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Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua

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Summary. — 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 labor-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, such as greater women's earnings and reduced deforestation.

Key words — electric light, time use, employment, labor-saving technology, slope gradient, population density

1. INTRODUCTION

The potential for electrification to modernize 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 labor 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 labor 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 labor 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 dramatically, 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, 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 KwaZulu-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.

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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 lengthening of the working day might impact employment propensities and time spent in firewood collection, even in the absence of labor-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 Study (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. 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 2005, 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 among 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 labor-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 labor 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, as 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 labor 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 labor 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 artificial 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 labor 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 labor 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

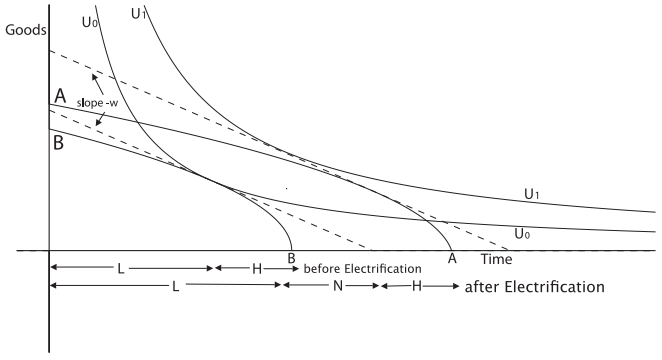

Figure 1. *Extension of working day with electrification.*