# Electrification and Time Allocation:Experimental Evidence from Northern El Salvador

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**DRAFT - NOT INTENDED FOR CIRCULATION**

**Abstract**

We implemented an experimental study to better understand how electrification affects the economic lives of rural households. By randomly allocating incentives to get a grid connection we generate exogenous variation in the probability that households connect to the grid, which we exploit to study the effects of electrification on time allocation. We find that electrification leads to (i) increased investment in education among school-age children, in the form of a 78 percent higher participation in activities related to education (e.g. time studying, time at school); and (ii) higher participation in income generating activities among adult women: electrification led to a 46 percentage point increase in participation in non farm employment and 25 percentage point higher probability of operating a home business. These are mostly home production activities that don't require large monetary investments or the participation of the male head. However, average profits from these activities are around $1,000 per year, suggesting that income increases due to electrification are potentially important.

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# 1 Introduction

Energy consumption in developing countries is a pressing matter in the fields of development and environmental economics (Wolfram, Shelef, and Gertler, 2012; Greenstone and Jack, 2013). The economic effects of electrification play a central role in this topic, but solid empirical evidence in this issue is scarce (Bernard, 2012). To help fill this gap, this paper explores, in an experimental setting, the mechanisms through which access to electricity affects household behavior and welfare in the short term. As we will see, these mechanisms can drive sizable effects on measures of human capital, welfare and income.

In 2009, 1.3 billion people still lacked access to electricity at home (International Energy Agency, 2011). At night, households with no access to electricity make do mostly with candles or kerosene lamps to satisfy their illumination needs. These sources of light provide poor illumination and, more importantly, emit high amounts of pollutants harmful for human health. In addition, these households lack adequate refrigeration technologies, and thus face limitations in food storage and food safety. Furthermore, due to the high costs of operating small electronics like radios or cellphones, these households have limited access to information and communication, and no access to power tools or electric water pumps, being caged by traditional technologies.

Access to electricity could unleash a series of changes in all these dimensions. In fact, some recent evidence suggests that electricity may increase female labor supply (Dinkelman, 2011; Grogan and Sadanand, 2012) or improvements in educational outcomes, consumption, and income (e.g. Khandker, Barnes, and Samad; van de Walle et al., 2013). However, some studies find no impacts beyond lighting (e.g. Bernard and Torero, 2013; Bensch, Kluve, and Peters, 2011). Besides these mixed results, there is almost no evidence on the mechanisms that drive the changes pointed above. Some of them, like improvements in indoor air quality, are expected to be present in most settings, but in most cases the effect will depend heavily on household and context characteristics. This is because before electricity can impact income or expenditure, households need to invest resources, acquire new tools and complementary inputs, or build knowledge on how to operate these technologies; and on the other side of the market they need demand for the goods and services. Constraints in access to credit or inputs, insufficient demand, or lack of know-how can prevent electrification from affecting economic outcomes like income or expenditure.

To better understand how access to electrification affects the economic lives of rural households, we implemented an experimental study in northern El Salvador, gathering longitudinal data on a sample households over a period of five years. Our experimental approach, which we detail below, is arguably less prone to violations in the exclusion restriction given random allocation of our instrumental variable. Furthermore, while most of the literature studies electrification of the village or community, our approach allows us to study electrification status at the household level.

Our research questions are located within the broader area of the effects of electrification, an active area of research in which the debate is far from settled. The massive amounts of resources allocated to rural electrification[1] have usually been justified on the assumed benefits of electrification on health, education, and income, but most of the empirical evidence on which these claims are based is weak (Bernard, 2012; Independent Evaluation Group, 2008) and, as noted above, the more recent literature shows mixed results. On the other hand, it is important to consider that rural electrification could have some unintended negative effects, like increasing child labor or worsening nutritional status (by increasing consumption of sodas, red meat, etc.). These unintended effects do not imply that electrification is negative *per se*, but offer insights on what type of policies should be paired with electrification programs, like offering incentives to remain in school or implementing nutrition campaigns.

We study the changes in time use by household members, uncovering a number of important changes in educational investment and income generating activities. The sign of the changes is in fact positive as the literature usually argues, and their magnitudes are surprisingly large. First, electrification increases participation in educational activities by 78 percentage points. It not only raises the share of children who study at home (54 percentage points), but also the share of children who participate in other educational activities (84 percentage points). We find a 14 percentage point increase in the probability of owning a computer, which can potentially intensify the effects of higher time allocated to education. The increased participation in education is accompanied by a higher participation in household chores, which is consistent with children taking the baton from adult females, who we observe starting home businesses and engaging in non farm activities. This type of activities generate average profits of around $1000 per year among women in our sample, suggesting that electrification led to a non-trivial increase in income. Increases in income controlled by women have been associated with higher intra-household bargaining power as well as with improved children welfare outcomes. The main type of activities are food preparation, clothes washing and ironing services. Consistent with this, we find that electrified households acquire appliances for home production like refrigerators, blenders, and washing machines that, except for refrigerators, usually require relatively small monetary investments. We find no significant changes in participation in no farm employment or in home businesses among

[1] For instance, the World Bank recommends investing $10 billion per year between 2010 and 2020 to production and distribution of electricity in rural areas in Africa (World Bank, 2009). Given that the institution aims to provide 250 million people across Africa with modern sources of energy by 2030 (World Bank, 2007), understanding the effects of electrification is of urgent importance.

men, who are usually the main providers of income in the household. This may be due to risk aversion or lack of resources for larger investment, among other things.

This study has two main caveats. First, as in any IV approach, the effects are valid for the population of compliers, which is a small fraction of our sample, around 16 percent. Second, our sample size is relatively small. Despite we do find significant effects in a number of dimensions as described in the preceding paragraphs, in instances in which the effects are not significant the confidence intervals are too wide to infer a precise zero. Lastly, given selection and truncation issues that we discuss in the main text, we focus our analysis on changes in the extensive margins. Getting at changes in the intensive margins would require a structural approach that we leave for future research.

The remainder of this document is organized as follows. Section 2 describes the conceptual framework that guides our study. Section 3 presents the study setting, the identification strategy, and discusses the data. Section 4 presents the econometric approach. We discuss the main results in section 5, and section 6 concludes.

# 2 Conceptual Background

In this section we discuss how electrification may lead to changes in time allocation. The basic point is that electricity can increase the marginal return to time in any activity, which implies increases in the opportunity cost as well (i.e. the marginal value of time in other activities), so the net effect of electrification on time allocated to any given activity is theoretically uncertain. The following sections outline the reasoning behind the changes in the major activities.

## 2.1 Leisure

Household electrification may open the doors to new types of economic activities, and shift the status of an activity from non-profitable to profitable, which should push towards a reduction in leisure time. However, it also facilitates the use of electronic appliances that increase the marginal value of leisure (most notably television sets, but also stereos and DVD players), which should push towards an increase in leisure, making the net effect theoretically uncertain. The effect is further complicated by the fact that, since electronic appliances are not free to buy or operate, households may decide to increase labor supply because they want to acquire and use these new items, pushing labor supply in the opposite direction and making the net effect on leisure theoretically uncertain.

On the other hand, Banerjee and Duflo (2007) argue that poor households may leave profitable opportunities unexploited because the extra income they could generate would not make a salient impact in their lives, especially after taking into account the effort required to produce this additional income. This suggests that the promise of access to electronic appliances that arguably have salient impacts on wellbeing, like TV sets and refrigerators, may induce households to pick up some of those pre-existing opportunities by trading leisure time for labor.

## 2.2 Time Studying

School age children (6-14 years old) split their time mostly in four types of activities: education, household chores, leisure, and work. Virtually all children have some leisure time at baseline and 67% do some sort of household chores. The shares for studying and work are lower, at 22.1 and 19.1 percent, respectively.

Education includes time studying at home, a key component of educational investment. By providing electric lighting, electrification improves radically the child's study environment, allowing a shift from dimly-lit, smokey rooms to well-lit, smokeless rooms. This reduces drastically the effort required to study, pushing towards more time studying. Even if time suiting is unaffected, a better study environment will likely result in better learning, raising the returns to education. The increase in the returns to education may in turn induce parents to incur in the cost of sending children to school, since they are more likely to perceive their children can actually learn more. In consequence, we could observe improvements in other educational variables like school absenteeism or even enrollment.

On the other hand, electrification also facilitates access to television, shifting up the marginal value of leisure. This is further complicated by the fact that children may change their participation in chores or labor to compensate for time allocation changes among adult household members. Hence, the net effect on time studying is theoretically uncertain. The theoretical ambiguity of the net effect is consistent with respondents' perceptions: at baseline 90% of parents said their children would study more with electricity, but at the same time 55% of parents said their children would waste their time watching TV.

## 2.3 Labor Supply and Household Chores

Electricity can increase the marginal productivity of labor: self-employed workers may now use power tools, farmers may use electric water pumps, shopkeepers may offer refrigerated goods. This should shift out the labor supply curve, but given the increase in the marginal utility of leisure, the net effect is theoretically uncertain[2].

It is important to note that all these changes require access to capital goods: tools, pumps, and refrigerators, which require the use of savings, access to credit or other sources of financing. They also require complementary inputs, human capital, and demand for the products or services. If credit and insurance markets are imperfect, as they seem to be in our empirical setting, better-off households should be more likely to start new activities than poorer households since they arguably have better access to resources and are more capable of assuming risks. Even if all households are equally constrained, we may still see some changes in income generating activities but at a small scale, for instance activities evolving from household chores to income-generating activities, like food preparation, ironing, and washing clothes. Despite this type of activities may not have sizable impacts on income, they may be attractive since they represent less of a risk to households given that they don't require a large monetary investment, or the male head's time, who in our sample usually provides a larger share of income than the female head.

# 3 The Study Setting

In this section we describe the study setting. Next we report descriptive statistics of the baseline survey and show that groups resulting from the randomization have balanced means across a wide set of observable characteristics.

## 3.1 Identification Strategy

A major challenge in the literature of the effects of electrification is the identification of causal effects because electrification potentially unleashes a number of changes through a complex chain of causality. The identification of causal effects is further complicated because the changes interact with each other, sometimes increasing the exacerbating the effects and others attenuating them. Since the electric grid cannot be expanded randomly, recent studies use time variation and instrumental variables (IV), mainly geographic variables, to deal with the endogeneity of connection. Studies have used land gradient (Dinkelman, 2011; Grogan and Sadanand, 2012), distance to hydroelectric dams (Grogan and Sadanand, 2012), distance to the electricity line (Samad, Khandker, and Barnes, 2009), and distance to power generating plants and baseline electrification rate in the locality (van de Walle et al., 2013).

[2]The net effect of an increase in labor productivity on labor supply is uncertain even without an increase in the marginal value of leisure, since it depends on the relative size of the income vs substitution effect. However, in poor households the substitution effect is arguably larger than the income effect, so the increase in marginal labor productivity should push out the labor supply curve.

The first-stage relationship in this type of studies is usually clear: since land gradient affects the cost of grid expansion, it is correlated with the probability of grid connection. The exclusion restriction is usually more difficult to justify. Land gradient, for instance, plausibly affects the cost of building and maintaining other types of infrastructure, like roads, schools or hospitals, thus potentially affecting transportation costs and access to markets as well as education and health outcomes. Land gradient also may affect the crop varieties that can be grown in a region (and their profitability), thus influencing directly economic activity and income flows.[3] Thus, the exclusion restriction requires the observed variation in land gradient to be in a range that does not affect other types of infrastructure, crops, or other economic activities; or, alternatively, it requires the variation in said variables generated by variation in land gradient to have no effect on the outcomes of interest. This may perhaps be not too far from reality in some settings, but it is ultimately an assumption that cannot be directly confronted with the data.

Randomized Encouragement Designs (RED) offer an appealing alternative. This approach, originated by Imbens and Angrist (1994), consists in randomly allocating *incentives* to connect to the grid, and using them as instruments in an IV estimation. It has been used extensively in other contexts (e.g. Hirano et al., 2000; Devoto et al., 2011; Mullally, Boucher, and Carter, 2013; Allcott and Mullainathan, 2010), but Bernard and Torero (2013) is the first study to implement a RED approach to study electrification in developing countries. We implemented an approach similar to theirs. In our study setting, households were required to pay a $100 fee for a security inspection in order to get an electric connection. We randomly allocated discount vouchers for 20% and 50% off the inspection fee, thus generating exogenous variation in the connection cost.

## 3.2 The Electrification Program and Experimental Design

The study takes place during a recent grid extension and intensification program in northern El Salvador, designed to be rolled-out in three phases according to construction costs and accessibility. In this program, the El Salvadorian government covered all the installation costs up to the electric meter, and households had to pay for their internal wiring and a connection fee (for a safety certification). The fee for the safety certification is of around US$ 100. It is non-trivial for a household, amounting to roughly 20% of annual per capita income in our sample.

[3] The same argument is valid for the other variables: electric lines, hydroelectric dams and power generating plants tend to be placed in areas with certain characteristics that arguably affect economic outcomes through channels other than electrification. Other papers (e.g. Coen-Pirani, León, and Lugauer, 2010; Khandker et al., 2012) use average electrification and appliance ownership rates in the locality. The same argument applies to them.

The experimental sample consists of 500 households located in subdistricts that were scheduled to be covered by the program during its first year. We generated experimental variation in the connection fee by offering discount vouchers to a randomly selected subsample. We randomly allocated 200 low-discount vouchers (20% discount), 200 high-discount vouchers (50% discount), and left the remainder households as control group (N=100). The exogenous variation in the connection fee generated by the random voucher allocation deals with self-selection in connection to the grid. Vouchers were valid for a discount towards the safety certification to be reimbursed after paying the full cost. Each voucher showed the name and address of the beneficiary, it was non-transferable, and it was valid for 9 months.[4]

Random voucher allocation also creates exogenous variation in the number of voucher recipients in a given neighborhood of household $i$ (controlling for the number of eligible neighbors). This generates variation in the number of new connections around household $i$, which allows to control for the role of spillovers on grid connection. The sign of the effect is theoretically ambiguous. On the one hand, observing their neighbors connect to the grid may make households more prone to connect, through a combination of social learning and imitation effects.[5] On the other, higher formal connection rates in a neighborhood reduce the cost of getting an informal connection, so the number of vouchers around a household may increase the number of informal connections. To estimate the role of spillovers on adoption, we use the number of household $i$'s neighbors that received a voucher in a given radius (0-100 meters, 100-200 meters, 200-300 meters), controlling by the number of eligible neighbors in that radius. Eligible households are households with no electricity at baseline.

*EHEIPCER*, the household survey implemented for this study, is a fairly standard survey that collected data on demographic characteristics, health, education, housing characteristics, energy use, income, consumption, among others. In particular, it includes a detailed module on time allocation for up to four household members: the male head, the female head, and up to two school-age children. Strict training sessions were conducted to ensure high quality in data collection, which was conducted with handheld computers. Enumerators were trained and selected by the authors with the assistance of *DIGESTYC* (the Salvadorian Bureau of Statistics) and *IFPRI* staff. The indoor air pollution data described below were collected by a subset of enumerators that underwent additional special training to this end.

The baseline household survey, designed using the 2007 Population Census as the sam-

[4] In a few cases there was a delay in the implementation of the program, so the expiration date was extended for the households from those areas.

[5] Social learning would occur if households observed the private benefits of electrification (better illumination, less smoke at night, better food availability, more enjoyable leisure time) from their neighbors. Imitation effects (also known as "preferences interactions" in the literature) are similar to a "keeping-up with the Joneses" story: a household wants electricity because its neighbors have it.

pling framework, was collected in November and December 2009. It covered 4,800 households all over northern El Salvador. Three follow-up surveys have been collected in the same months in 2010, 2011, and 2012 respectively. An additional follow-up survey is scheduled for November 2013, and a final round is scheduled to be fielded in November 2015.

### 3.3 Descriptive Statistics and Balance

According to the 2007 National Census around 80% of the El Salvadorian population had access to electricity. Although this figure is high, there are strong correlations between socioeconomic status, electrification, and use of traditional fuels for lighting or cooking. Figure 1 shows that the poorest municipalities are the ones with the lowest electrification rates and the highest use of traditional fuels for cooking and lighting.

Table 1 shows descriptive statistics split by treatment arm. Column 1 shows the means for the control group, column 2 shows the means for the households that received a 20% discount, and column 4 shows the means for households that received a 50% discount. Columns 3 and 5 test for differences between each of the treatment arms and the control group. Household heads are on average 50 years old, 69% of them are male and have 2.4 years of schooling on average. Literacy rates among household heads are low, with only 54% of them reporting being literate. The average age in the households is 30.8 and households are composed by 4.5 members, with a total dependency ratio of roughly 0.45. Annual income is around US$770 per head, roughly US$2.11 per person per day.

The main source of energy expenditure is kerosene (US$2.11 per month) mainly used for lighting, and propane (US$2.09 per month), mainly used for cooking, followed by candles (US$0.46/month) and car battery recharging (US$0.08/month), used to power TV sets. Use of wood for cooking was reported by 70% of households. Thirty-eight percent of households had informal access to electricity at baseline. Informal connections consist on a series of extension cables connected to each other and plugged into a neighbor's sockets. They are at most enough for two lightbulbs and some times a television set. For our purposes, households with informal connections were treated as off-grid. This can attenuate the effects of electrification on indoor air quality if we think that households with informal connections rely less on kerosene for lighting than those with no connection at all. However, since it is difficult for the government or the electric utility to determine if a household has informal access to the grid, we argue that the results from our strategy are more relevant for policy purposes.

Households were also balanced regarding their ex-ante perceptions towards energy sources. The vast majority agreed that electricity illuminates better than kerosene (96%) and that woodsmoke generates respiratory problems (87%). Between 30 to 40% of respondents said that kerosene is not an expensive source of lighting, and 20-30% said it as the best way to illuminate their household.

# 4 Empirical Approach

In this section we describe the econometric approach on which our empirical estimates are based. Our main specification is an IV estimation.

The first stage regression is given by:

$$\text{conn}_{it} = \alpha_0 + \beta_1 \text{voucher}_i \times \text{Post}_t + \beta_2 \text{s100}_i \times Post_t + \lambda_i + \mu_t + u_{it} \tag{1}$$

, where $\text{conn}_{it}$ is the connection status of household $i$ at time $t$. Our main connection measure is simply a connection indicator, that takes the value of 1 if the household has a formal connection to the grid and 0 otherwise. As robustness checks, we employ time connected to the grid and having a grid connection for at least $k$ years , with $k$ running from 1 to 4 (given that we have four follow-up rounds). The results with these variables are strongly consistent with the results of our main connection variable.

The second stage is given by:

$$y_{it} = \beta_0 + \delta \widehat{\text{conn}}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \tag{2}$$

As usual, the reduced form provides the ITT estimates:

$$y_{it} = \beta_0 + \gamma_1 \text{Voucher}_i \times Post_t + \gamma_2 \text{S100} \times Post_t + \lambda_i + \mu_t + \varepsilon_{it} \tag{3}$$

$y_{it}$ is the outcome of interest, Voucher takes the value of 1 if the individual received a discount voucher and 0 otherwise, Post takes the value of 1 for all the follow-up rounds and 0 at baseline, S100 is the share of eligible neighbors in 100 meters that received a voucher; $\mu_t$ are time fixed effects, and $\lambda_i$ denotes individual fixed effects (or household-level fixed effects in specifications in which the unit of observation is the household). Since vouchers were allocated at the household level, standard errors are clustered at the household level (in the household and individual-level regressions).

Due to random allocation, Voucher and S100 are not correlated with $u_{it}$ in equation (1). Under the assumption that vouchers affected the outcome variables only through their effect on the probability of connection, IV should render consistent estimates of the true effects of electrification for the compliers.

There are two features of the data worth highlighting in this setting. First, a key outcome of this paper is time allocation, which is prone to corner solutions. For example, time allocated to activities like studying or working is zero for sizable shares of our sample. If electrification affected the probability of participation in a particular activity and the time spent in such activity, neglecting the selection process will produce biased coefficients even in an RCT[6], so it would be necessary to deal with selection. Parametric models that deal with selection require establishing strong parametric assumptions about the distribution of the residual term. Non-parametric models, on the other hand, make no such assumptions but require imposing an exclusion restriction: they need a continuous variable that affects participation in an activity but not the amount of time spent in such activity. These type of questions are better suited for a structural approach, which we leave for future research.

Second, in some cases, the outcome variables of interest may be thought of belonging in a system. For instance, the time allocation to different activities or appliance ownership. To account for this, we estimate seemingly unrelated regressions (SUR). This methodology takes into account the correlation in the disturbance terms across different equations. An additional advantage is SUR models indicate whether each pair of outcomes are substitutes or complements, thus providing deeper economic insight. The equation-by-equation IV results are qualitatively similar to the results from SUR systems.

# 5 Results

This section presents the main results of the paper. The relation between voucher allocation and electrification status has been discussed more in depth in Barron and Torero (2014). Table 2 reports the most important facts. First, both low- and high-discount vouchers increase the probability of adoption of a formal connection. Individual discount vouchers made households 11 to 19 percentage points more likely to connect to the grid. Second, the effect of low-discount and high discount vouchers is roughly similar. This suggests that either demand for connections is inelastic in this price range, or that vouchers are operate through, like increasing awareness about the electrification program, reducing credit constraints, or nudging households against procrastinating in the decision to connect. Third, there are large spillovers: the share of neighbors receiving vouchers strongly increases the probability

[6] If an explanatory variable affects the outcome and the probability that the outcome is greater than zero, ignoring selection will render biased estimates even if said explanatory variable is randomly allocated. For instance, in a tobit model

$$E[y|x, y > 0] = x\beta + \sigma \frac{\phi(x\beta/\sigma)}{\Phi(x\beta/\sigma)} \tag{4}$$

of connection to the grid.

## 5.1 Time Use - Children

We first study how electrification affects the probability of participation in certain activities among school-age children (6-14 year olds). We consider four categories: education, labor, chores, and leisure. Conditional on participation in each activity, the children spend an average of 6.1 hours in educational activities, 3.5 in household chores, 6.7 hours in work, and 8.7 in leisure. The dependent variable in each column is an indicator of participation in each activity and the results are reported in Table 3A. Electrification increases the probability of participating in education activities by 78 percentage points. These include studying at home, spending time at school, and going to and from school. Table 3B shows that there are effects on time studying (a 54 percentage point increase), but also in other activities activities related to education, like spending time in school or commute time between home and school (an 84 percentage point increase). This increase in participation is consistent with a perceived increase in the returns to education (through better learning). Children who study at home do so for an average of 2 hours a day. Due to selection issues discussed in the methodological section this cannot be interpreted as electrification leading to a 2-hour increase in study time, but it serves for illustrative purposes. Average time allocated to education, by those who participate in such activities, is 6.1 hours per day. A higher share of children studying at home is an important indicator of improved learning, especially given that this increase is paired with a better study environment. In addition, there is an interesting increase in computer ownership, of 14 percentage points (Table 7, discussed below). Although the literature has not reached a consensus on the effects of computers on learning, this increase may have additional impacts on learning.

The probability of engaging in household chores increases by 96 percentage points. Some of this chores may be in fact home production, which are sometimes difficult to tell apart in the field. The increase in time on household chores is important given that, as we will see in the next section, there is an increase in home production mostly among adult women. Taken together, this suggests that children are taking on some household chores previously undertaken by the female head, who are now allocating some time to other activities.

The point estimate on the probability of working is negative, but not statistically significant.[7] Only 1.7 percent of our sample engage simultaneously in education and work, which may suggest that a higher participation in education could be accompanied by a reduction in the share of children who work.

[7]The coefficient on leisure is just to show consistency: since virtually everybody enjoys at least some leisure the effect of electrification should be null. In fact the coefficient is close to zero.

## 5.2 Time Use Adults

Table 4 shows that electrification increases participation in non farm employment and in home business operations. On average, workers from connected households are 26 percentage points more likely to engage in non farm employment. Columns 3 and 4 show that the probability of engaging in non farm employment at some point over the four periods following grid extension is 47 percentage points higher among on-grid households. Each year on the grid increases this probability by 22 percentage points. These figures can be thought of as an upper bound of the true effect, given that they include people who may have participated for just one month out of the four post-treatment years for which we have data.

In a similar vein, Panel B shows that electrification increased the probability of operating a home business by 12 percentage points. This is more than a 150% increase compared to the control group. The effect is concentrated among women, with women from on-grid households being 25 percentage points more likely to operate a home business. For reference, average annual profits are around $1,000 a year for females and $1,500 for males, suggesting that the new businesses may provide non-trivial income source to the household.

The point estimates for males are lower than for females and not statistically significant. Furthermore, the point estimates for home business operations differ statistically by gender and are practically null for males.This type of changes suggest that electrification has important consequences in women's income that may lead to changes in intra-household bargaining power.

## 5.3 Income

Table 6 reports the effect on total household income. Given that most households have positive income, truncation at zero is not a problem. Note that we are not addressing how electricity would affect potential income (which would require addressing selection into different activities) but how income compares between on-grid and off-grid households. The IV estimates of connection on income suggest that electrification increased annual household income by around $1,600 per year. Although this is no formal proof, an effect of this magnitude is consistent with the average profits of non-farm businesses.

Around X percent of households report non-labor income only, so selection starts to be a more important issue in the labor income regression. Ignoring selection would suggest an increase in labor income of $4,800. The results of non-labor income are presented for completeness only, given that selection is an apparent problem in this income category.

### 5.4 Electronic Appliance Ownership

Table 7 shows that electrification led to important changes in appliance ownership. Since some households owned some of these appliances at baseline, the sample for each regression is formed by households that did not own that appliance at baseline. This underestimates the effects of electrification on appliance ownership, given that households may buy new appliances to replace old ones.

There are significant increases in appliance ownership of "leisure" items like TV sets and DVD players, but also in ownership of appliances s that could be used for home production. Electrification led to increased ownership of refrigerators (54 percentage points), blenders (25 percentage points) and washers (13 percentage points). This is consistent with households starting small businesses based on home production for sale.[8] This is consistent with non-significant changes in access to credit.

## 6 Preliminary Conclusions

This paper provides the first experimental evidence on some of the main mechanisms through which household electrification affects human capital formation and income in rural settings. Most importantly, we find that electrification increases investment in education among school-age children and participation in income generating activities among adult women.

The increases in educational investment are materialized through an increase in the participation in educational activities. Electrification increases the probability of studying at home by 54 percentage points, and of performing other school-related activities (time in school, time commuting between school and home) by 84 percentage points. One of the main mechanisms for this increase is a dramatic improvement in the study environment, which raises the returns to time studying. A second mechanism may be changes in aspirations: if parents feel that electrification is a sign of progress, which would make their children's schooling more profitable once they reach adulthood, they are more likely to send the kids to school.

Our second main finding is that adult females increase their participation in income generating activities as a result of electrification. These are generally small-scale activities, mostly consisting of offering services like washing and ironing clothes, or preparing food for sale. These activities require relatively small investments and don't require the participation

[8]Although ironing clothes for the neighbors is a common activity in our sample, there is no significant increase in the number of households owning irons probably, probably because a nontrivial share of households owned charcoal irons at baseline. These households may have switched to electric irons, but the survey did not include information on the type of iron.

of the male head, who typically is the main income earner in the household, and thus imply low risk to the household. However, these activities generate on average $1,000 per year, suggesting the effect of electrification on income controlled by women is non-trivial. This type of changes can unleash important gender dynamics in the household. The literature associates higher income controlled by women with higher intra-household bargaining power among women and with improved welfare outcomes among children (better nutrition, higher expenditure in education).

The evidence we present in this paper complements the findings in Barron and Torero (2014), where we show that electrification leads to improvements in indoor air pollution, which reduced the incidence of acute respiratory infections among children, and lowered exposure to pollutants among adult household members.

To avoid issues with selection and truncation, our analysis is focused participation in activities. The importance of this questions is of first order, but it is also important to understand the changes in the intensive margins, i.e. the time spent on these activities. Similarly, and also due to selection, we do not address directly the relationship between electrification and profitability of home businesses. The answer to this type of questions require a structural approach that we leave for future work.

# References


Allcott, Hunt and Sendhil Mullainathan. 2010. "Behavioral science and energy policy." *Science* 327 (5970):1204–1205.

Banerjee, Abhijit V and Esther Duflo. 2007. "The economic lives of the poor." *The journal of economic perspectives: a journal of the American Economic Association* 21 (1):141.

Barron, Manuel and Maximo Torero. 2014. "Household Electrification and Indoor Air Pollution." *Mimeo* .

Bensch, Gunther, Jochen Kluve, and Jörg Peters. 2011. "Impacts of rural electrification in Rwanda." *Journal of Development Effectiveness* 3 (4):567–588.

Bernard, Tanguy. 2012. "Impact analysis of rural electrification projects in sub-Saharan Africa." *The World Bank Research Observer* 27 (1):33–51.

Bernard, Tanguy and Maximo Torero. 2013. "Bandwagon Effects in Poor Communities Experimental Evidence from a Rural Electrification Program in Ethiopia." .

Coen-Pirani, Daniele, Alexis León, and Steven Lugauer. 2010. "The effect of household appliances on female labor force participation: Evidence from microdata." *Labour Economics* 17 (3):503–513.

Devoto, Florencia, Esther Duflo, Pascaline Dupas, William Pariente, and Vincent Pons. 2011. "Happiness on tap: piped water adoption in urban Morocco." Tech. rep., National Bureau of Economic Research.

Dinkelman, Taryn. 2011. "The effects of rural electrification on employment: New evidence from South Africa." *The American Economic Review* 101 (7):3078–3108.

Greenstone, Michael and B Kelsey Jack. 2013. "Envirodevonomics: A Research Agenda for a Young Field." Tech. rep., National Bureau of Economic Research.

Grogan, Louise and Asha Sadanand. 2012. "Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua." *World Development* .

Hirano, Keisuke, Guido W Imbens, Donald B Rubin, and Xiao-Hua Zhou. 2000. "Assessing the effect of an influenza vaccine in an encouragement design." *Biostatistics* 1 (1):69–88.

Imbens, Guido W and Joshua D Angrist. 1994. "Identification and estimation of local average treatment effects." *Econometrica* 62 (2):467–475.

Independent Evaluation Group. 2008. "The Welfare Impacts of Rural Electrification: A Reassessment of the Costs and Benefits." Tech. rep., World Bank.

International Energy Agency. 2011. "World Energy Outlook 2011."

Khandker, Shahidur R, Douglas F Barnes, and Hussain A Samad. ???? "Forthcoming.– Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam." *Economic Development and Cultural Change* .

Khandker, Shahidur R, Hussain A Samad, Rubaba Ali, and Douglas F Barnes. 2012. "Who Benefits Most from Rural Electrification?" *World Bank Policy Research Working Paper* (6095).

Mullally, Conner, Steve Boucher, and Michael Carter. 2013. "Encouraging Development: Randomized Encouragement Designs in Agriculture." *American Journal of Agricultural Economics* .

Samad, Hussain A, Shahidur R Khandker, and Douglas F Barnes. 2009. "Welfare Impacts of Rural Electrification: A Case Study from Bangladesh." .

van de Walle, Dominique, Martin Ravallion, Vibhuti Mendiratta, and Gayatri Koolwal. 2013. "Long-term impacts of household electrification in rural India." *World Bank Policy Research Working Paper* (6527).

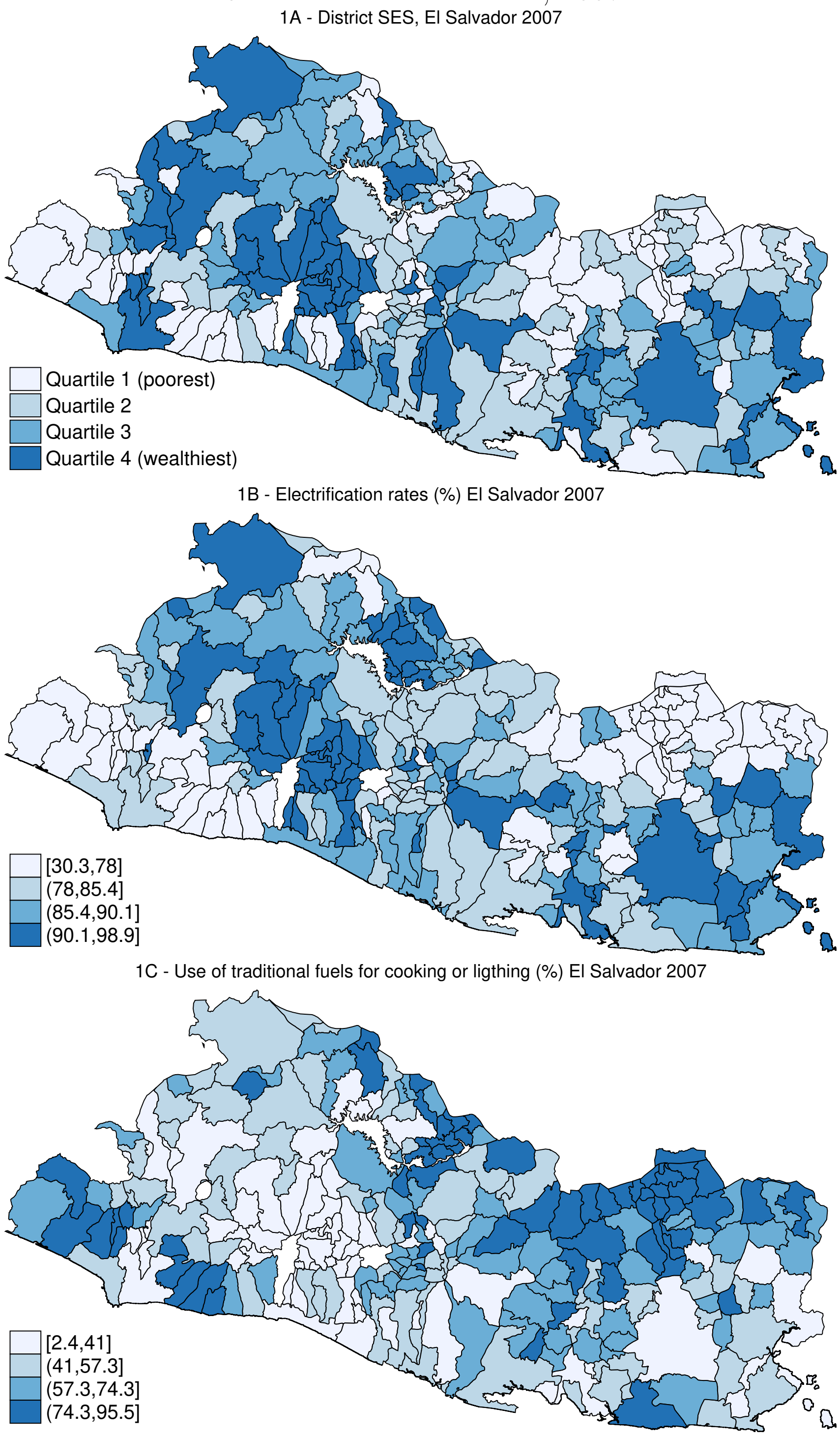
Wolfram, Catherine, Orie Shelef, and Paul J Gertler. 2012. "How Will Energy Demand Develop in the Developing World?" Tech. rep., National Bureau of Economic Research.

World Bank. 2007. "Clean Energy for Development Investment Framework: The World Bank Group Action Plan." Tech. rep., The World Bank.

———. 2009. Tech. rep., The World bank.

# Figures And Tables

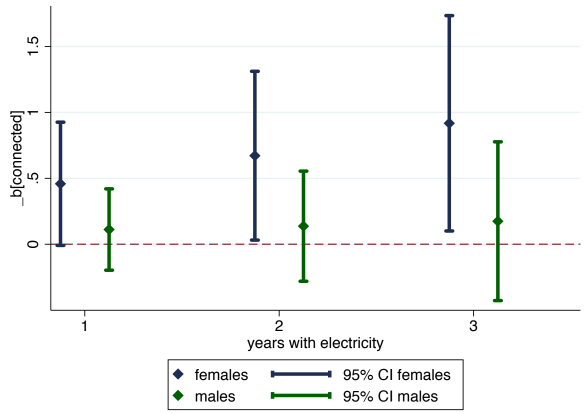
Figure 1. El Salvador: Socio-economic Status, Electrification, and Use of Traditional Fuels, 2007



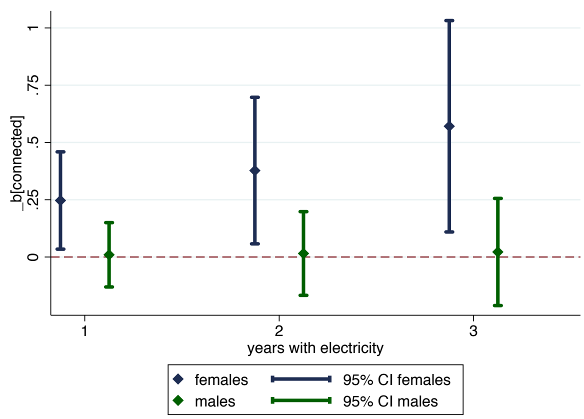

*Source:* 2007 National Census

Figure 2. Years with Electricity and Income Generating Activities by Gender, IV Estimates

a) Nonfarm Employment




b) Home Business Ownership




*Notes*: This figure plots the IV coefficients of Table 5. The horizontal axis indicates having electricity for at least $t$ years. These graphs show that the effect of electrification is positive and significant for women under different lengths of connection to the grid.

Table 1A - Summary Statistics and Balance by Treatment Arm

| | Control Group | 20% Discount | Diff: C-20% | 50% Discount | Diff: C-50% |
|---|---|---|---|---|---|
| Age of household head | 49.20 | 50.80 | -1.60 | 48.99 | 0.21 |
| | (1.47) | (1.25) | (1.92) | (1.29) | (1.96) |
| Household head is male | 0.62 | 0.72 | -0.10* | 0.72 | -0.10* |
| | (0.04) | (0.03) | (0.05) | (0.03) | (0.05) |
| Household size | 4.19 | 4.65 | -0.46* | 4.82 | -0.63** |
| | (0.18) | (0.19) | (0.27) | (0.18) | (0.27) |
| Total dependency ratio | 0.47 | 0.44 | 0.02 | 0.43 | 0.03 |
| | (0.02) | (0.02) | (0.03) | (0.02) | (0.03) |
| Maximum schooling in the household | 5.51 | 5.76 | -0.26 | 5.76 | -0.26 |
| | (0.33) | (0.33) | (0.47) | (0.32) | (0.47) |
| Schooling of the household head | 1.90 | 2.03 | -0.14 | 2.23 | -0.33 |
| | (0.25) | (0.25) | (0.36) | (0.26) | (0.37) |
| Household head is literate | 0.49 | 0.49 | -0.00 | 0.52 | -0.03 |
| | (0.04) | (0.04) | (0.06) | (0.04) | (0.06) |
| Income pc, 1000USD per year | 0.55 | 0.52 | 0.03 | 0.57 | -0.02 |
| | (0.12) | (0.07) | (0.13) | (0.08) | (0.14) |
| Monthly expenditure in kerosene | 2.96 | 2.56 | 0.41 | 2.20 | 0.76 |
| | (0.39) | (0.32) | (0.50) | (0.27) | (0.46) |
| Monthly expenditure in propane | 1.69 | 2.11 | -0.42 | 1.78 | -0.09 |
| | (0.25) | (0.22) | (0.33) | (0.22) | (0.33) |
| Monthly expenditure in candles | 0.57 | 0.55 | 0.01 | 0.55 | 0.01 |
| | (0.14) | (0.13) | (0.19) | (0.13) | (0.19) |
| Monhtly expenditure in car battery rchg | 0.12 | 0.04 | 0.08 | 0.12 | 0.00 |
| | (0.06) | (0.03) | (0.06) | (0.05) | (0.07) |
| Cooks with wood | 0.76 | 0.73 | 0.04 | 0.73 | 0.03 |
| | (0.04) | (0.03) | (0.05) | (0.03) | (0.05) |
| Informal electricity | 0.39 | 0.50 | -0.11* | 0.48 | -0.09* |
| | (0.04) | (0.04) | (0.06) | (0.04) | (0.06) |
| **Agrees with the following statement** | | | | | |
| Electricity illuminates better than kerosene. | 0.96 | 0.95 | 0.01 | 0.97 | -0.00 |
| | (0.02) | (0.02) | (0.02) | (0.01) | (0.02) |
| Powering a TV is cheaper w/elect than battery. | 0.79 | 0.74 | 0.05 | 0.81 | -0.03 |
| | (0.04) | (0.03) | (0.05) | (0.03) | (0.05) |
| Cooking with electricity is not convenient | 0.61 | 0.46 | 0.15*** | 0.50 | 0.11* |
| | (0.04) | (0.04) | (0.06) | (0.04) | (0.06) |
| Electricity is very expensive | 0.54 | 0.43 | 0.10* | 0.47 | 0.06 |
| | (0.04) | (0.04) | (0.06) | (0.04) | (0.06) |
| Woodsmoke generates respiratory problems | 0.87 | 0.84 | 0.04 | 0.87 | -0.00 |
| | (0.03) | (0.03) | (0.04) | (0.02) | (0.04) |
| Kerosene is not an expensive source of lighting | 0.42 | 0.35 | 0.07 | 0.32 | 0.10* |
| | (0.04) | (0.04) | (0.06) | (0.03) | (0.05) |
| Kerosene is the best way to illuminate my household | 0.28 | 0.20 | 0.08 | 0.20 | 0.08 |
| | (0.04) | (0.03) | (0.05) | (0.03) | (0.05) |

*Notes*: Columns 1, 2, and 4 show the mean values for each of the treatment arms at baseline (standard errors in parentheses). Column 3 and 5 report the difference in means between the control group and households that received a 20% or 50% discount voucher, respectively (standard errors in parentheses). Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey*

Table 1B - Validating the Randomization of Voucher Density, OLS estimates

| | (1) Age Head | (2) Head Male | (3) Head Schooling | (4) Household Size | (5) Adequate Walls | (6) Income | (7) Group Member |
|---|---|---|---|---|---|---|---|
| Vouchers, 0-100m radius | 0.995* | 0.004 | 0.189* | -0.017 | -0.007 | 0.008 | 0.012 |
| | (0.525) | (0.015) | (0.098) | (0.078) | (0.013) | (0.037) | (0.011) |
| Vouchers, 100-200m radius | 0.589 | -0.000 | -0.022 | -0.072 | 0.022 | 0.010 | 0.005 |
| | (0.565) | (0.017) | (0.106) | (0.083) | (0.014) | (0.039) | (0.012) |
| Vouchers, 200-300m radius | 0.036 | 0.001 | -0.005 | -0.043 | 0.003 | 0.043 | -0.002 |
| | (0.453) | (0.013) | (0.085) | (0.067) | (0.011) | (0.032) | (0.010) |
| Eligible Neighbors, 0-100m radius | -1.157** | 0.002 | -0.026 | 0.015 | -0.001 | -0.035 | -0.005 |
| | (0.496) | (0.015) | (0.093) | (0.073) | (0.012) | (0.035) | (0.011) |
| Eligible Neighbors, 100-200m radius | -0.452 | -0.001 | -0.095 | -0.026 | -0.019** | 0.007 | 0.004 |
| | (0.315) | (0.009) | (0.059) | (0.046) | (0.008) | (0.022) | (0.007) |
| Eligible Neighbors, 200-300m radius | 0.073 | 0.002 | 0.027 | 0.027 | -0.028*** | -0.025 | -0.003 |
| | (0.246) | (0.007) | (0.046) | (0.036) | (0.006) | (0.017) | (0.005) |
| Mean Dependent Variable | 49.76 | 0.69 | 2.08 | 4.58 | 0.76 | 0.55 | 0.13 |
| Number of Observations | 486 | 486 | 486 | 486 | 486 | 486 | 486 |
| R squared | 0.184 | 0.054 | 0.246 | 0.065 | 0.199 | 0.081 | 0.030 |

*Notes*: The dependent variable in each regression is indicated in the column name. Adequate walls indicates adobe, brick, or concrete walls; group member indicates whether any of the household members is a community group member. The controls in each regression include age, sex, and schooling of the household head; number of household members; an indicator for adobe, brick or concrete walls; monthly kerosene expenditure; per capita income; and an indicator for households that have at least one community group member; but when any of these is the dependent variable, it is not included as an explanatory variable. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey*

Table 2 - Illustrating the First Stage. Voucher Allocation and Connection to the Grid.

Panel A: Connection Status at period t

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Voucher x post | 0.157*** | 0.157*** | 0.120*** | 0.116*** |
| | (0.039) | (0.039) | (0.041) | (0.042) |
| s100 x post | | | 0.130*** | 0.126*** |
| | | | (0.037) | (0.037) |
| s200 x post | | | | 0.025 |
| | | | | (0.035) |
| Household Fixed Effects | No | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes |
| Households | 494 | 494 | 494 | 494 |
| Mean Y, Control | 0.606 | 0.606 | 0.606 | 0.606 |
| Mean Voucher | 0.729 | 0.729 | 0.729 | 0.729 |
| Mean s100 | 0.448 | 0.448 | 0.448 | 0.448 |
| Mean s200 | 0.371 | 0.371 | 0.371 | 0.371 |

Panel B: Time Connected by period t

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Voucher x post | 0.365*** | 0.360*** | 0.264** | 0.261** |
| | (0.100) | (0.100) | (0.105) | (0.107) |
| s100 x post | | | 0.341*** | 0.338*** |
| | | | (0.097) | (0.098) |
| s200 x post | | | | 0.018 |
| | | | | (0.095) |
| Household Fixed Effects | No | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes |
| Households | 494 | 494 | 494 | 494 |
| Mean Y, Control | 1.325 | 1.325 | 1.325 | 1.325 |
| Mean Voucher | 0.729 | 0.729 | 0.729 | 0.729 |
| Mean s100 | 0.448 | 0.448 | 0.448 | 0.448 |
| Mean s200 | 0.371 | 0.371 | 0.371 | 0.371 |

*Notes*: **Panel A:** The dependent variable is an indicator of formal connection to the grid at year $t$. **Panel B:** The dependent variable is years on the grid by year $t$. **Both Panels:** s100 is the percentage of eligible neighbors located within a 100 m radius that received a voucher; s200 is the percentage of eligible neighbors between located between 100 and 200m radius from the household that received a voucher. Post is an indcator. Standard errors clustered at the household level, reported in parentheses. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey*

Table 3 Time Allocation, Children 6-14 (IV Estimates).

Panel A: Main Activities

| | (1) Education | (2) Chores | (3) Work | (4) Leisure |
|---|---|---|---|---|
| Connected | 0.779** | 0.963* | -0.230 | -0.045 |
| | (0.397) | (0.506) | (0.330) | (0.075) |
| Household and Year Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 747 | 747 | 747 | 747 |
| Individuals | 196 | 196 | 196 | 196 |
| Mean Y, t=1 | 0.221 | 0.669 | 0.191 | 1.000 |
| Mean Y, t>1 | 0.157 | 0.577 | 0.264 | 0.960 |
| Mean Y $\|Y > 0$ | 6.123 | 3.486 | 6.700 | 8.682 |

Panel B: Education

| | Education | | Studying | | Other Educ | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Connected | 0.779** | | 0.539* | | 0.840** | |
| | (0.397) | | (0.292) | | (0.398) | |
| connected x female | | 0.621 | | 0.566** | | 0.621 |
| | | (0.379) | | (0.274) | | (0.379) |
| connected x male | | 1.209 | | 0.415 | | 1.454 |
| | | (1.297) | | (0.840) | | (1.394) |
| Household and Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 747 | 747 | 747 | 747 | 747 | 747 |
| Individuals | 196 | 196 | 196 | 196 | 196 | 196 |
| Mean Y, t=1 | 0.221 | 0.221 | 0.147 | 0.147 | 0.213 | 0.213 |
| Mean Y, t>1 | 0.157 | 0.157 | 0.068 | 0.068 | 0.152 | 0.152 |
| Mean Y $\|Y > 0$ | 6.123 | 6.123 | 2.073 | 2.073 | 5.298 | 5.298 |

*Notes:* The dependent variable takes the value of 1 if the respondent participated in the activity indicated in the column and 0 otherwise. The excluded instruments are voucher allocation and s100. Standard errors are clustered at the household level and reported in parenthesis. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey.*

Table 4- Electrification and Income Generating Activities by Gender, Adults 18-65 (IV Estimates).

Panel A: Nonfarm Employment

| | All | | Females | | Males | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Connected | 0.264* | | 0.458* | | 0.111 | |
| | (0.138) | | (0.238) | | (0.157) | |
| Time Connected (years) | | 0.113** | | 0.187** | | 0.042 |
| | | (0.055) | | (0.091) | | (0.063) |
| Household and Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3728 | 3728 | 1968 | 1968 | 1760 | 1760 |
| individuals | 952 | 952 | 495 | 495 | 457 | 457 |
| Mean Y, t=1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mean Y, t>1 | 0.178 | 0.178 | 0.211 | 0.211 | 0.140 | 0.140 |
| Mean X, t>1 | 0.738 | 1.596 | 0.758 | 1.635 | 0.717 | 1.553 |

Panel B: Home Business

| | All | | Females | | Males | |
|---|---|---|---|---|---|---|
| Connected | 0.122* | | 0.247** | | 0.010 | |
| | (0.063) | | (0.108) | | (0.071) | |
| Time Connected (years) | | 0.052** | | 0.109** | | 0.004 |
| | | (0.025) | | (0.046) | | (0.027) |
| Household and Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 5789 | 5789 | 3040 | 3040 | 2749 | 2749 |
| individuals | 1403 | 1403 | 736 | 736 | 667 | 667 |
| Mean Y, t>1 | 0.070 | 0.070 | 0.097 | 0.097 | 0.040 | 0.040 |
| Mean Profits$\|Y = 1$, 1000USD/year | 1.284 | 1.284 | 1.053 | 1.053 | 1.519 | 1.519 |

*Notes:* **Panel A:** the dependent variable is a dichotomous indicator of participation in non farm employment. The sample is formed by individuals that did not engage in non farm employment in the year leading to the baseline survey. **Panel B:** the dependent variable is a dichotomous indicator of operation of a home business. **Both Panels:** The excluded instruments are voucher and s100. Standard errors are clustered at the household level and reported in parenthesis. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey.*

Table 5- Time on the Grid and Income Generating Activites, Adults 18-65 (IV Estimates).

Panel A - Non Farm Employment

| | t=4 | t>=3 | t>=2 | t>=1 |
|---|---|---|---|---|
| time connected | 1.123* | 0.577** | 0.394** | 0.264* |
| | (0.614) | (0.265) | (0.190) | (0.138) |
| Time Fixed Effects | Yes | Yes | Yes | Yes |
| Household Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 3728 | 3728 | 3728 | 3728 |
| individuals | 952 | 952 | 952 | 952 |
| Mean Y, t=1 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mean Y, t>1 | 0.178 | 0.178 | 0.178 | 0.178 |
| Mean X, t>1 | 0.427 | 0.436 | 0.467 | 0.530 |

Panel B - Home Business

| | t=4 | t>=3 | t>=2 | t>=1 |
|---|---|---|---|---|
| time connected | 0.499* | 0.264** | 0.182** | 0.122* |
| | (0.259) | (0.120) | (0.089) | (0.063) |
| Time Fixed Effects | Yes | Yes | Yes | Yes |
| Household Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 5789 | 5789 | 5789 | 5789 |
| individuals | 1403 | 1403 | 1403 | 1403 |
| Mean Y, t=1 | 0.190 | 0.190 | 0.190 | 0.190 |
| Mean Y, t>1 | 0.241 | 0.241 | 0.241 | 0.241 |
| Mean X, t>1 | 0.115 | 0.304 | 0.524 | 0.751 |

*Notes:* **Panel A** the dependent variable is a dichotomous indicator of participation in non farm employment. The sample is formed by individuals that did not engage in non farm employment in the year leading to the baseline survey. **Panel B** the dependent variable is a dichotomous indicator of operation of a home business. **Both Panels** The excluded instruments are voucher and s100. Standard errors are clustered at the household level and reported in parenthesis. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey.*

Table 6- Electrification and Household Income (IV Estimates).

| | Total Income | | Labor Income | | Non-Labor Income | |
|---|---|---|---|---|---|---|
| (mean) connected | 5.449* | | 5.923** | | -0.474 | |
| | (2.854) | | (2.883) | | (0.510) | |
| (mean) t_conn | | 2.252* | | 2.423** | | -0.170 |
| | | (1.187) | | (1.197) | | (0.207) |
| Household and Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2147 | 2147 | 2147 | 2147 | 2147 | 2147 |
| Households | 469 | 469 | 469 | 469 | 469 | 469 |
| Mean Y, t=1 | 1.776 | 1.776 | 1.465 | 1.465 | 0.312 | 0.312 |
| Mean Y, t>1 | 2.567 | 2.567 | 2.005 | 2.005 | 0.562 | 0.562 |
| Mean X, t>1 | 0.730 | 1.628 | 0.730 | 1.628 | 0.730 | 1.628 |

Panel B: Net Income

| | Total Income | | Labor Income | | Non-Labor Income | |
|---|---|---|---|---|---|---|
| Connected | 1.631 | | 4.792* | | -0.474 | |
| | (1.165) | | (2.537) | | (0.510) | |
| Time Connected (years) | | 0.646 | | 1.914* | | -0.170 |
| | | (0.474) | | (1.035) | | (0.207) |
| Household and Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2147 | 2147 | 2147 | 2147 | 2147 | 2147 |
| Households | 469 | 469 | 469 | 469 | 469 | 469 |
| Mean Y, t=1 | 1.182 | 1.182 | 1.089 | 1.089 | 0.312 | 0.312 |
| Mean Y, t>1 | 1.883 | 1.883 | 1.616 | 1.616 | 0.562 | 0.562 |
| Mean X, t>1 | 0.730 | 1.628 | 0.730 | 1.628 | 0.730 | 1.628 |

*Notes:* The dependent variable is gross annual income in US$. The excluded instruments are voucher allocation and s100. Standard errors are clustered at the household level and reported in parenthesis. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey.*

Table 7- Household Appliances, IV Estimates

Panel A: Appliances

| | Radio | Stereo | TV | DVD | Fridge | Blender |
|---|---|---|---|---|---|---|
| Connected | -0.026 | 0.437** | 0.578* | 0.220* | 0.544** | 0.246* |
| | (0.361) | (0.180) | (0.341) | (0.118) | (0.250) | (0.144) |
| Household Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean Dep. Var., Control | 0.335 | 0.163 | 0.327 | 0.089 | 0.189 | 0.099 |
| Number of Households | 219 | 386 | 278 | 414 | 362 | 405 |

Panel B: Appliances (continued)

| | Computer | Sewing | Iron | Microwave | Washer | Fan |
|---|---|---|---|---|---|---|
| Connected | 0.136*** | -0.047 | 0.241 | 0.054 | 0.180*** | 0.165** |
| | (0.049) | (0.064) | (0.170) | (0.066) | (0.055) | (0.080) |
| Household Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Mean Dep. Var., Control | 0.004 | 0.026 | 0.199 | 0.012 | 0.000 | 0.035 |
| Number of Households | 467 | 447 | 367 | 460 | 481 | 481 |

*Notes:* The dependent variable takes the value of 1 if the household owns the appliance indicated in the column and 0 otherwise. The sample for each regression is households that did not own the appliance at baseline, except for washing machines and fans, because these appliances were not included in the baseline sample. The excluded instruments are voucher allocation and s100. Standard errors, clustered at the household level, are reported in parenthesis. Significantly different than zero at 90(*), 95(**), and 99(***) percent confidence. Source: *Household Electrification Survey*