ELECTRIFICATION AND DEVELOPMENT: EMPIRICAL EVIDENCE ON THE EFFECT OF ELECTRICITY PROVISION ON HOUSEHOLD WELFARE

UJJAYANT **CHAKRAVORTY**
MARTINO **PELLI**

2022s-05
WORKING PAPER

CS

ISSN 2292-0838 (online version)

Electrification and development: Empirical evidence on the effect of electricity provision on household welfare

Ujjayant Chakravorty and Martino Pelli†*

January 2021

Abstract/Résumé

The effect of electrification on economic outcomes is a major new area of study in environment and development economics. Almost a billion people in the world do not have access to grid electricity. Providing them a grid connection will be costly and polluting as well, even if powered by cleaner fossil fuels such as natural gas, instead of coal. However, the economic benefits of electricity are not well understood. Some studies find large effects on economic development in the long run, while others find small or negligible impacts on households in the short run. These benefits may also depend on household characteristics such as credit constraints that prevent them from consuming power or investing in complimentary assets. This paper highlights the state of current knowledge on the costs and benefits of electrification by reviewing the recent empirical literature. We discuss the identification strategies employed and evaluate the effect of electrification on a variety of household-level outcomes such as income, employment and education.

L'effet de l'électrification sur les résultats économiques est un nouveau domaine d'étude majeur en économie de l'environnement et du développement. Près d'un milliard de personnes dans le monde n'ont pas accès au réseau électrique. Leur fournir un raccordement au réseau sera coûteux et polluant, même s'ils sont alimentés par des combustibles fossiles plus propres, comme le gaz naturel, au lieu du charbon. Cependant, les avantages économiques de l'électricité ne sont pas bien compris. Certaines études font état d'effets importants sur le développement économique à long terme, tandis que d'autres constatent des impacts faibles ou négligeables sur les ménages à court terme. Ces avantages peuvent également dépendre des caractéristiques des ménages, telles que les contraintes de crédit qui les empêchent de consommer de l'électricité ou d'investir dans des actifs complémentaires. Ce document met en lumière l'état des connaissances actuelles sur les coûts et les avantages de l'électrification en passant en revue la littérature empirique récente. Nous discutons des stratégies d'identification utilisées et évaluons l'effet de l'électrification sur une variété de résultats au niveau des ménages tels que le revenu, l'emploi et l'éducation.

Keywords/Mots-clés: electricity provision, economic impacts, grid connection, energy access, infrastructure / fourniture d'électricité, impacts économiques, connexion au réseau, accès à l'énergie, infrastructure

Pour citer ce document / To quote this document

Chakravorty, U. and Pelli, M. (2022). Electrification and development: Empirical evidence on the effect of electricity provision on household welfare (2022s-05, CIRANO).

https://doi.org/10.54932/SOAN1297

* Department of Economics, Tufts University, Medford, MA, USA. Email: ujjayant.chakravorty@tufts.edu
† Department of Economics, Universit�e de Sherbrooke, Sherbrooke, Qc, Canada; CIREQ, CIRANO. Email: martino.pelli@usherbrooke.ca

1 Introduction

Nearly a billion people in the world do not have access to grid electricity, in spite of significant increases in access in the last few decades. Providing these large numbers of people with electricity has major implications – first, it is costly, especially for developing countries with limited budgets and ability of the consumer to fully pay for these services.[1] Moreover, if the electricity is generated by fossil fuels such as coal or even cleaner natural gas, there will be significant adverse impacts on the environment in terms of increased carbon emissions. This is why a focus of recent research in environment and development economics has been to disentangle and study the causal effect of electricity access at the household level. This chapter reviews the current literature on this topic.

In order to interpret the results of the different studies presented here, it is important to clarify what is meant by access to electricity. There are different definitions in circulation. For instance, the Government of India declares a village to be electrified if the following three conditions are met: i) provision of basic infrastructure such as distribution transformers and lines in the inhabited locality, ii) provision of electricity in public places like schools, panchayat offices, health centers, dispensaries, and community centers, and iii) at least 10% of the total number of households in the village electrified.[2] On the other hand, the International Energy Agency (IEA) defines access by setting a minimum level of electricity consumption of 250 kWh per year for rural households and 500 kWh for urban households.

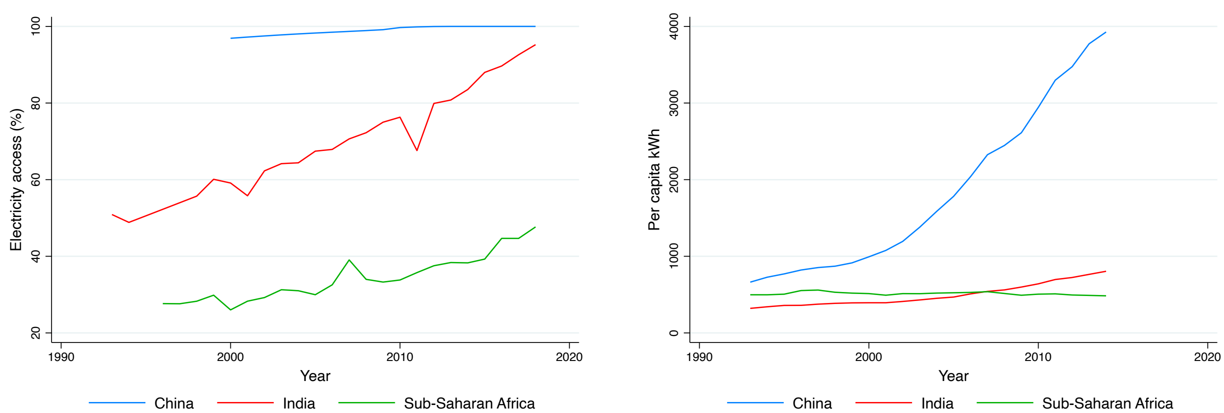
In order to clarify the importance of a good definition of electricity access let us look at Figure 1. The left panel shows electricity access as the percentage of population connected to the grid, while the right panel shows average per capita consumption in kWh for China,

[1]For instance the electrification of a village located 15 kilometers away from the grid in India costs about 150 thousand dollars (Greenstone and Weisbrod, 2014).

[2]"Office memorandum: Deendayal Upadhyaya Gram Jyoti Yojana", Ministry of Power, December 3, 2014, `https://powermin.nic.in/sites/default/files/uploads/Deendayal_Upadhyaya_Gram_Jyoti_Yojana.pdf`.

India, and Sub-Saharan Africa (excluding its high income countries). Note that China has been at almost 100% access since early this century, yet per capita average consumption started growing only after the year 2000. In India, by 2018 over 90% of the population was considered connected to the grid yet, average consumption per capita has increased only from roughly 272 kWh in 1990 to 804 kWh in 2014. In the same period, mean Chinese per capita consumption went from 511 kWh to 3,927 KWh. The increase in consumption in India is still a remarkable 195%, yet it pales when compared to the 545% increase experienced in China.

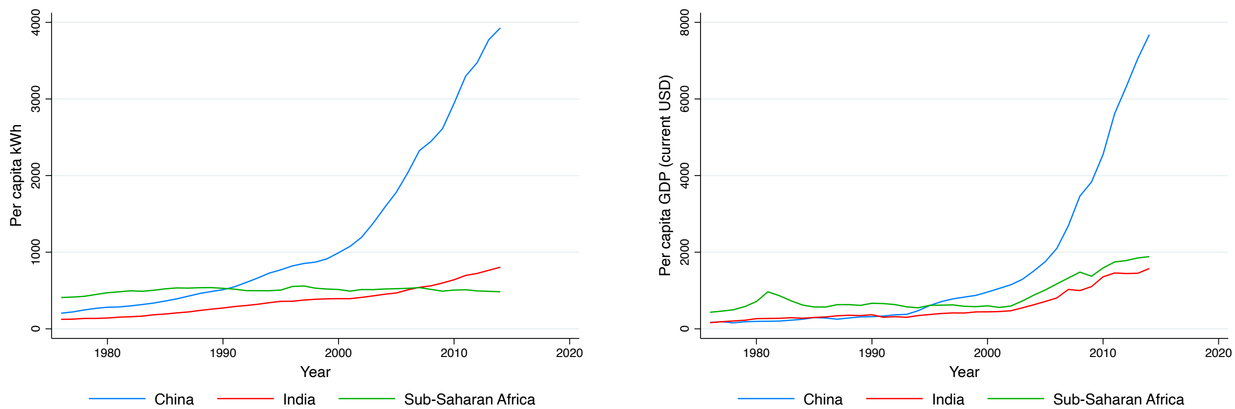
Figure 1: Access to electricity and average per capita consumption



Source: World Development Indicators 2020.

Figure 2 shows why researchers and policy makers link electrification to development. Panel A shows average per capita electricity consumption since the mid 1970s for the same three regions as before, and in Panel B we have per capita GDP over the same period. It seems that the increase in electricity consumption is strongly correlated with an increase in GDP. The only way to properly answer this question is to adopt a micro perspective. The literature needs to focus on individuals and households and see whether electrification causes an improvement in their socio-economic status.

Figure 2: Per capita average electricity consumption and GDP



Source: World Development Indicators 2020.

Access to electricity may have many impacts at the household level. Individuals may increase their labor supply since various tasks can now be performed at night. Food can be stored in a refrigerator, requiring fewer trips to the market. Children can study at night as well and that may affect educational outcomes. On the other hand increased opportunities to provide labor or participate in household income-generating activities may draw them away from schooling. School instruction may improve if there is access to electricity. Agricultural productivity may increase if irrigation pumps are run using electricity. Firms can produce more efficiently and offer newer products with reliable access to power. Electricity access may also boost entrepreneurship and artisanal activity. At the regional level, these channels can lead to changes in employment, income and more broadly, higher levels of economic development. Access to electricity can also help in reducing indoor air pollution, one of the leading causes of death and morbidity in the developing world. The possibility of generating light, heating, and cooking energy with electricity reduces the need to use solid fuels.

The identification of a causal effect of access to electricity is a challenging task from an empirical perspective. The placement of an electric grid and the availability of electric power may be endogenous for a variety of reasons. Access to electricity may be affected by reverse causality, especially if we are trying to capture its effect on income, as seen in Figure 2. Regions that are more wealthy may be better at lobbying for an extension of the electric grid. Areas that are flat and easy to access may be attractive as candidates for grid extension, but for the same reason may exhibit faster economic growth which may be confounded with electricity provision. Governments do not randomly electrify villages, and their choice of villages to electrify can be dictated by a variety of arguments: they could start with the poorest villages/households, or the richer areas, or with the least costly to connect, or again with neighborhoods that are closer to urban areas or to the transportation network. The availability of electricity may be jointly determined together with other outcomes of interest through numerous potentially omitted variables.

There may be important network effects, e.g., a household, even if not connected to the grid could be impacted if neighboring households get electricity. For instance, the spillover may be positive – if village residents can watch television at the home of the household that has electricity. On the other hand, electrified households may increase their productivity which may reduce local crop prices and hurt those not able to do the same.

2 Findings from the literature

In this section we review a few selected studies of the effect of electrification on household outcomes. We will first present the studies that find a positive impact of access to electricity and then those that do not find any statistically significant effect. We will then discuss some of the factors that may contribute to this diversity of results. For instance, one of the issues when studying electrification in developing countries which is by itself a recent phenomenon, we only have access to short term impacts, so these effects may only tell part of the story. We also have to keep in mind that the results obtained are highly dependent on the subsample of population studied, on whether we are estimating an average or a local treatment effect, on the level of aggregation of the outcomes studied and on many other factors. As pointed out by Lee et al. (2020a), often a set of complementary factors must be in place in order to allow a population to reap the full benefits of electrification. If these factors are not in place, then electrification should be accompanied by complementary programs. Table 1 presents a summary of the papers presented in this chapter and their results.

2.1 Statistically significant impacts

Dinkelman (2011) was among the first papers trying to identify the causal effect of electrification. She focuses on the effect of a mass electricity roll-out in rural South Africa on labor market outcomes. Her choice of an instrument for placement of the electricity grid is the gradient of the land in which the community is located. The intuition is that a sloped terrain significantly increases the cost of electrification. She shows using a placebo experiment that gradient is unlikely to affect employment outcomes directly. She finds that electrification increases female employment by 30-35% within five years. It also increases female wages and number of hours worked: male employment also increases but not in a statistically significant sense. The impact of electrification on females works through a re-organization of the labor supply and a boost in entrepreneurship. One mechanism through which electrification works is by shifting households from using wood towards electric cooking and lighting. Thus electricity works as a labor-saving technology. She finds evidence that there was no clear increase in labor demand in the electrified areas, and wages actually declined somewhat. These findings suggest that electricity only affected labor supply, and had little effect on labor demand. She also finds some reduced form evidence that in the electrified districts households not only supplied more labor but also engaged in creating new products and services that raised both female and male labor employment. There was limited in-migration to the electrified areas and out-migration as well, but it was not clear whether these effects were due to electrification. These results are similar to the one found by Grogan and Sadanand (2013) for Nicaragua. Using initial population density and the mean slope gradient as instruments for electricity placement, they find that access to electricity has no impact on male employment, but increases female employment. In Nicaragua, electrification is linked to an increase (of about 23%) in the propensity of women to work outside the home.

Another study that uses geography variables as instrument for project placement is Lipscomb et al. (2013). Their focus is on long term development over several decades (1960-2000). Based on hydropower potential in Brazil, this study produces a set of hypothetical maps that show how electrification would have evolved over time had it been based purely on the power generation potential of the rivers and the budget constraint of the government. This instrument works well for Brazil because power there is almost exclusively sourced from hydropower (over 60%). A possible concern with this instrument is that people and firms could settle following this predicted evolution of the electrification grid. Yet, most areas in Brazil were already settled by the beginning of the sample period so this is not a major issue. The authors find large effects of electrification at the county level on the Human Development Index and on average housing values, the idea being that economic development was capitalized into housing prices. OLS estimates are lower than IV estimates, suggesting that either poor areas were targeted or that the IV compliers are much more efficient than the hydro power plants which were placed for political reasons. The authors find that the impact of electrification did not occur through immigration to the electrified areas but through increased employment and salaries and investments in education, but not health. One of the issues with health is that it is not clear whether electricity should improve health, because it may increase incomes and improve productivity of the health sector but there may be negative effects on health through increased industrialization and pollution. One key conclusion of the paper is that the long run effects of grid electricity may be quite high, when one takes into account general equilibrium effects, and much of the benefits may accrue from people and resources moving to electrified areas even within the same jurisdiction.

Khandker et al. (2013) use a simple fixed effects model to identify the impact of electrification in Vietnam which provides an improved identification strategy compared to previous papers that did not use fixed effects and simply compared households before and after electrification. This paper does not deal with the endogeneity of electrification and, therefore, establishes a correlation rather than a causal impact. Making the strong assumption that unobserved heterogeneity is time invariant, Khandker et al. (2013) find that following electrification non-farm incomes rise by 20-30%, total income by 28% and expenditures by 23%. The study also acknowledges the importance of spillovers and community level connections. Community-level spillovers are analyzed in greater detail in Van de Walle et al. (2017). This paper studies the impact of electrification over the long run (17 years) and focuses on both internal (household) and external (village) effects. They use the distance from the village to the power generation source about two decades before the study period in order to instrument for electrification. The article finds a large asymmetry in the external effects between connected and unconnected households. The results show an increase in annualized consumption of roughly 0.5% for households connected to the grid and of 0.8% for household not directly connected, bur belonging to an electrified village. These results suggest that external effects of electrification are larger than the internal ones.

Thomas et al. (2020) use an IV approach that exploits the geographic discontinuity in legal access to electricity in the Bahraich/Lakhimpur districts of Uttar Pradesh in India. They exploit a law in that state which allows households within a 40 meter distance from an electric pole to be officially eligible to receive electricity from that pole while those living outside that range are not eligible. The authors conducted a survey among 686 households in 120 habitations (clusters) within villages. They found that access to electricity increases household expenditures, adult household activity, and ownership and usage of appliances. This study is unique because unlike many other micro studies, the residents had an average of 4 years of electricity which is a reasonable interval of time. They measured total household expenditures and expenditures on food, kerosene and education. They also find that in the electrified households both adults and children spend more time at home although their leisure time does not increase, suggesting that this increased time is being spent on productive activities. These households also have more appliances like bulbs, radios and refrigerators. These results are more optimistic than other studies and may indicate that the longer term effects of grid connections may be quite different than the short term effects of studies which fail to find major changes at the household level.

Chakravorty et al. (2016) adopt a least cost approach and focus on the impact of access to electricity on agricultural incomes in the Philippines. The identification in this paper is based on the projected expansion of the electricity grid under a least-cost first principle. The hypothesis is that the first villages to be electrified are those closest to the existing grid. The predicted electrification status resulting from this exercise is then used as an instrument for the actual electrification status. Access to electricity in the village raises households' expenditures and total income by roughly 40%. Most of these expenditures were on energy consumption. These results suggest that the cost of the physical infrastructure needed to extend the grid may be recovered after only one year.[3]

Rud (2012) focuses on the other side of the labor market and investigates whether electrification increases labor demand using a state-level panel between 1965 and 1984. He finds that, in India, a one standard deviation increase in the rate of electrification leads to an increase in industrialization of roughly 14%. The paper uses the large disparity in electrification across regions and across time. For instance, while average village electrification was

[3]The estimated cost for electrifying an additional household is $325, while an increase in expenditures of 38% corresponds to an increase of roughly $615.

10% in 1965, it was 50% in Tamil Nadu while being close to 3% in Assam and West Bengal. In order to solve for the endogeneity of electrification the author uses the introduction of a new agricultural technology intensive in irrigation (the Green Revolution) and the uneven distribution of groundwater as a natural experiment to develop an instrumental variable. Since the new high-yield varieties are water intensive, and most irrigation in India is done by pumping groundwater to the surface with electricity, an easier access to groundwater is a good predictor of electrification.

Most of the above studies focus on economic outcomes, however, access to electricity affects other household level outcomes. Barron and Torero (2017) examine the effect of grid connection on indoor air quality using a randomized encouragement experiment in Northern El Salvador between 2009 and 2013, which offers connection subsidies to a subsample of study households. Two years after the beginning of the program, the electrification rate of encouraged households was 19 percentage points higher than that of the rest of the sample. Barron and Torero (2017) measured indoor minute-by-minute night-time $PM_{2.5}$ concentrations and found that concentration for encouraged households was 66% lower, which contributed to an important reduction in acute respiratory infections among children under the age of six. Newly electrified households changed the fuel used for lighting, switching from candles, kerosene lamps, and wood sticks to electric light and these changes brought about measurable reductions in air pollution and morbidity. Gupta and Pelli (2020) also look at the pollution question by focusing on the impact of electrification on cooking fuel choice. If electrification improves the socio-economic status of a household, it should contribute to pushing households up the energy ladder. They use hydro-supply shifts, developed in Allcott et al. (2016), interacted with initial levels of electrification as an instrument. A positive shock to the availability of power in a district which historically has a higher degree of electrification results in a higher number of new connections. Using this strategy, they find that for poor households, electrification alone, without accompanying policies, has an adverse effect on cooking fuel choices in the form of increased use of biomass and less of cleaner fuels. Electrification increases expenditures, for instance on entertainment and on energy, and pushes poor households towards reducing their expenditures on other items. A relatively easy way is to switch from costly Liquefied Petroleum Gas (LPG) to virtually free fuelwood, dung, and crop residues for cooking.

2.2 Little or No impact

For electrification to have the expected outcome – a boost in development – certain preconditions need to be met. For instance if the people receiving grid connections are too poor, they will not be able to take advantage of it. One place where this seems to be the case is Africa, which accounts for some of the lowest electrification rates in the world. For example, in 2016 the electrification rate in Chad was 8.83% and in South Sudan was just slightly higher at 8.95%.

Lee et al. (2020b) study electrification in rural Kenya by randomly selecting clusters of households and offering them subsidized rates for connecting to the electric grid. By varying the subsidy offered, they can elicit the demand curve for grid electricity and using administrative data, they also plot the average and marginal cost curves for household grid connections of various sizes. Newly connected households are found to consume very low amounts of electricity, and no impacts are found in the medium-run. The study also finds low demand among the poor, a subsidy of roughly 60% on the price of a connection leads to an increase in demand by only 25%. They find that the supply cost of providing connections is higher than the demand. Estimated consumer surplus through this revealed preference approach is almost a fifth of total construction costs. Household surveys conducted 16 and 32 months after connections were completed find no significant impacts across a range of economic and non-economic outcomes.[4] The authors suggest that credit constraints may have contributed to low demand and low usage of electricity among connected households, and bureaucratic red tape and low system reliability may have driven up supply costs.

Burlig and Preonas (2016) study the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) electrification program in India which initially targeted villages with habitations of more than 300 people for connecting to the grid. This rule allows for the execution of a Regression Discontinuity (RD) design. The authors use night lights data to study villages around the cutoff and show that indeed the villages above it exhibit a higher degree of brightness. Of course one concern is whether night time brightness as observed from sky satellites can correctly measure electricity consumption within the household. Other studies have suggested a positive correlation between street lighting and lighting within the household (see for instance Kiran Chand et al., 2009; Min et al., 2013; Min and Gaba, 2014). The authors find that despite significant increases in electrification, there was little impact of the program on a wide range of economic outcomes such as employment, asset ownership, housing stock and village level variables such as school enrollment, but male agricultural employment declined somewhat and non-agricultural employment increased by a small magnitude. Analysis conducted on the sample of villages with above average power reliability also leads to the same conclusion, suggesting that reliability may not be an issue. These effects were measured roughly 3-5 years after the program received funding. If there were large implementation delays because of administrative red tape which are quite common in India, then it is possible that the time between being connected to the grid and the economic surveys conducted was small enough that the medium term effects of electrification did not manifest in the surveys.

[4] Another paper focusing on an African country which does not find any statistically significant effect of electrification is Bensch et al. (2011) who use data from the *EnDev* rural electrification program in Rwanda and generate probabilities of electrification by looking at a subset of already electrified households. These probabilities are then used to match electrified with non electrified households and produce a counterfactual. The article finds a strong impact on lighting hours and a small significant effect on kids studying at home, yet the effect disappears once regional differences are taken into account. Income also shows a positive response, but again vanishes when regional differences are accounted for.

Several reasons could explain the lack of impact of electrification. First, village-level aggregation may have hidden some of the heterogeneity of the effect of access to electricity across households or habitations. Second, the sample studied, Burlig and Preonas (2016) focuses on the smallest and least developed villages, which may not be able to reap all the benefits of access to electricity (Aklin et al., 2017) as in the Kenya study.

3 Reasons for Difference in Impacts

Several reasons could explain the diversity of results obtained in the literature. Lee et al. (2020a) suggests that the results may depend on factors like the population of interest or pre-existing conditions.

A possible reason for the lack of an effect in some of these studies may be the quality of the power supply. Households connected to the grid in rural India still have power only for a fraction of the day (see for instance Desai and Vanneman, 2005, 2012). Chakravorty et al. (2014) focus on the issue of reliability. The identification strategy uses the transmission network which connects power generation to distribution as an instrumental variable. The transmission network is mainly used to transport electricity from generation plants to large consumption poles using the shortest and, therefore, cheapest route available. Once this network is installed, it is relatively cheaper to electrify neighboring areas. The study uses a panel of over 9,000 Indian rural households and finds that the effect on non-agricultural incomes of a high quality power supply is three times larger (roughly 30%) than the impact of a grid connection of average quality (around 9%).

Another way to shed light on the impact of electrification is to look at its impact in the long term. This is difficult for developing countries, where at best we can look at 15-20 years of data. In order to investigate the long term effects of electrification we need to focus on the outcomes of connecting the grid in developed countries. Lewis and Severnini (2020) look at the short- and long-run impact of rural electrification in the US. Access to electricity in the rural US went from 10% to 100% between 1930 and 1960. The paper uses a difference-in-difference approach based on local access to electricity, where local access is measured by the distance to the closest power plant. This rather simple identification strategy is supported by three facts: i) records show that location decisions were based on costs and urban demand, ii) urban demand used up more than 90% of the production of these plants, and iii) no statistically meaningful difference is detectable in the rural population that was electrified first or at a later stage. In the short run electrification is not found to have an impact on income, but on housing and farmland values. Lewis and Severnini (2020) estimate that the average farmer would have paid 24% of farm income in order to obtain an electricity connection. Electrification also had long lasting effects in the US. In 2000, counties that gained access to the grid earlier are on average 15% more populous relative to counties which gained access later but had similar characteristics before electrification. It is important to keep these long term impacts in mind when analyzing the impact of electrification in developing countries, where, at best, we can observe some medium-run effects.

4 Concluding Remarks

The above review, although selective shows that the jury is still out on whether grid connections have significant impacts on poor households in developing countries. Most studies find large effects, and in some studies the effects are small or statistically insignificant. Most of the studies focusing on developing countries focus on short term effects, and only a few on the long term. In the long run the literature seems to agree on a generally positive effect of electrification. The context is important as well, making the impact of electrification heterogeneous. In very poor areas, such as sub-saharan Africa, the immediate benefits of connecting to the grid seem small. On the other hand, in regions where credit and other constraints are not severely binding, the effects on employment, education and other outcomes seem to be encouraging. More work needs to be done to understand the precise mechanisms through which households benefit from electricity.

Table 1: Literature

Article	Country of Study	Methodology	Results
Dinkelman (2011)	South Africa (1996-2001)	IV, instrument: gradient	Female employment +9-9.5% (N=1,816 communities)
Bensch et al. (2011)	Rwanda (2007-2008)	Propensity score matching	Positive effect on lighting hours, no effect on other outcomes (N=537 households)
Rud (2012)	India (1965-1984)	IV, instrument: introduction of a new agricultural technology	manufacturing output +14% (N=15 states)
Khandker et al. (2013)	Vietnam (2002-2005)	Fixed effects	Income +28%, expenditures +23% (N=1,120 households)
Grogan and Sadanand (2013)	Nicaragua (1998-2005)	IV, instruments: land slope and pre-civil war population density	Probability of work for females +23% (N=6,882 households)
Lipscomb et al. (2013)	Brazil (1960-2000)	IV, instrument ideal electricity network placement	10% increase in electrification leads to 10% increase in income per capita, 7% decrease in poverty; positive effect on education (N=2,184 counties)
Chakravorty et al. (2014)	India (1994-2005)	IV, instrument: transmission cable density	Non-agricultural income +9% for a connection, +28.6% for a high-quality connection (N=9,791 households)
Chakravorty et al. (2016)	Philippines (2003-2012)	IV, instrument: least-cost projected grid expansion	Income +42%, expenditures + 38% (N=209 villages)
Burlig and Preonas (2016)	India (2001-2011)	Regression discontinuity, population of a village in order to be in the program	No impact (N=25,942 villages)
van de Walle et al. (2017)	India (1982-1999)	IV, instrument: proximity to power generators	Consumption +0.5% per annum for connected HH, +0.8% per annum for neighbors (N=6,008 households)
Barron and Torero (2017)	El Salvador (2009-2013)	RCT, Intent-to-treat	Indoor $PM_{2.}$ $PM_{2.5}$ -66% (N=2,269 households)
Gupta and Pelli (2020)	India (2004-2009)	IV, instrument: hydro supply shifts	Adoption of LPG -6.02%, adoption of fuelwood +5.53% (N=136,221 households)
Thomas et al. (2020)	India (2018)	IV based on local randomization, instrument: proximity to a pole	Positive impact on expenditures (N=686 households)
Lee et al. (2020)	Kenya (2013-2017)	RCT	No impact (N=2,504 households)

References

Aklin, M., Bayer, P., Harish, S. P., and Urpelainen, J. (2017). Does Basic Energy Access Generate Socioeconomic Benefits? A Field Experiment with Off-Grid Solar Power in India. *Science Advances*, 3(5).

Allcott, H., Collard-Wexler, A., and O'Connell, S. D. (2016). How do electricity shortages affect industry? evidence from india. *The American Economic Review*, 106(3):587–624.

Barron, M. and Torero, M. (2017). Household Electrification and Indoor Air Pollution. *Journal of Environmental Economics and Management*, 86:81–92.

Bensch, G., Kluve, J., and Peters, J. (2011). Impacts of Rural Electrification in Rwanda. *Journal of Development Effectiveness*, 3(4):567–588.

Burlig, F. and Preonas, L. (2016). Out of the Darkness and Into the Light? Development Effects of Rural Electrification. Working Paper 268, Energy Institute at HAAS.

Chakravorty, U., Emerick, K., and Ravago, M.-L. (2016). Lighting Up the Last Mile: The Benefits and Costs of Extending Electricity to the Rural Poor. *Resources for the Future Discussion Paper*, pages 16–22.

Chakravorty, U., Pelli, M., and Ural Marchand, B. (2014). Does the Quality of Electricity Matter? Evidence from Rural India. *Journal of Economic Behavior & Organization*, 107:228–247.

Desai, S. and Vanneman, R. (2005). India Human Development Survey (IHDS). Technical report, New Delhi National Council of Applied Economic Research.

Desai, S. and Vanneman, R. (2012). India human development survey-ii (ihds-ii), 2011-12. Technical report, New Delhi National Council of Applied Economic Research.

Dinkelman, T. (2011). The Effects of Rural Electrification on Employment: New Evidence from South Africa. *American Economic Review*, 101(7):3078–3108.

Greenstone, M. and Weisbrod, A. (2014). Energy, growth and development. *International Growth Center Evidence Paper*.

Grogan, L. and Sadanand, A. (2013). Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua. *World Development*, 43(C):252–265.

Gupta, R. and Pelli, M. (2020). Electrification and Cookinf Fuel Choice in Rural India. Working Paper 01-2020, CIREQ.

Khandker, S., Barnes, D., and Samad, H. (2013). Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam. *Economic Development and Cultural Change*, 61(3):659–692.

Kiran Chand, T., Badarinath, K., Elvidge, C., and Tuttle, B. T. (2009). Spatial Characterization of Electrical Power Consumption Patterns over India Using Temporal DMSP–OLS Night–Time Satellite Data. *International Journal of Remote Sensing*, 30(3):647–661.

Lee, K., Miguel, E., and Wolfram, C. (2020a). Does Household Electrification Supercharge Economic Development? *Journal of Economic Perspectives*, 34(1):122–44.

Lee, K., Miguel, E., and Wolfram, C. (2020b). Experimental Evidence on the Economics of Rural Electrification. *Journal of Political Economy*, 128(4):1523–1565.

Lewis, J. and Severnini, E. (2020). Short- and Long-Run Impacts of Rural Electrification: Evidence from the Historical Rollout of the U.S. Power Grid. *Journal of Development Economics*, 143:102412.

Lipscomb, M., Mobarak, A., and Barham, T. (2013). Development Effects of Electrification: Evidence from the Geologic Placement of Hydropower Plants in Brazil. *American Economic Journal: Applied Economics*, 5(2):200–231.

Min, B. and Gaba, K. (2014). Tracking Electrification in Vietnam Using Nighttime Lights. *Remote Sensing*, 6(10):9511–9529.

Min, B., Gaba, K., Sarr, O., and Agalassou, A. (2013). Detection of Rural Electrification in Africa Using DMSP-OLS Night Lights Imagery. *International Journal of Remote Sensing*, 34(22):8118–8141.

Rud, J. (2012). Electricity Provision and Industrial Development: Evidence from India. *Journal of Development Economics*, 97(2):352–367.

Thomas, D., Harish, S., Kennedy, R., and Urpelainen, J. (2020). The Effects of Rural Electrification in India: An Instrumental Variable Approach at the Household Level. *Journal of Development Economics*, 146.

Van de Walle, D., Ravallion, M., Mendiratta, V., and Koolwal, G. (2017). Long-Term Gains from Electrification in Rural India. *The World Bank Economic Review*, 31(2):385–411.