Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua

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This paper shows that rural electrification is associated with big changes in the time use of men and women in Nicaragua, even in the absence of labour-saving appliances. Electricity is shown to increase the propensity of rural Nicaraguan women to work outside the home by about 23%, but to have no impact on male employment. These findings suggest significant potential benefits to rural electrification that are not generally captured in cost-benefit analyses of rural electrification projects, such as greater women's earnings and reduced deforestation.

JEL codes: H4, I3, O1, O3, R18

Key words: electric light, time use, employment, labour-saving technology, slope gradient, population density.

1 Introduction

The potential for electrification to modernise societies has been recognized at least since the Russian Revolution. Speaking to the newly-formed Russian Soviet on November 8th 1917, Lenin stated "Communism is Soviet power plus the electrification of the entire country"[1]. According to the World Bank (2007), more than one billion people gained access to electricity between 1975 and 2000. Still, at least 1.6 billion people, mainly in rural areas, do not have such access. The recent emergence of new technologies for off-grid electrification makes understanding the impact of household electrification all the more policy-relevant[2]. Rud (2012) shows that electricity provision was very important to the development of manufacturing in India and Lipscomb, Mobarak, and Barham (2011) find similar results for Brazil.

This paper investigates how electrification changes resource allocation in rural households in a poor country. We modify a simple Gronau (1977) model of time allocation to show how electrification might impact the labour supply of household members. We then test the model using nationally-representative household survey data from Nicaragua, the Latin American country with the lowest rural household electrification rate. We show that individuals in rural households with electricity allocate their time across productive activities very differently from those without electricity. The causal effects of household electrification on male and female labour supply are then identified, using an instrumental variables strategy to overcome potential endogeneity. Specifically, the differential cost of extending the electric grid from urban to rural areas of a municipality is proxied by two plausibly exogenous factors: the 1971 population density in the municipality, and the mean slope gradient of the land in the municipality. Conditional on extensive individual, household, municipal, and county fixed effects, these two instruments are strong predictors of the probability that a rural household reports having electric light in Nicaragua in 2005, but are not correlated with unobserved factors impacting labour supply.

Why would having electric light change intrahousehold resource allocation decisions, even in the absence of labor-saving appliances in the home? After all, gas lighting or candles can be used to extend the day even without electricity. However, electric lighting, and especially that provided by the electric grid, is generally much cheaper than other ways of lighting the home. The World Bank (2008) (p.40) estimates that moving from kerosene lighting to electricity reduces the cost of providing a lumen of light dramically, under reasonable assumptions about the cost of electricity and kerosene. This means both that households with connections to the grid are much more likely to use artificial lighting to extend the day, and also that they are likely to use such lighting for longer periods than otherwise[3]. Having the possibility to light the home with cheap grid-provided electricity should change decisions regarding the preferred extent of artificial light use, as well as the medium used for lighting. The money and time saved when artificial light becomes less expensive can be allocated to other expenditures and activities. Perhaps for this reason, virtually all Nicaraguan households with connections to the electric grid report that they use electricity provided by the grid for lighting.

There is some evidence that the introduction of electricity to a home is associated with resource allocation changes. Heltberg (2003) and Heltberg (2004) find that household electrification is strongly correlated with the uptake of modern cooking fuels in Nicaragua, as well as in Brazil, Ghana, Guatemala, India, Nepal, South Africa, and Vietnam. If there is also a causal effect of having electricity on the type of fuel used in cooking, the provision of electric connections may both mitigate deforestation and improve the quality of air breathed by family members. Indeed, Dinkleman (2011) finds that the use of firewood for fuel is significantly lowered because of electrification in Kwa-Zulu Natal, South Africa, using community-level data from periods before and after electrification projects were implemented. This finding is consistent with households using electricity and perhaps kerosene or butane gas as a result of electrification. Dinkleman shows that electrification projects caused an increase in the employment of women in the communities which obtained electricity, and that most of this employment increase derives from smallscale self-employment activities.

This paper proceeds as follows. Section 2 provides basic background information on electrification and infrastructure provision in Nicaragua. Section 3 presents a simple extension to the Gronau (1977) model of time allocation in the household, which can explain how the extension of the working day might impact employment propensities and time spent in firewood collection, even in the absence of labour-saving appliances. Section 4 introduces the Nicaraguan household data to be employed, and discusses the data and summary statistics. Section 5 examines the conditional association between time use and household electrification, and identifies the causal effects of household electrification on work propensities of both women and men. Section 6 concludes.

2 Background

Nicaragua is the poorest country in Central America, has the lowest household electrification rate, and has been the slowest to increase generating capacity. Rural electrification rates in existing World Bank Living Standards Monitoring Studys (LSMS) from Nicaragua were 32% in 1993 and 35% in 2005. Urban electrification rates were also essentially unchanged in Nicaragua during this period, at 90%.

Political obstacles are partially responsible for continuing low rural electrification rates in Nicaragua. Nicaragua experienced the Contra War and a communist government from the late 1970s until 1988. Much of the infrastructure and the economy was destroyed during this war, before the defeat of the communist Sandinista government in the 1990 election. As in Guatemala during the 1980s, the civil war delayed both the extension of the electric grid, and investments in new and existing generation capacity.

Geography poses a major obstacle to the extension of the electric grid, as much of the country is mountainous. Nicaragua's electricity is largely generated by burning imported oil. High oil prices and irregular oil supply also disrupted electricity since the late 1980s.

A major post-war privatization of electricity provision was undertaken to try to improve the access of the population to electricity, but was mostly unsuccessful. As of the 2005 LSMS, firewood was the major fuel source for residents of rural areas, and electrification rates in rural areas remained low. This trend contrasts with that in Guatemala, which had essentially the same household electrification rate as Nicaragua in 1996. By 2005, 87% of Guatemalans had access to electricity, versus only 63% of Nicaraguans (Acevedo (2005))[4]. In the early 2000s, electricity costs were the highest in Nicaragua amongst all Central American countries (Acevedo (2005)), partly because of the dependence on imported oil rather than domestic hydro or geothermal generation.

3 Theory

To fix ideas, we illustrate how electrification might both increase work outside the household and cause a switch away from firewood collection. A simple Gronau (1977) model would predict that increases in productivity at home make women substitute out of market work. In reality, electrification, particularly for poor people, may be more about the extension of the working day than about labour-saving appliances. Why might having electric light in the household cause rural residents to spend less time collecting firewood? Even in electrified households, electricity is seldom used as a cooking fuel, but the association between having electric light and using modern cooking fuels is salient across countries.

When a household has no possibility of choosing electricity, effective hours available for home production are constrained by daylight. If electric light becomes available, potential hours of activity are expanded dramatically. For example, women who received solar, off-grid electricity in Estelí, a municipality of Nicaragua, confirmed that this light extends their day. Comments included in a subjective case study of the project included *"Its easier to live this way. My kids can read and do homework during the night."* and *"Solar energy is forever. We leave our lights on and sit around the table and talk. This is happiness."* (van der Jagt (2011)).

Whereas appliance diffusion tends to increase the efficiency of home production, which reduces market labour supply, the extension of the working day impacts work propensities in the opposite direction. The extension of the electric grid allows the choice between two technologies for home production. Assume, as in the Gronau (1977) model, that people derive utility both from goods and leisure, and that the rate at which they are willing to substitute goods for leisure can be depicted by indifference curves. Household residents allocate their time between market work (N), leisure (L), and home production time (H). This time allocation process can be depicted in a two-dimensional diagram with goods on the Y axis, and time on the X axis. This situation is depicted in Figure 1. With the extension of the electric grid, a resident will chose electricity if this choice puts her on an indifference curve further from the origin. Figure 1 depicts a situation in which, before arrival of the grid, a resident had home production possibilities AA, and an optimal division of labour such that she was indifferent between working at the prevailing wage (w). With the extension of the grid, it is possible to choose home production possibility curve BB. In Figure 1, this choice will result in the resident choosing electricity and working in the labour market, since the feasible indifference curve farthest from the origin is now no longer U0 but U1[5].

Prior to electricity becoming available an individual may not choose modern cooking fuels, but rather to spend time collecting firewood for cooking. The opportunity cost of time spent in firewood collection is low in this case, since productivity in other activities is low. Potential home production hours expand with cheap artifical light, and previously non-working individuals may decide to enter paid work. Whereas without electricity a person could not earn money to pay for modern fuels, a switch into the labour market with electricity might provide necessary cash for a gas stove and fuel. This choice is depicted in Figure 2. When fuel is purchased, the home production possibility curve begins below the X axis, because this fuel is purchased. Even in the absence of changes in labour demand and wages due to electricity provision in an area, women might both work more in electrified households and also be more likely to use purchased cooking fuel. The extension of the working day may not result in home productivity improvements, but it could provide a new source of cash earnings for fuel purchase.

In Nicaragua, it turns out that rural residents who do not collect firewood still commonly buy firewood rather than modern cooking fuels. Deforestation is strongly attributed to cooking with firewood[6]. As well, cooking with firewood on open fires in enclosed spaces is associated with the very high infant mortality rates still prevailing[7]. Still, if electrification increases the feasibility of purchasing cooking fuel, changes in the relative prices of firewood versus modern fuels might then yield greater environmental dividends.

In the remainder of the paper, we test the implications of our model. We investigate the impact of having electricity in the household on time use of individuals and employment propensities of women and men.

4 Data

Our data come from the nationally-representative LSMS for Nicaragua from 1998 and 2005, from the 1971 Nicaraguan census, and from geographic information systems (GIS) information. Our main data source, the 2005 LSMS household survey contains information on the living standards of 6882 households, and health and labour supply information for each resident[8]. The April 20th 1971 Nicaragua census was taken during the latter part of the Somoza regime, which had consolidated ownership of national infrastructure and industries under the presidential family, since taking power in the late 1930s (Trachtenberg (1989), Tulchin (1988)). This census was fielded 20 months prior to the massive earthquake that destroyed 80% of Managua's commercial buildings, and left a large fraction of the population homeless. Following the 1971 census the population grew rapidly, from 2 470 000 in 1971 to 5 460 000 in 2005, with substantial migration into urban areas.

4.1 Summary statistics

Our analysis focuses on rural households, for several reasons. First, it is in rural areas of Nicaragua and all countries that electrification has historically been most costly and most sparse. Because new technology has markedly decreased the cost of providing electricity to rural households, it is important to understand how electricity provision in households might impact socioeconomic outcomes that have traditionally not entered cost-benefit analyses. Second, there is much more likely to be truly exogenous variation in electricity access in rural than in urban areas. Decisions regarding grid provision within a municipality will depend much more on the situation in urban areas than rural, since urban electrification is relatively low cost per household. Whether or not a household has electricity in a rural area likely depends substantially on the characteristics of the nearby urban areas, with which the household might otherwise have little contact.

Many Nicaraguans residing in rural communities also remain without access to basic infrastructure provisions such as piped water, telephones, sanitation, and electricity. Electricity provisions were not part of a massive, 'industrialisation package', occurring rapidly and simultaneously across the country[9].

In rural areas, about 10% of households with electric connections use modern fuel for cooking, whereas about about 58% of electrified households in urban areas do so. In urban areas, about 10% of households without electricity use modern cooking fuels, but in rural areas essentially none do. In rural areas, only about 20% of households with electricity have any type of cooking stove, and only about 2% of those without. Only 1% of electrified rural households have a refrigerator.

Amongst those residing in rural households, there are substantial differences in the observable characteristics by electrification status. As shown in Table 1, men and women are more than twice as likely to have completed primary education if they have electricity. The fraction of women working outside of the household is about 27% in unelectrified households and about 41% in electrified ones. In contrast, men are slightly more likely to work if they reside in households without electricity. Those in electrified households are more likely to have been born in the same municipality, live closer to the nearest highway, are more likely to have piped water and a garbage pick-up service. They are less likely to reside in a dwelling with a dirt floor. Amongst rural residents, the urban electrification rate is higher in the nearby urban area for those with electricity than those without, consistent with the idea that greater provision to urban areas of a municipality reduces the cost of extending lines to rural ones.

4.2 Time use in the 1998 LSMS

Although there is no time use module included in the 2005 LSMS survey, detailed information on the time use of household members is available from the 1998 LSMS. This is an earlier round of the panel survey which includes the 2005 LSMS. About 1/2 of 1998 LSMS respondents completed the time use module. The module documented time spent in the day prior to the interview in an extensive list of work and recreation activities.

Rural individuals residing in households with electricity have substantially different work patterns from those residing in households without electricity. Table 2 presents summary statistics on time use for the 1998 rural sample, by sex and electrification status of the household. The left-hand panel gives mean minutes spent in the day prior to the interview, while the right-hand panel gives the probability that people spent any time in a given activity in the day prior to the interview. Women spent much less time than did men in family agriculture and salaried work, in both households with and without electricity. However, for both men and women, having electricity was associated with a substantially different allocation of time amongst productive activities outside of the household. For example, mean minutes spent in salaried work amongst rural women in unelectrified households was 31, versus 90 amongst women in electrified households. Mean time spent by women in family agriculture was 22 minutes in unelectrified households, versus 4 minutes in electrified. For men, having electricity was associated with a decrease of half in time spent in family agriculture (270 minutes versus 128 minutes), a doubling of time spent in family non-agricultural activities (from 22 to 45 minutes), and a doubling of time spent in non-salaried work (from 116 to 250 minutes). As shown in the right-hand panel of Table 2, having electricity is associated with a substantial increase in the probability of engaging in salaried work, for both men and women.

Similarly, time spent in both home production and leisure activities was different across electrified and unelectrified rural households. Women spent much less time cooking in electrified than in unelectrified households (113 versus 148 minutes), and also less time getting water and firewood. For men, mean time spent collecting firewood was about half in electrified households, at 14 minutes, than in electrified. Consistent with a conjecture that having low-cost light extends the working day, both men and women spent about half an hour less sleeping in electrified versus electrified households. Men had about 25 minutes more leisure in electrified than in unelectrified households, but having electricity was not associated with more leisure time for women.

5 Estimation

This section employs multivariate analyses to further investigate the role electricity plays in determining time allocation choices of individuals. We first examine the association between having electricity and time spent in major market and home production activities, after accounting for individual, household, and county level characteristics. We next identify the impact of rural household electrification on the probability that a woman or man works outside the home.

5.1 Time use regressions

To examine the conditional association between time use in productive activities in the 1998 LSMS and household electrification, we estimate the following tobit regressions.

$$
\begin{aligned}
MINACTIVITY_{ihc} &= \beta_0 + \beta_1 * ELECHH_{hc} + \eta * INDCONTROLS_{ihc} \\
&\quad + \alpha * HHLDCONTROL_{hc} + \gamma * MUNICONTROLS_{hc} + \mu_c + \epsilon_{ihc}
\end{aligned}
$$

We examine, for each of 5 activities, minutes spent in the activity on the day prior to the interview. The 5 activities categories are: family agriculture, family non-agriculture, salaried work, cooking, and firewood collection, since it is these activities which best allow us to examine the predictions of our model. Here i refers to individuals in household h and county c. Each specification includes dummies for 5 year age cohort, marital status, whether or not the person has completed primary education, and whether he or she was locally born. As well, controls are included for the number of children in the household under age 3, age 3 to 5, and age 6 to 18. We control for whether the household has a water pipe, and a dirt floor, factors which likely reflect both municipal infrastructure levels and a household's wealth. We also control for the distance between the respondent's house and the nearest primary school, which may partly reflect the scope of local labour market opportunities. County (*departamento*) level fixed effects are included in all specifications, and are denoted μ_c. There are 15 counties and two autonomous regions, containing between 250 000 (Autonomous North Atlantic Region, RAAN) and 1 400 000 inhabitants (Managua) as of 2005 (Minnesota Population Center (2010))[10]. In the specifications for women, we also control for the mean earnings of rural men, and for the mean employment rate of rural men aged 20-55.

The county level fixed effects are particularly important because these refer to small geographic areas where local economic conditions are likely similar. The number of municipalities represented in each county varies from 3 in Granada to 11 in the Southern Atlantic Autonomous Region (RAAS). The extent of electrification also varies greatly both within and between counties: In Jinotega county, the mean urban electrification rate amongst the 8 municipalities is only 30%, and there is also wide variation within Jinotega in that rate (a standard error of 0.16). Only in Granada, where the municipal urban electrification mean was 97%, is there relatively little variation in the urban electrification rate amongst municipalities. Both within and between counties, the variation amongst municipalities in other indicators of living standards, such as the fraction of households with dirt floors, the fraction of women working outside of the household, or the fraction with piped water, is substantially less. In Jinotega, a mean of 70% of rural households has a dirt floor (with a standard error 0.05 amongst municipalities), versus 62% in Granada (standard error 0.07), despite the much greater prevalence of electricity in urban areas of Granada.

Even with the extensive individual, household, and county fixed effects, there remains a strong conditional association between time spent in most productive activities and household electrification status. Table 3 shows that, having electricity is associated with about 6 hours less spent by rural women on family agriculture, and about 3 hours less by men, *ceteris paribus*. Conditional on all other observables, women spent about 67 minutes more on family non-agricultural work when their household had electricity, but for men electricity was not associated with a change in family non-agricultural work. For both men and women, having electricity was associated with increases of more than 4 hours in time spent in salaried work. While there was no significant conditional association between time spent cooking and household electrification status for either men or women, having electricity was associated with a mean reduction of almost an hour (45 minutes for women, 65 minutes for men) in time spent collecting firewood.

Our findings that electrification is associated with a substantial reduction in time spent looking for firewood concur with those of Heltberg (2003) and Heltberg (2004). As well, Dinkleman (2011) finds that electrification in KwaZulu-Natal caused a decrease the use of firewood for cooking. In South Africa, however, rural households tend to switch to using some electricity for cooking when it becomes available. As well, electrified rural households in South Africa are much more likely to have refrigerators, irons, kettles, and stoves (hot plates) than are electrified rural households in Nicaragua (Thom (2000)).

5.2 Electrification and work propensities: Identification strategy

Clearly the conditional associations between household electrification status and time spent in different productive activities do not prove causality from electricity to observed outcomes. Similarly, simple probit specifications of the relationship between a household's electrification status and employment propensities may give biased results. This is both because of potential reverse causality from employment status to having electricity, and also because there are likely unobservables correlated with both having electricity in the household and with employment propensities. For example, wealthier households may be more likely to have electricity but be relatively more or less likely to have working household members. As well, people may want electricity because they want to work more or they desire more leisure. For these reasons, we might expect biased coefficients on our electricity dummy in specifications which do not attempt to overcome the endogeneity issue.

There will be different costs of electrifying households in rural areas across municipalities, both because of the historical population levels in the municipality and because of geographical factors. These considerations can be summarised in two measures. First, the extension of a given length of grid cable reaches fewer customers where customers are more widely dispersed. Where the historic population density in the muncipality was low, the marginal cost of an additional household connection is thus relatively high. Second, where the slope of the land in a municipality is relatively steep, the cost of extending the electric grid to rural households will also be relatively high. These two cost-related factors are key to our identification strategy.

The large variation in both land slopes and pre-civil war population densities across municipalities in Nicaragua is helpful key to identification of electrification effects. There are 136 municipalities in Nicaragua. For each, we measure the population density in 1971, and the mean slope gradient of the land. These variables are employed as instruments explaining whether or not a rural household has an electric connection in 2005[11].

The historic population density in the municipality is calculated from the Nicaraguan census and reported by the Nicaraguan National Institute of Statistics[12]. The lowest 1971 population density is found in in *Prinzapolka*, in the Autonomous North Atlantic Region (RAAN), and the highest in Managua, in the area which had become the municipality of *Ciudad Sandino* in 1969. Population densities have historically been the lowest on the Atlantic Coast, and highest in Managua and the municipalities of the fertile Pacific Coast. The second instrument, the mean slope of the land in a municipality, is calculated using ArcGIS version 9.3 geographical software. The municipal maps used are from ESRI Data and Maps (2008). The slope gradient instrument is also used by Dinkleman (2011) in her study of the employment impact of electrification projects in KwaZulu-Natal, South Africa[13]. This slope gradient is calculated as rise over run, as a mean across the territory spanned by the municipality. The minimum mean slope gradient is found in *El Realejo* (1.3), on the Pacific Coast, and the maximum in *Murra* (29), in a high mountain region of Nueva Segovia.

Clearly both of our instruments might be associated with other factors that have direct impacts on our outcome of interest, employment propensities. This is mainly because the vast majority of potential employment in rural areas is agricultural. For example, the slope of the land in a municipality may reflect agricultural productivity, which would impact the potential wages earned by men and women outside of the home. As well, population density in a municipality in 1971 might also reflect the size of agricultural plots available in 2005, or impact the price of land. It might also be correlated with the extent of non-farm employment. Rural areas with more electricity might also have higher wages, if electrification facilitates business opportunities and diversification out of agriculture. Thus, while both of our instruments are arguably exogenous to a given household, we are particularly concerned about municipal unobservables which could be correlated both with our instruments and with our outcome of interest, employment propensities.

To ensure that our instrumental variables strategy is valid, we include controls for municipal and individual-level factors that reflect the local labour market situation. In all specifications, we control for the fraction of the municipal population which currently resides in urban areas. This means that the historic municipal population density instrument, $(\frac{\text{total population}}{\text{municipal km}^2})$, also partially captures the sparcity of population outside of urban areas. As well, we control for the distance between an individual's household and the nearest highway or road. In specifications examining the impact of electrification on women's employment propensities, we control for the fraction of rural males who are employed in the municipality, and for the mean monthly earnings of rural males in the municipality. These two variables are assumed to proxy the level of dynamism of the local labour market. Together, these controls help ensure that unobservable municipal level factors are not biasing our estimated impact of electrification on employment propensities.

We can be relatively confident that our results reflect causal effects of a household's having electricity on work propensities of its' members. Because we include county-level fixed effects in all specifications, we are still able to control for quite detailed local, but unobserved, fixed factors. As well, because we have two instruments for one endogenous variable, we are able to test the joint validity of these instruments, and thus to show that municipal level unobservables pass an overidentification test. Our employment results will turn out to be robust to the inclusion of extensive municipal level economic controls, and to the exclusion of all other covariates.

5.3 Electrification and work outside the home

Individuals aged 20 through 55 are considered to be working if they report that they did so in the week prior to the interview, or if they were on holiday from a job in the previous week. Estimation is by probit and, for the instrumented specifications, recursive bivariate probit. Standard errors are clustered at the municipality level.

To identify the causal effects of household electrification on work propensities, the following equation is estimated by recursive bivariate probit:

$$\begin{aligned} PR(WORK)_{ihc} &= \beta_0 + \beta_1 * EL\widehat{ECH}H_{hc} + \eta * INDCONTROLS_{ihc} \\ &\quad + \alpha * HHLDCONTROL_{hc} + \gamma * MUNICONTROLS_{hc} + \mu_c + \epsilon_{ihc} \end{aligned}$$

Here i refers to individuals in household h and county c. The endogenous variable, $\widehat{ELECHH}$, is predicted by the log of the population density in a municipality in 1971, and the mean slope of the land in the municipality. Each specification includes dummies for 5 year age cohort, marital status, whether or not the person has completed primary education, and whether he or she was locally born. As well, controls are included for the number of children in the household under age 3, age 3 to 5, and age 6 to 18. We control for whether the household has a water pipe, garbage collection, and a dirt floor, factors which likely reflect both municipal infrastructure levels and a household's wealth. We also control for the distance between the respondent's house and the nearest highway or road, which may partly reflect the scope of local labour market opportunities. County (*departamento*) level fixed effects are included in all specifications, and are denoted μ_c.

We have three further municipal level controls. The fraction of the municipal population living in urban areas in 2005, $\frac{\text{urban population}}{\text{total population}}$, is included as a control variable in all specifications. In the specifications for women, the mean earnings of rural males and the mean employment rates of rural males in the municipality are also included as controls.

Estimation is performed for women and men separately, first using the full sample of individuals aged 20-55, and then separately for those aged 20-35 and 35 and older, respectively.

For women, both the probit and recursive bivariate probit specifications suggest a positive impact of having electricity on female work propensities. Table 4 illustrates. The preferred specification, with instrumentation, suggests a larger effect than does the probit specification. We would expect this if, for example, unobserved preferences for leisure make having electricity more likely, but also reduce the probability that a woman works. Using our instrumental variables, we find that a woman is 23% more likely to work outside of the home because there is electricity in the household. Given a female employment rate of 33% in our sample, this is a substantial impact. Our F-statistic for the instruments, shown at the bottom of Table 4, confirms that these instruments are not weak. The p-value of the J-test also confirms that the instruments jointly satisfy the overidentification restrictions. The standard errors are much larger in the instrumented than uninstrumented specification, but they still show that electrification causes a statistically significant increase in the probability that a woman works outside the home. The differences between the uninstrumented and instrumented specifications for women are plausibly attributable bias caused by unobservables in the uninstrumented specification. Women with greater preferences for leisure, or who are relatively productive at home, may be both more likely to have electricity and not to be employed.

For men, results differ across the uninstrumented and instrumented specifications. While the simple probit specification suggests a negative association between electrification and work outside the home, this association disappears once potential endogeneity has been accounted for. Potentially, unobserved preferences for leisure are both positively associated with having electricity and also negatively associated with mens' work propensities. This would explain why the recursive bivariate probit specification suggests that electrification has no impact on male employment propensities, as our model would predict. If women do most home production, we expect that the impact of better home production technology impacts their labour supply decisions the most.

The differences in results across instrumented and uninstrumented specifications are suggestive of the potential bias caused by unobservables. For women we find that the causal effect of electrification on work propensities is significantly larger than the conditional association obtained by simple probit. This is consistent with preferences for leisure positively impacting the probability that a rural household has electricity, but negatively impacting a woman's work propensity. For men, it appears that greater (unobserved) household wealth is also associated with both more electricity and less work, but that there is no causal effect from electricity to work.

5.3.1 Robustness

We next examine the sensitivity of our employment results to the inclusion of an extensive, 'kitchen sink'-style list of municipal controls. To our original specifications we add variables to control for the mean urban electrification rate in the municipality, the fraction of urban residents of the municipality with a dirt floor (a proxy for urban wealth), the fraction of urban residents with garbage disposal service, and the employment rate of urban females in the municipality. The results are presented in Data Appendix A, along with those of the firststage regressions. To summarise, coefficients on the electrification dummy are essentially unaltered for either men or women. This gives us confidence that municipal-level unobservables were not driving our key findings.

The strong observed effects of household electrification on female employment propensities are robust in specifications excluding municipal, county, household and individual covariates. To summarise the results of these specifications, presented in Data Appendix A, the observed employment effect of electrification is statistically the same in a specification with no control variables and with only instrumentation for household electrification. This specification also easily passes the overidentification test. Thus, our instrumental variables can be considered even unconditionally exogenous to rural Nicaraguan women. Neither historic population density nor land slope seem to have direct effects on female employment propensities in rural Nicaragua. This is perhaps because a lack of other basic infrastructure has prevented electrification from broadly stimulating labour demand, or from tricking down from urban areas to rural.

5.3.2 Younger versus older people

Since the majority of available work in rural areas is physically-intensive agricultural work, we might expect that the employment impact of electrification is greater on younger people than on older, *ceteris paribus*. For example, after conditioning on the number and age of children, we might expect people who are fitter or healthier to be more likely to take up work when their household obtains electricity. The reason is simple: They are relatively productive in agricultural work, and so their implicit wages are higher. The data show that, indeed, younger individuals are less likely to have health problems: The probability that a person under 35 was free of sickness in the month prior to the LSMS was 66% for people under 35, versus only 50% for people above this age.

We next examine the impact of household electrification amongst those under 35 and those aged 35 to 55, respectively, using the same identification strategy and control variables as previously.

We find that the effects of electrification on work propensities are concentrated amongst women aged 20 to 35. In fact, for neither older women, nor for men of either age group, do we find statistically significant impacts of electrification on work propensities. For women under 35, having electricity in the household causes 28% increase in the probability of working outside of the home. These findings, shown in Table 5, are consistent with an assumption regarding the gendered division of labour in the home, and also with the stylised fact that women's productivity outside the household is greater when they are younger and fitter, after conditioning on the number and age of children. Note that, for women we include controls for the strength of the rural labour market in the municipality (the rural employment rate in the municipality and the mean male monthly earnings in rural areas) in these specifications. This means that the greater effects found for younger than for older women are systematic across municipalities with diverse labour market situations.

6 Conclusions

This paper models the effect of household electrification on labour supply decisions in the household, in a context in which home production time is initially constrained to daylight hours. We provide a theoretical reasoning why households might switch away from firewood collection when they obtain electric light. We find a strong positive association in rural areas between having electricity and working for a salary, conditional on an extensive array of observable characteristics. There is a strong negative association between electricity in the household and time spent in family agricultural activities or in firewood collection. The causal effects of having electricity on men's and women's employment propensities are then examined using plausibly-exogenous variation in the cost of extending the electric grid in Nicaragua from urban to rural areas. Consistent with our model, it is found that household electrification causes rural women to be about 23% more likely to work outside the home, but that there are no such effects for men. These impacts are concentrated amongst women under 35.

The fact that our findings regarding employment broadly concur with Dinkleman (2011) for KwaZulu-Natal, South Africa is perhaps surprising. In KwaZulu-Natal, households are far more likely to have cooking appliances and refrigerators, and to cook with electricity than in Nicaragua. One difference in findings is that Dinkleman observes female employment effects to be concentrated amongst women older than 30, whereas we find these effects to be concentrated amongst younger women. This difference may be attributable to differences in the physical demands of available non-agricultural jobs in rural Nicaragua versus in KwaZulu-Natal. Still, both studies provide support for our model. The fact that both the Nicaraguan individual level data, and KwaZulu-Natal community level data show similar employment effects for men and women, respectively, suggest that household electrification significantly changes household resource allocation. Whereas a simple Gronau (1977) model would predict that women substitute out of market work when home production becomes more efficient, our model explains why this low-cost innovation could result in women working more.

Although most households have few labour-saving appliances in Nicaragua, it is apparent that just having electricity for light is enough to induce major changes in intrahousehold resource allocation. Cooking with gas takes uses less time than the main alternative, burning self-collected firewood, but requires more money. Thus, the provision of electric light to households appears to make it more likely that households become monetised, in the sense of both having women earning money outside the home and buying, rather than gathering, cooking fuel. Electricity, even if not accompanied by vacuum cleaners, dishwashers and washing machines, impacts intrahousehold resource allocation in ways that are positive for female employment. Although electricity has historically been provided by burning oil in Nicaragua, the recent advent of geothermal electric plants suggest that rural electrification might reduce deforestation without causing other environmental damage.

Notes

[1]Lenin's address continued "…. We must show the peasants that the organization of industry on the basis of modern, advanced technology, on electrification which will provide a link between town and country, will put an end to the division between town and country, will make it possible to raise the level of culture in the countryside and to overcome, even in the most remote corners of land, backwardness, ignorance, poverty, disease, and barbarism." (Lenin (1965))

[2]For recent policy papers examining the potential role of new technologies in expanding access to electricity, see Peter Lorenz and Dickon Pinner and Thomas Seitz (2008), World Health Organisation (WHO) and United Nations Development Program (2009), and World Bank (2010). For recent case studies of solar cell use, see Peter Fairley (2009) and Burney, Woltering, Burke, Naylor, and Pasternak (2010).

[3]Off-grid electricity, from solar panels, batteries, and generators, was used as a main source of artificial light by less than 2% of Nicaraguan households in 2005.

[4]Because power generation was still insufficient to meet demand in the early 2000s, rolling blackouts of 6 to 8 hours were common in Nicaragua (Herrera (2005)). The privatization of power generation in the 1990s has been widely criticized because of its' failure to increase capacity, the high tariffs subsequently faced by consumers, and the failure of private companies to further extend the grid to unconnected households (McKenzie, Mookherjee, Castaneda, and Saavedra (2003)). While Nicaragua is known to have great potential to exploit geothermal energy, and thus to eliminate dependence on imported oil-burning plants, geothermal capacity has also been very slow to expand.

[5]Note that, for simplicity, we have not included the fixed cost of connecting to the electric grid, or monthly costs, in BB. Clearly these costs do impact the choice between AA and BB, but we wish to isolate here the impact of the extension of the working day on market work choices. For this reason we have also depicted BB as not causing great improvements in productivity in the home.

[6]See, for example, Miranda (1999) and Alberts, Moreira, and Pérez (1997).

[7]For background information on the relationship between firewood use for cooking and health outcomes, see, for example, Rodríguez and Romano-Riquer (2007), Ezzati and Kammen (2001), and Ezzati and Kammen (2002).

[8]More information on LSMS surveys, their questionnaires, and data can be found on the World Bank website, *www.worldbank.org/lsms*. Recent examples of work employing the LSMS data from Nicaragua include Grosh and Glewwe (1998), Pradhan and Rawlings (2002), Deininger, Zegarra, and Lavandez (2003), and Heltberg (2004).

[9]Perhaps the greatest historical example of electrification is that of the Soviet Union from the 1920s. Within thirty years, and at huge cost, nearly every person in the Soviet Union had obtained access to electricity. An opera memorialising this feat, *The Electrification of the Soviet Union*, by Nigel Osborne, premiered in 1987. Because all Former Soviet Union countries still have nearly universal community and household electrification, and it is of similar vintage, it would very difficult to identify electrification effects in these countries using either historical or current household survey data.

[10]The IPUMS archive contains publicly available data, samples of censuses from many countries. It is available without cost at: *https://international.ipums.org/international/*. The Nicaraguan censuses will also be made available by IPUMS, in June 2012.

[11]For two municipalities, Santa Teresa in Carazo county, and Mulukuku(RAAN), we were unable to calculate mean slope.

[12]Municipal-level information is available on the website *http://www.inifom.gob.ni/municipios/*.

[13]Duflo and Pande (2007) use the interaction between the mean slope gradient of land in Indian states and the number of power plants in the state to predict the presence of irrigation dams.

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Table 1: Socioeconomic characteristics of individuals in households with and without electricity, Nicaragua 2005

	Women:			**Men:**		
	no elec	elec. in hhld	P-value	no elec	elec. in hhld	P-value
Works outside home	0.2740	0.4137	0.0000	0.9745	0.9267	0.0000
	(0.010)	(0.013)		(0.003)	(0.007)	
Age	33.5801	33.8926	0.3578	32.6976	33.4179	0.0385
	(0.206)	(0.275)		(0.203)	(0.288)	
Has primary ed.	0.1927	0.4565	0.0000	0.2000	0.4332	0.000
	(0.008)	(0.014)		(0.008)	(0.014)	
married	0.7210	0.6194	0.0000	0.5909	0.5306	0.0005
	(0.010)	(0.013)		(0.010)	(0.014)	
born in muni (local)	0.6430	0.7372	0.0000	0.6657	0.7391	0.0000
	(0.010)	(0.012)		(0.010)	(0.012)	
Hhld distance from highway (km)	7.1271	3.3131	0.0000	7.1054	3.3293	0.0000
	(0.178)	(0.133)		(0.163)	(0.131)	
Hhld has piped water	0.0179	0.1359	0.0000	0.0186	0.1151	0.0000
	(0.003)	(0.009)		(0.003)	(0.009)	
Hhld has garbage service	0.0000	0.0315	0.0000	0.0000	0.0290	0.0000
	-	(0.005)		(0.000)	(0.005)	
Hhld has dirt floor	0.6746	0.4872	0.0000	0.6873	0.5105	0.0000
	(0.010)	(0.014)		(0.010)	(0.014)	
mean urban electrification rate in muni.	0.5739	0.7443	0.0000	0.5728	0.7340	0.0000
	(0.009)	(0.011)		(0.009)	(0.011)	

Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. P-values refer to tests of equality of means of the preceeding two columns.

Table 2: Socioeconomic characteristics of individuals in households with and without electricity, Nicaragua 2005

	Panel A: Minutes spent in activity, previous day						**Panel B: Prob. spent time in activity, previous day**					
	Women:			**Men:**			**Women:**			**Men:**		
Activity	no elec	hhld elec	P-value	no elec	hhld elec	P-value	no elec	hhld elec	P-value	no elec	hhld elec	P-value
Family agri.	22.2706	3.6585	0.0014	270.1574	128.3062	0.0000	0.5484	0.5396	0.7129	0.7899	0.6672	0.0000
	(3.859)	(2.080)		(9.732)	(13.396)		(0.014)	(0.020)		(0.011)	(0.019)	
Family non-agri.	23.3693	53.1676	0.0007	22.5014	44.9232	0.0092	0.5484	0.5886	0.0947	0.5271	0.5796	0.0287
	(4.195)	(9.066)		(4.048)	(9.105)		(0.014)	(0.020)		(0.014)	(0.020)	
salaried work	30.7212	89.8022	0.0000	116.4658	249.7030	0.0000	0.5492	0.6108	0.0102	0.6149	0.7500	0.0000
	(5.089)	(12.286)		(8.664)	(17.199)		(0.014)	(0.019)		(0.013)	(0.017)	
Non-salaried work	8.1307	15.0771	0.1333	15.1348	12.3292	0.6182	0.5347	0.5554	0.3918	0.5227	0.5525	0.2148
	(2.226)	(4.802)		(3.124)	(4.553)		(0.014)	(0.020)		(0.014)	(0.020)	
looking for work	2.8761	0.4154	0.1394	2.3516	6.8139	0.0844	0.5263	0.5332	0.7751	0.5081	0.5478	0.0992
	(1.126)	(0.405)		(0.986)	(3.208)		(0.014)	(0.020)		(0.014)	(0.020)	
cooking	148.0604	112.6372	0.0000	4.6414	7.3289	0.1626	0.9306	0.9019	0.0278	0.5234	0.5685	0.0610
	(4.092)	(5.057)		(1.024)	(1.708)		(0.007)	(0.012)		(0.014)	(0.020)	
cleaning	135.0525	129.2858	0.4059	7.0713	8.7239	0.5125	0.9252	0.9035	0.1011	0.5315	0.5780	0.0525
	(3.706)	(6.344)		(1.440)	(1.886)		(0.007)	(0.012)		(0.014)	(0.020)	
repairing	10.3990	11.0899	0.8028	33.8515	21.3999	0.0205	0.5759	0.5870	0.6417	0.6201	0.6210	0.9673
	(1.577)	(2.246)		(3.245)	(3.132)		(0.014)	(0.020)		(0.013)	(0.019)	
getting water	38.2168	20.3447	0.0000	14.5220	11.2114	0.1743	0.7605	0.6804	0.0002	0.6032	0.5971	0.7966
	(1.980)	(2.238)		(1.345)	(1.996)		(0.012)	(0.019)		(0.013)	(0.020)	
getting firewood	11.5930	5.7864	0.0103	31.8005	14.0979	0.0000	0.5873	0.5601	0.2554	0.6676	0.6019	0.0043
	(1.369)	(1.545)		(2.149)	(2.289)		(0.014)	(0.020)		(0.013)	(0.020)	
shopping	14.8893	19.1122	0.2406	10.9738	8.9265	0.5390	0.5812	0.6519	0.0028	0.5432	0.5860	0.0740
	(2.136)	(2.625)		(2.012)	(1.962)		(0.014)	(0.019)		(0.013)	(0.020)	
taking care of kids	81.1759	58.6955	0.0054	8.6175	10.8339	0.4144	0.7361	0.7041	0.1392	0.5381	0.5780	0.0958
	(4.739)	(6.062)		(1.436)	(2.442)		(0.012)	(0.018)		(0.013)	(0.020)	
taking care of sick	5.9014	6.8339	0.7772	1.7036	2.0717	0.8423	0.5362	0.5506	0.5509	0.5073	0.5446	0.1220
	(1.981)	(2.312)		(1.101)	(1.171)		(0.014)	(0.020)		(0.014)	(0.020)	
eating	52.4634	46.8311	0.0185	50.8041	47.0310	0.1921	0.9969	1.0000	0.1647	0.9993	0.9968	0.1895
	(1.527)	(1.259)		(1.572)	(2.458)		(0.002)	(0.000)		(0.001)	(0.002)	
sleeping	532.1274	509.6655	0.0004	528.5965	501.9072	0.0000	0.9985	1.0000	0.3261	0.9993	1.0000	0.4979
	(3.612)	(4.953)		(3.325)	(5.641)		(0.001)	(0.000)		(0.001)	(0.000)	
recreation	208.0171	219.7475	0.3149	212.7034	239.2858		0.9443	0.9573	0.2260	0.9575	0.9713	0.1351
	(6.512)	(9.893)		(6.133)	(10.025)	(0.020)	(0.006)	(0.008)		(0.005)	(0.007)	

Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. P-values refer to tests of equality of means of the preceeding two columns.

Table 3: Electrification and time use in rural Nicaragua, 1998

Dependent variable: Minutes spent in activity
Tobit regression. Marginal effects at $\bar{X}$ reported.

	Women:					**Men:**			
	family agri.	family non-agri.	salaried work	cooking	firewood collection	family agri.	family non-agri.	salaried work	cooking
hhld uses electric light	-317.5151**	67.5545**	241.6888*	-7.3748	-44.6822**	-175.0531**	201.8934	313.5675**	-1.6154
	(143.152)	(25.730)	(129.052)	(8.805)	(20.503)	(54.001)	(135.476)	(66.750)	(42.466)
primary ed completed	-238.1340	65.1060**	232.9902*	-26.1655**	-57.9812**	-94.8905**	58.4955	49.4889	-63.0430
	(156.370)	(25.765)	(130.029)	(10.860)	(27.206)	(40.549)	(142.875)	(64.151)	(43.081)
married, common law	-124.7811	27.6796	-322.2376**	32.5958**	-40.7993**	54.7131	30.3488	75.8643	-18.7924
	(119.823)	(28.183)	(128.173)	(10.544)	(19.185)	(36.519)	(146.547)	(65.332)	(33.652)
born here	133.1955	104.8152**	-53.7395	-23.5808**	73.9161**	57.0488	138.1058	-157.1690**	-2.7843
	(166.589)	(31.733)	(126.682)	(11.829)	(32.262)	(47.938)	(215.415)	(71.814)	(51.921)
hhld kids <3	-132.2073*	67.4891**	-56.8677	-9.4092**	11.1931	-18.5079	32.8768	31.0981	-16.5499
	(78.907)	(15.247)	(75.581)	(4.767)	(10.457)	(22.889)	(76.177)	(36.344)	(21.713)
hhld kids ≥ 3, <6	0.9195	17.0871	-111.9549	10.1991	-6.6575	29.9866	74.1190	-6.8342	-4.3415
	(73.913)	(15.174)	(72.276)	(9.428)	(10.099)	(18.582)	(63.633)	(31.366)	(24.098)
hhld kids ≥ 6, <12	111.3951**	-76.1841**	106.5914**	4.0961	-21.9415**	14.6629	89.6972*	-38.2122	-17.3489
	(33.627)	(13.300)	(42.403)	(3.497)	(7.485)	(15.573)	(53.342)	(26.872)	(14.289)
hhld kids ≥ 12, <18	-58.7157	6.0096	14.6346	-6.8110**	-16.4749**	38.0868**	-175.5728**	-22.8268	-32.0109**
	(48.462)	(10.796)	(44.176)	(3.213)	(8.217)	(15.181)	(48.183)	(25.975)	(14.339)
% rural pop. in muni	35.0422	-235.6132**	103.3715	-8.2250	-95.8717**	-12.3283	-111.4851	-131.3560	-39.0481
	(264.631)	(38.771)	(235.401)	(16.143)	(39.129)	(69.129)	(205.094)	(101.569)	(54.581)
hhld km primary school	16.4342*	-74.5552**	-35.1499*	0.2551	-0.5738	3.9397	-93.1493**	-18.3271**	3.9418
	(9.027)	(7.037)	(21.103)	(1.101)	(2.023)	(3.691)	(39.504)	(7.571)	(4.775)
hhld has piped water	-296.5534	210.5251**	161.0162	0.6388	3.5250	59.2231	-90.9965	-84.1814	-52.3787
	(187.732)	(27.568)	(136.937)	(9.636)	(27.699)	(62.605)	(156.708)	(75.104)	(35.159)
hhld has dirt floor	-71.5898	79.2667**	-33.6698	-11.5162	8.1597	68.1818	-5.6898	79.2065	-57.4088**
	(131.239)	(28.052)	(111.305)	(7.965)	(16.224)	(43.003)	(131.589)	(60.366)	(28.499)
mean earnings rural men	84.5119	89.2038**	352.4559**	-13.0026	-37.5969*				
	(165.783)	(23.800)	(139.663)	(10.475)	(20.788)				
mean male rural emp.	1739.4291	-59.3146	160.4371	169.2030**	-106.7109				
	(1076.748)	(38.115)	(1061.554)	(77.940)	(175.014)				
F-stat	10.01	9.58	6.60	8.17	4.57	11.11	4.42	6.47	8.91
No. obs.	922	922	922	922	922	967	967	967	967

Source: Nicaragua EMNV 1998. Individuals aged 20-55 included. County (departamento) fixed effects are included in all specifications, as are 5-year age cohort dummies. Standard errors are clustered at the municipality level. Note that this is not an exhaustive list of activity categories, and also that some of these activities may have taken place concurrently, according to the EMNV questionnaire structure.

Table 4: Electrification and work in rural Nicaragua

Dummy dependent variable: individual is currently working
Marginal effects at $\bar{X}$ reported.

	Women		**Men**	
	Probit	**Bivariate Probit**	**Probit**	**Bivariate Probit**
hhld uses electric light	0.0727**	0.2328**	-0.0203**	-0.0455
	(0.022)	(0.087)	(0.009)	(0.041)
completed primary ed.	0.1030**	0.0808**	-0.0220**	-0.0194*
	(0.022)	(0.029)	(0.010)	(0.011)
married, common law	-0.0845**	-0.0759**	0.0381**	0.0360**
	(0.022)	(0.023)	(0.010)	(0.010)
local	0.0389**	0.0469**	0.0152*	0.0160*
	(0.019)	(0.019)	(0.009)	(0.009)
hhld kids <3	-0.0288**	-0.0304**	0.0068	0.0068
	(0.011)	(0.011)	(0.005)	(0.005)
hhld kids ≥3, <6	-0.0071	-0.0023	0.0028	0.0032
	(0.013)	(0.012)	(0.005)	(0.005)
hhld kids ≥6<18	-0.0017	-0.0004	-0.0026	-0.0028*
	(0.005)	(0.005)	(0.002)	(0.002)
% urban	0.0232	0.0098	-0.0315*	-0.0256
	(0.039)	(0.036)	(0.019)	(0.017)
hhld. km to highway	-0.0019	-0.0006	0.0004	0.0002
	(0.001)	(0.002)	(0.001)	(0.001)
hhld has own water pipe	0.0157	-0.0315	-0.0342	-0.0229
	(0.043)	(0.058)	(0.023)	(0.025)
hhld garbage collection	0.2066**	0.1807**	0.0930**	0.0984**
	(0.058)	(0.058)	(0.020)	(0.024)
hhld dirt floor	-0.0254	-0.0015	0.0128	0.0101
	(0.020)	(0.028)	(0.008)	(0.009)
mean earnings rural men muni	0.1133**	0.0861**		
	(0.033)	(0.036)		
mean male rural emp. muni	0.0947	0.1114		
	(0.267)	(0.253)		
Pseudo-R^2	0.07	0.05	0.04	0.04
F-stat	11.92	11.71	7.26	7.14
F-stat instruments		13.56		14.73
P-value J-test (OVERID)		0.7109		0.6441
Observed prob ($\bar{Y}$)	0.33	0.33	0.96	0.96
No. obs.	3380	3340	3431	3389

Source: Nicaragua LSMS 2005. Individuals aged 20-55 included. Bivariate probit specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and the log of 1971 population density in the municipality, as instruments. County (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level.

Table 5: Electrification and work by age group

Dummy dependent variable: individual is currently working
Marginal effects at $\bar{X}$ reported.

	Women				Men			
	age≤ 35		age>35		age≤ 35		age>35	
	Probit	Bivariate Probit	Probit	Bivariate Probit	Probit	Bivariate Probit	Probit	Bivariate Probit
Specification:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
hhld uses electric light	0.0540*	0.2838**	0.0848**	0.1257	-0.0288**	-0.1115	-0.0081	0.0848
	(0.029)	(0.128)	(0.032)	(0.201)	(0.013)	(0.070)	(0.012)	(0.074)
complete primary ed.	0.0932**	0.0699**	0.1300**	0.1170**	-0.0244**	-0.0162	-0.0128	-0.0342
	(0.027)	(0.031)	(0.039)	(0.059)	(0.012)	(0.014)	(0.014)	(0.022)
married, common law	-0.0910**	-0.0697**	-0.0797*	-0.0816*	0.0411**	0.0387**	0.0352*	0.0286
	(0.025)	(0.027)	(0.044)	(0.043)	(0.011)	(0.011)	(0.020)	(0.019)
local	0.0412*	0.0482**	0.0337	0.0398	0.0333**	0.0360**	-0.0106	-0.0088
	(0.023)	(0.024)	(0.031)	(0.032)	(0.013)	(0.014)	(0.010)	(0.011)
hhld kids <3	-0.0491**	-0.0510**	0.0147	0.0141	0.0091	0.0088	0.0057	0.0053
	(0.016)	(0.016)	(0.019)	(0.019)	(0.007)	(0.007)	(0.006)	(0.006)
hhld kids ≥3, <6	0.0046	0.0119	-0.0337*	-0.0295	0.0009	0.0006	0.0052	0.0091
	(0.015)	(0.015)	(0.019)	(0.018)	(0.006)	(0.006)	(0.006)	(0.006)
hhld kids ≥6<18	-0.0008	0.0014	-0.0031	-0.0027	-0.0019	-0.0014	-0.0034	-0.0029
	(0.006)	(0.006)	(0.009)	(0.009)	(0.003)	(0.003)	(0.002)	(0.002)
% urban	-0.0508	-0.0659	0.1252**	0.1238**	-0.0492*	-0.0357	0.0020	-0.0224
	(0.047)	(0.043)	(0.054)	(0.059)	(0.029)	(0.028)	(0.018)	(0.019)
hhld. km to highway	-0.0007	0.0009	-0.0036	-0.0032	-0.0002	-0.0008	0.0013**	0.0020**
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
hhld has own water pipe	-0.0083	-0.0714	0.0518	0.0350	-0.0531	-0.0331	-0.0113	-0.0143
	(0.050)	(0.065)	(0.057)	(0.079)	(0.037)	(0.040)	(0.025)	(0.024)
hhld has garbage collection	0.3764**	0.3195**	-0.0192	-0.0115	0.1007**	0.1330**	0.0793**	0.0649**
	(0.091)	(0.071)	(0.148)	(0.147)	(0.029)	(0.042)	(0.032)	(0.029)
hhld has dirt floor	-0.0268	0.0035	-0.0303	-0.0208	0.0186	0.0087	0.0024	0.0119
	(0.022)	(0.027)	(0.036)	(0.047)	(0.012)	(0.015)	(0.009)	(0.012)
mean earnings rural men muni	0.1875**	0.1341**	0.0086	0.0020				
	(0.036)	(0.047)	(0.047)	(0.043)				
mean male rural emp. muni	0.1617	0.1964	-0.0226	-0.0345				
	(0.258)	(0.264)	(0.422)	(0.405)				
Pseudo-R^2	0.08	0.04	0.05	0.05	0.05	0.03	0.01	-0.03
F-stat	11.60	14.26	6.06	5.81	3.90	3.96	2.27	2.41
F-stat instruments		10.39		14.48		14.95		10.45
P-value J-test (OVERID)		0.5281		0.8822		0.5503		0.5041
Observed prob ($\bar{Y}$)	0.31	0.31	0.35	0.35	0.95	0.95	0.97	0.97
No. obs.	2036	2010	1344	1330	2161	2135	1270	1254

Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. Bivariate probit specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and the log of 1971 population density in the municipality as instruments. County (departamento) fixed effects are included in all specifications, as are 5 year age dummies. Standard errors are clustered at the municipality level.

Data Appendix A

Table 6: Firststage regressions for electrification and work in rural Nicaragua

Dummy dependent variable: Individual has electric light in hhld **Probit marginal effects at $\bar{X}$ reported.**						
	Women:			**Men:**		
	All	**age $\leq$ 35**	**age >35**	**All**	**$\leq$age 35**	**age >35**
mean slope of land in muni.	**-0.0096****	**-0.0088****	**-0.0107****	**-0.0106****	**-0.0118****	**-0.0087****
	(0.003)	**(0.004)**	**(0.004)**	**(0.003)**	**(0.003)**	**(0.004)**
ln(muni. population density in 1971)	**0.1028****	**0.1039****	**0.0945****	**0.1037****	**0.1072****	**0.0957****
	(0.022)	**(0.024)**	**(0.022)**	**(0.022)**	**(0.024)**	**(0.022)**
complete primary ed.	0.1281**	0.1037**	0.1884**	0.1300**	0.1018**	0.2013**
	(0.023)	(0.027)	(0.039)	(0.023)	(0.027)	(0.036)
married, common law	-0.0415**	-0.0738**	0.0404	-0.0226	-0.0315	0.0143
	(0.020)	(0.026)	(0.032)	(0.019)	(0.022)	(0.035)
local	-0.0088	-0.0016	-0.0225	-0.0082	0.0036	-0.0305
	(0.022)	(0.028)	(0.028)	(0.020)	(0.023)	(0.030)
hhld kids <3	-0.0014	-0.0009	-0.0045	-0.0044	-0.0060	0.0001
	(0.015)	(0.016)	(0.019)	(0.016)	(0.017)	(0.021)
hhld kids $\geq$3, <6	-0.0058	-0.0163	0.0092	-0.0094	-0.0030	-0.0252*
	(0.011)	(0.012)	(0.015)	(0.013)	(0.018)	(0.015)
hhld kids $\geq$6<18	-0.0031	-0.0037	-0.0069	0.0023	0.0069	-0.0067
	(0.006)	(0.007)	(0.007)	(0.006)	(0.008)	(0.007)
% urban in muni	-0.0069	-0.0383	0.0520	0.0151	-0.0516	0.1159*
	(0.062)	(0.077)	(0.063)	(0.063)	(0.070)	(0.064)
hhld. km to highway	-0.0055**	-0.0047**	-0.0062**	-0.0065**	-0.0066**	-0.0064**
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
hhld has own water pipe	0.2606**	0.2521**	0.2675**	0.2177**	0.2340**	0.1851**
	(0.049)	(0.047)	(0.073)	(0.054)	(0.066)	(0.053)
hhld garbage collection	0.2056*	0.2865**	0.0391	0.2719*	0.3893**	0.0867
	(0.122)	(0.135)	(0.113)	(0.146)	(0.174)	(0.118)
hhld dirt floor	-0.1525**	-0.1446**	-0.1574**	-0.1357**	-0.1419**	-0.1285**
	(0.024)	(0.026)	(0.030)	(0.023)	(0.028)	(0.026)
mean earnings rural men muni	0.1371**	0.2054**	0.0459			
	(0.063)	(0.074)	(0.058)			
mean male rural emp. muni	-0.1248	-0.1216	-0.1126			
	(0.380)	(0.407)	(0.402)			
Pseudo-R^2	0.36	0.37	0.35	0.34	0.33	0.35
F-stat	32.63	33.13	24.72	22.63	21.43	30.81
No. obs.	3340	2010	1330	3389	2135	1254

Source: Nicaragua EMNV/LSMS 2005. Individuals aged 20-55 included. County (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level. Values in bold refer to the instrumental variables.

Table 7: Robustness check: Electrification and work in rural Nicaragua, with extensive municipal means as controls

Dummy dependent variable: individual is currently working
Marginal effects at $\bar{X}$ reported.

	Women		Men	
	Probit	**Bivariate Probit**	**Probit**	**Bivariate Probit**
hhld uses electric light	0.0724**	0.2453*	-0.0212**	-0.0550
	(0.022)	(0.151)	(0.009)	(0.050)
complete primary ed.	0.0987**	0.0758**	-0.0205**	-0.0168
	(0.022)	(0.031)	(0.010)	(0.012)
married, common law	-0.0834**	-0.0753**	0.0382**	0.0360**
	(0.022)	(0.023)	(0.010)	(0.010)
local	0.0381*	0.0447**	0.0163*	0.0171*
	(0.019)	(0.019)	(0.009)	(0.009)
% urban in muni	-0.0731	-0.0747	-0.0050	0.0011
	(0.049)	(0.053)	(0.020)	(0.020)
hhld km to highway	-0.0014	-0.0000	0.0002	-0.0000
	(0.001)	(0.002)	(0.001)	(0.001)
hhld has own water pipe	0.0167	-0.0333	-0.0347	-0.0214
	(0.044)	(0.066)	(0.024)	(0.025)
hhld garbage collection	0.1535	0.0881	0.1001**	0.1148**
	(0.110)	(0.120)	(0.018)	(0.029)
hhld dirt floor	-0.0103	0.0200	0.0058	0.0013
	(0.019)	(0.031)	(0.008)	(0.010)
mean earnings rural men muni	0.1042**	0.0748		
	(0.040)	(0.048)		
mean male rural emp. muni	0.2789	0.2874		
	(0.275)	(0.257)		
mean urban depa elechh rate now	-0.0267	-0.0503	0.0046	0.0072
	(0.039)	(0.042)	(0.013)	(0.015)
fr. rural dirt floor house in muni.	-0.1095**	-0.1217**	0.0436**	0.0466**
	(0.050)	(0.049)	(0.019)	(0.021)
fr. rural w. garbage service in muni.	0.0587	0.1640	-0.0032	-0.0263
	(0.147)	(0.169)	(0.063)	(0.068)
mean urban female emp. rate in muni.	0.4631**	0.4479**	-0.0714	-0.0719
	(0.188)	(0.184)	(0.061)	(0.064)
Pseudo-R^2	0.07	0.05	0.04	0.04
F-stat	13.81	11.08	6.81	6.54
No. obs.	3380	3340	3431	3389

Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. Bivariate probit specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and 1971 population density in the municipality, as instruments. As well, 5-year age cohort dummies and controls for numbers of children under 3, 3-5, and 6-18 are included. County (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level.

Table 8: Robustness Check for Women: Electrification and work in rural Nicaragua with various controls omitted

Dummy dependent variable: individual is currently working
Marginal effects at $\bar{X}$ reported.

	Probit	**Bivariate Probit**	**Probit**	**Bivariate Probit**	**Probit**	**Bivariate Probit**	**Probit**	**Bivariate Probit**
hhld uses electric light	0.0768**	0.2459*	0.0896**	0.1746**	0.0945**	0.1789**	0.1397**	0.2428**
	(0.022)	(0.131)	(0.023)	(0.071)	(0.023)	(0.065)	(0.023)	(0.062)
complete primary ed.	0.1076**	0.0820**	0.1206**	0.0933**	0.1231**	0.0944**		
	(0.021)	(0.030)	(0.020)	(0.028)	(0.019)	(0.027)		
married, common law	-0.0792**	-0.0717**	-0.0836**	-0.0765**	-0.0791**	-0.0727**		
	(0.021)	(0.022)	(0.021)	(0.022)	(0.021)	(0.022)		
local	0.0336*	0.0403**	0.0513**	0.0504**	0.0480**	0.0456**		
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)		
hhld kids <3	-0.0266**	-0.0278**	-0.0239*	-0.0252*				
	(0.011)	(0.011)	(0.013)	(0.013)				
hhld kids ≥3, <6	-0.0076	-0.0023	-0.0100	-0.0035				
	(0.012)	(0.011)	(0.012)	(0.012)				
hhld kids ≥6<18	-0.0006	0.0005	-0.0025	-0.0003				
	(0.004)	(0.004)	(0.005)	(0.005)				
hhld km to highway	-0.0024*	-0.0009						
	(0.001)	(0.002)						
hhld has own water pipe	0.0002	-0.0423						
	(0.041)	(0.055)						
hhld garbage collection	0.1472**	0.1406**						
	(0.044)	(0.046)						
hhld dirt floor	-0.0249	0.0011						
	(0.019)	(0.028)						
Pseudo-R^2	0.06	0.04	0.05	0.05	0.05	0.04	0.02	0.01
F-stat	13.16	12.62	14.78	14.51	14.84	14.16	35.70	15.00
No. obs.	3735	3683	3511	3460	3735	3683	3511	3460

Source: Nicaragua EMNV 2005. Women aged 20-55 included. Bivariate probit specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and 1971 population density in the municipality as instruments. County (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level.

Table 9: Robustness check: Electrification and work in rural Nicaragua, with extensive municipal means as controls

MAIN OUTCOME: individual is currently working (Table 7) Firststage regression explaining hhld electrification status Marginal effects at $\bar{X}$ reported.		
	Women:	Men:
mean slope of land in muni	**-0.0092****	**-0.0101****
	(0.004)	**(0.004)**
pop. density in muni. 1971	**0.0988****	**0.1046****
	(0.029)	**(0.029)**
complete primary ed.	0.1255**	0.1275**
	(0.022)	(0.022)
married, common law	-0.0376**	-0.0180
	(0.019)	(0.018)
local	-0.0094	-0.0048
	(0.021)	(0.020)
% urban	-0.0006	0.0425
	(0.092)	(0.088)
hhld. km to highway	-0.0058**	-0.0067**
	(0.002)	(0.002)
hhld has own water pipe	0.2632**	0.2216**
	(0.049)	(0.055)
hhld garbage collection	0.3993**	0.4423**
	(0.075)	(0.112)
hhld dirt floor	-0.1531**	-0.1450**
	(0.021)	(0.020)
mean earnings rural men muni	0.1458**	0.1341**
	(0.068)	(0.062)
mean male rural emp. muni	-0.0602	0.0244
	(0.427)	(0.423)
mean urban depa elechh rate now	0.0925	0.0808
	(0.062)	(0.058)
fr. urban dirt floor house in muni.	-0.0335	0.0102
	(0.106)	(0.113)
fr. urban w. garbage service in muni.	-0.5655**	-0.5639*
	(0.198)	(0.290)
mean urban female emp. rate in muni.	-0.2302	-0.3441
	(0.287)	(0.281)
Pseudo-R^2	0.36	0.34
J-stat (OVERID)	0.1241	0.6551
F-stat	42.94	33.67
No. obs.	3340	3389

In all specifications, the dependent variable is a dummy taking the value 1 if the household has electricity, zero otherwise. Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. These specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and 1971 population density in the municipality, as instruments. As well, 5-year age cohort dummies and controls for numbers of children under 3, 3-5, and 6-18 are included. County (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level.

Table 10: Firststage regression for robustness check for women: Electrification and work in rural Nicaragua with various controls omitted

Dummy dependent variable in main specification: individual is currently working (Table 8)				
Dependent variable is probability that household has electricity				
Specification:	(1)	(2)	(3)	(4)
mean slope in muni.	**-0.0107****	**-0.0141****	**-0.0141****	**-0.0153****
	(0.003)	**(0.003)**	**(0.003)**	**(0.003)**
population density muni. 1971	**0.0969****	**0.1703****	**0.1735****	**0.1934****
	(0.023)	**(0.014)**	**(0.013)**	**(0.014)**
complete primary ed.	0.1305**	0.2145**	0.2201**	
	(0.022)	(0.027)	(0.026)	
married, common law	-0.0399**	-0.0482**	-0.0464**	
	(0.019)	(0.021)	(0.022)	
local	-0.0154	0.0282	0.0295	
	(0.021)	(0.026)	(0.025)	
hhld kids <3	-0.0011	-0.0032		
	(0.014)	(0.014)		
hhld kids ≥ 3, <6	-0.0042	-0.0145		
	(0.011)	(0.013)		
hhld kids $\geq 6 < 18$	-0.0033	-0.0111*		
	(0.006)	(0.006)		
hhld. km to highway	-0.0061**			
	(0.002)			
hhld has own water pipe	0.2388**			
	(0.046)			
hhld garbage collection	0.1072			
	(0.091)			
hhld dirt floor	-0.1558**			
	(0.023)			
Pseudo-R^2	0.37	0.28	0.28	0.24
F-stat	34.78	28.98	32.66	98.34
J-stat (OVERID)	0.7308	0.6741	0.8691	0.8856
No. obs.	3683	3460	3683	3460

Source: Nicaragua EMNV 2005. Women aged 20-55 included. The main bivariate probit specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and 1971 population density in the municipality as instruments. Age cohort dummies (5-year) and county (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level.

Data Appendix B: Additional robustness checks: NOT INTENDED FOR PUBLICATION.

Table 11: Robustness check: Validity of instrument

Linear IV regression estimates reported. Dependent variables:	Women:					Men:				
	complete primary	age <35	Kids < 2 in hhld	hhld has garbage pickup	hhld has piped water	complete primary	age <35	Kids < 2 in hhld	hhld has garbage pickup	hhld has piped water
hhld uses electric light	0.1473	0.0541	-0.2544	-0.0280	0.1661	0.0037	0.1168	-0.3338	-0.0138	0.1828
	(0.127)	(0.093)	(0.221)	(0.036)	(0.111)	(0.148)	(0.093)	(0.242)	(0.021)	(0.118)
married, common law	-0.1242**	-0.3225**	-0.0704**	-0.0014	0.0062	-0.0529**	-0.4738**	0.0265	0.0024	-0.0002
	(0.019)	(0.020)	(0.028)	(0.003)	(0.013)	(0.019)	(0.017)	(0.031)	(0.003)	(0.009)
local	0.0287*	0.1118**	0.0428	-0.0017	0.0116	-0.0129	0.0956**	-0.0092	-0.0061	0.0057
	(0.017)	(0.022)	(0.031)	(0.003)	(0.010)	(0.020)	(0.019)	(0.034)	(0.004)	(0.011)
hhld kids <3	-0.0420**	0.0856**		0.0073	-0.0141*	-0.0330**	0.0728**		0.0023	-0.0047
	(0.010)	(0.010)		(0.006)	(0.007)	(0.011)	(0.012)		(0.003)	(0.008)
hhld kids ≥3, <6	-0.0185*	0.0879**	0.0955**	-0.0021	-0.0095	-0.0247**	0.0600**	0.0795**	-0.0025	0.0021
	(0.010)	(0.010)	(0.030)	(0.003)	(0.006)	(0.010)	(0.013)	(0.027)	(0.002)	(0.006)
hhld kids ≥6<18	-0.0096**	-0.0453**	0.0484**	0.0007	-0.0014	-0.0089**	-0.0471**	0.0439**	0.0012	-0.0036
	(0.004)	(0.004)	(0.010)	(0.001)	(0.004)	(0.004)	(0.005)	(0.010)	(0.001)	(0.002)
% urban in muni	-0.0434	0.0131	-0.0503	0.0082	-0.0180	0.0578	0.0020	-0.0196	0.0021	-0.0202
	(0.051)	(0.031)	(0.062)	(0.013)	(0.032)	(0.064)	(0.029)	(0.084)	(0.008)	(0.028)
hhld. km to highway	-0.0022*	0.0028**	-0.0025	-0.0006	0.0006	-0.0016	0.0039**	-0.0024	-0.0004	0.0006
	(0.001)	(0.001)	(0.003)	(0.000)	(0.001)	(0.001)	(0.001)	(0.004)	(0.000)	(0.001)
hhld has own water pipe	0.0720	-0.0450	-0.0694	0.0530		0.1139**	-0.0772**	0.0173	0.0449	
	(0.051)	(0.041)	(0.075)	(0.039)		(0.052)	(0.031)	(0.094)	(0.034)	
hhld garbage collection	0.0432	-0.1200**	0.5565		0.3101*	0.2352**	0.0890	0.3126		0.3709
	(0.075)	(0.058)	(0.348)		(0.166)	(0.117)	(0.102)	(0.253)		(0.227)
hhld dirt floor	-0.1292**	0.0736**	-0.0949**	-0.0071	-0.0414**	-0.1614**	0.0783**	-0.0922*	-0.0045	-0.0369**
	(0.030)	(0.019)	(0.045)	(0.008)	(0.019)	(0.035)	(0.023)	(0.048)	(0.005)	(0.019)
mean earnings rural men muni	0.0266	0.0431	0.0155	0.0076	0.0100	0.0776*	0.0368	0.0099	0.0020	0.0036
	(0.037)	(0.037)	(0.057)	(0.008)	(0.029)	(0.047)	(0.025)	(0.052)	(0.004)	(0.026)
mean male rural emp. muni	-0.4687**	0.1740	-0.1360	0.0606	0.2760	-0.1769	0.5454**	-0.1947	0.0185	0.2107
	(0.222)	(0.226)	(0.370)	(0.098)	(0.177)	(0.306)	(0.227)	(0.435)	(0.058)	(0.158)
complete primary ed.		0.2153**	-0.0858*	0.0065	0.0116		0.1088**	-0.0407	0.0076	0.0054
		(0.022)	(0.044)	(0.005)	(0.019)		(0.021)	(0.042)	(0.005)	(0.018)
Pseudo-R^2	0.22	0.24	0.08	0.05	0.07	0.15	0.30	0.04	0.04	0.04
F-stat	42.47	92.23	18.18	1.01	3.18	21.17	104.92	8.23	0.73	3.63
No. obs.	3556	3556	3556	3556	3556	3646	3646	3646	3646	3646

Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. IV regression specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and 1971 population density in the municipality as instruments. Dummies for 5 year age group are included, as are county (departamento) fixed effects are included in all specifications. Standard errors are clustered at the municipality level.

Table 12: First stage regressions for robustness checks: further checks for validity of instrument

Linear IV regression estimates reported.	**Women:**					**Men:**				
MAIN OUTCOME:	complete primary	age <35	Kids < 2 in hhld	hhld has garbage pickup	hhld has piped water	complete primary	age <35	Kids < 2 in hhld	hhld has garbage pickup	hhld has piped water
population density in muni. 1971	0.1041**	0.1035**	0.1034**	0.1026**	0.1074**	0.1085**	0.1087**	0.1099**	0.1092**	0.1144**
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
mean slope of land in muni.	-0.0096**	-0.0090**	-0.0089**	-0.0090**	-0.0095**	-0.0098**	-0.0093**	-0.0093**	-0.0094**	-0.0095**
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
married, common law	-0.0615**	-0.0275*	-0.0444**	-0.0445**	-0.0447**	-0.0231	0.0034	-0.0165	-0.0158	-0.0171
	(0.020)	(0.016)	(0.020)	(0.020)	(0.020)	(0.018)	(0.015)	(0.018)	(0.018)	(0.019)
local	-0.0054	-0.0136	-0.0085	-0.0089	-0.0060	-0.0069	-0.0100	-0.0049	-0.0064	-0.0038
	(0.021)	(0.020)	(0.021)	(0.021)	(0.022)	(0.020)	(0.019)	(0.020)	(0.019)	(0.020)
hhld kids <3	-0.0063	-0.0050		0.0007	-0.0045	-0.0066	-0.0044		-0.0017	-0.0033
	(0.014)	(0.014)		(0.014)	(0.014)	(0.015)	(0.015)		(0.015)	(0.015)
hhld kids ≥3, <6	-0.0095	-0.0126	-0.0069	-0.0072	-0.0096	-0.0113	-0.0099	-0.0083	-0.0087	-0.0080
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)
hhld kids ≥6<18	-0.0054	-0.0032	-0.0041	-0.0039	-0.0046	0.0016	0.0036	0.0027	0.0030	0.0021
	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
% urban	0.0165	0.0222	0.0243	0.0252	0.0197	0.0249	0.0221	0.0206	0.0204	0.0176
	(0.068)	(0.065)	(0.064)	(0.065)	(0.065)	(0.069)	(0.065)	(0.065)	(0.065)	(0.065)
hhld. km to highway	-0.0060**	-0.0058**	-0.0056**	-0.0057**	-0.0057**	-0.0067**	-0.0066**	-0.0065**	-0.0066**	-0.0067**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
hhld has own water pipe	0.2632**	0.2499**	0.2492**	0.2580**		0.2228**	0.2114**	0.2084**	0.2186**	
	(0.049)	(0.049)	(0.048)	(0.047)		(0.052)	(0.052)	(0.052)	(0.051)	
hhld garbage collection	0.2034	0.2004	0.1945		0.2835**	0.2757*	0.2406*	0.2466*		0.3374**
	(0.135)	(0.131)	(0.128)		(0.093)	(0.147)	(0.139)	(0.139)		(0.099)
hhld dirt floor	-0.1759**	-0.1599**	-0.1568**	-0.1572**	-0.1741**	-0.1741**	-0.1574**	-0.1545**	-0.1550**	-0.1689**
	(0.024)	(0.024)	(0.023)	(0.023)	(0.022)	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)
mean earnings rural men muni	0.1532**	0.1509**	0.1497**	0.1498**	0.1577**	0.1553**	0.1480**	0.1488**	0.1480**	0.1559**
	(0.066)	(0.065)	(0.065)	(0.065)	(0.066)	(0.060)	(0.058)	(0.058)	(0.058)	(0.058)
mean male rural emp. muni	-0.1979	-0.1431	-0.1406	-0.1268	-0.0724	-0.0263	-0.0210	-0.0116	-0.0058	0.0316
	(0.389)	(0.378)	(0.378)	(0.379)	(0.386)	(0.416)	(0.401)	(0.400)	(0.402)	(0.403)
complete primary ed.		0.1144**	0.1284**	0.1288**	0.1368**		0.1200**	0.1260**	0.1272**	0.1320**
		(0.022)	(0.023)	(0.023)	(0.024)		(0.021)	(0.022)	(0.022)	(0.023)
Pseudo-R^2	0.35	0.36	0.36	0.36	0.34	0.33	0.34	0.34	0.34	0.33
F-stat	30.11	36.70	32.21	37.18	26.91	21.64	26.23	22.38	23.35	23.09
J-stat (OVERID)	0.0691	0.2449	0.1969	0.1929	0.5977	0.0481	0.9166	0.0544	0.2039	0.6603
No. obs.	3556	3556	3556	3556	3556	3646	3646	3646	3646	3646

In all specifications, the dependent variable is a dummy taking the value 1 if the household has electricity, zero otherwise. Source: Nicaragua EMNV 2005. Individuals aged 20-55 included. The main IV regression specifications employ the mean slope gradient in the municipality, as calculated by geographic information systems (GIS), and 1971 population density in the municipality as instruments for electricity in the household. County (departamento) fixed effects and 5-year age cohort dummies are included in all specifications. Standard errors are clustered at the municipality level.