	(0.4842)		
Observations	987		654	333		
Head of household´s social characteristics						
Time living in the populated center	22.867	17.791	22.7584	23.0778	-0.3194	0.7907
			(18.2324)	(16.9200)		
Education of head of household (years)	7.176	3.921	6.9931	7.5360	-0.5429	0.0396
			(3.8297)	(4.0759)		
Age of head of household (years)	45.409	15.013	44.2324	47.7207	-3.4883	0.0005
			(14.9276)	(14.9327)		
Sex of head of household (Male=1, Female=0)	0.881	0.323	0.8761	0.8919	-0.0157	0.4699
			(0.3297)	(0.3109)		
Household size	3.806	1.763	3.7431	3.9309	-0.1878	0.1136
			(1.8183)	(1.6441)		
Observations	987		654	333		
Intermediate outcome						
Children's time studying at home (in hours)	4.091	2.414998	3.9198	4.3731	-0.4533	0.0340
			(2.3359)	(2.4894)		
Observations.	542		337	205		

Note: For columns (4) and (5), standard deviations are in parentheses, Non-C: non-connected households; C: connected households.

Figure 1. Connection to electricity status of population centers and topographic distance to transmission lines

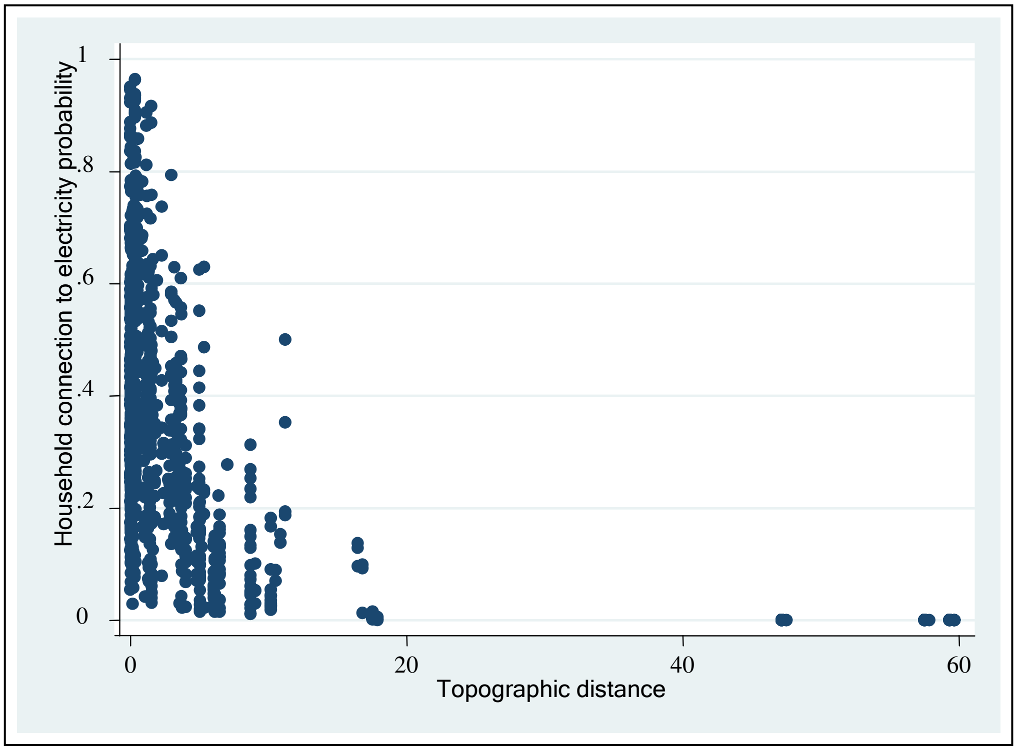

Table 2. First stage at a national level

	Dependant variable: household´s connection to electricity	
	(3)	(4)
Topographic distance	-0.1831**	-0.1783**
	(0.0615)	(0.0593)
Constant	-1.4028*	-1.3782*
	(0.6033)	(0.5777)
Dummy regions	No	Yes
Method	OLS	OLS

Notes: Standard errors are in the parenthesis. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

Table 3. Estimates of the impact of connection to electricity on children's time studying at home on the national level

	Dependant variable: children studying at home (hours)					
	(1)	(2)	(3)	(4)	(5)	(6)
Household´s connection to electricity	0.399	0.739			1.561*	2.235***
	(0.472)	(0.384)			(0.682)	(0.529)
Topographic distance			-00246*	-0.0418***		
			(0.0099)	(0.0101)		
Dummy regions	No	Yes	No	Yes	No	Yes
Observations	537	537	537	537	537	537
Method	OLS	OLS	OLS	OLS	2SLS	2SLS

Notes: Standard errors are in the parenthesis. *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level. Models in columns (5) and (6) use topographic distance as an instrument variable. The Haussman test for endogeneity was applied. In all cases the null hypothesis was rejected at 5% levels, confirming that IV estimations is a better method [models (1) and (5): $x^2(1)$=6.39 Prob> x^2=0.0115; models (2) and (6): $x^2(1)$=18.96 Prob> x^2=0.0000]