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Flickering Lifelines: Electrification and Household Welfare in India

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Abstract

Access to reliable energy is central to improvements in living standards and is a recognized Sustainable Development Goal. This study moves beyond counting the electrified households and examines the effect of the hours of electricity households receives on their welfare. We hypothesize that additional hours of electricity have different effects on the poor, the middle income and the rich, in rural and urban areas. The methods used are panel fixed effects instrumental variables, cross sectional fixed effects instrumental variables, and logistic regression with data from the Indian Human Development Survey 2005-2012. We focus on extensive and the intensity margins, i.e. how access and additional hours of electricity affect household welfare in terms of consumption expenditure, income, assets and poverty status. The results show large gaps between benefits and costs of electricity supply among consumer groups. We also find that electricity theft is positively correlated with the net returns from electrification. A progressive pricing mechanism with targeted subsidies for the poor could therefore increase household welfare while reducing the financial losses of the State Electricity Boards.

Keywords

Reliable Energy, Electrification, Household Welfare, Panel Fixed Effects, Instrumental Variables Approach

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1. Introduction

The seventh Sustainable Development Goal (SDG) focuses on access, cleanliness, renewability along with efficiency in terms of supply intensity, research, and upgrading of technologies to produce energy (United Nations Economic and Social Council, 2019). Although the United Nations recognizes the significance of reliability, the policy impetus has been on counting electrified households without measuring the intensive margins of electricity supply in a day. Affordability, availability, and quality of service varies significantly among those who have and receive connections in developing countries. This is qualitatively well known, but not well characterized or quantifies in research on benefits of energy access to households. There is also a gap in the research in the analyzes of the intensive margin, i.e. how additional hours of electricity affects household welfare.

Some studies have examined the effect of extensive margin of electricity availability on household income in India at a cross sectional level (Khandker et al., 2014), the effect of intensive margin of quality on non-farm enterprise income in India at a cross sectional level (Rao, 2013), and a satisfaction survey of electricity reliability at the household level in India (Aklin et al., 2016), but until date, there has been no study of how household welfare has changed overtime with changes at the intensive margin of electricity given that not all people can afford private sources of electricity. We measure household consumption, income, assets and poverty status associated for different income levels and in areas where private energy supply is weak and during a time when significant reforms were undertaken to electrify all households in India and claims were made of a successful intervention.

Economic activity depends on reliable supply – not access only, as reliability affects the economic realm through income generating activities, business operations being able to stay open for longer durations through the day and thereby increasing the utilization of the installed capacity. Electricity lowers the burden and time required for household work, which has potential effects on labor supply decisions. Reliability of electricity affects capacity utilization and rate of employment (Abbas & Choudhury, 2013). Wages and household incomes are affected by the ability to access and utilize available capital resources. If electrification is the backbone of inclusive development,

it should be considered a social good with positive externalities a reliable access to which should be a perennial right.

An extensive literature[1] exists on the relationship between electricity consumption and economic growth at national and household level across the developed and developing economies (Abbas & Choudhury, 2013; Bose & Shukla, 1999; Ferguson et al., 2000; Ghosh, 2002). Literature contains a wide range of findings on the correlations and the direction of causality and a majority of them support the growth hypothesis. At the household level, rural electrification is credited to providing numerous benefits for household welfare related to education, health care, productivity and quality of life (Rao, 2013). Reliable and continuity of electric supply economizes the time allocation to home production which could increase labor supply of adults, especially women in the household. Time saved from fuel collection for cooking can be used for entrepreneurial purposes thereby increasing household consumption, income and assets.

In rural areas, productivity improvement from the ability to reliably use household electric appliances, electric motors and technologies to generate mechanical power fosters livelihoods and provides income generating activities for small and medium enterprises. Although these benefits are self-evident, there is limited empirical quantitative evidence of these benefits at the household level owing to complex a link between electrification and development confounding the attempts to possible attributions. There have been recent attempts to quantitatively assess the impact of electrification, but evidence is mixed and often derived through confounding variables. Rao (2013) cites productivity related increases in income due to improved lighting in India and the Philippines, the positive impact on income is found as a return to education. Khandker et al. (2014) shows how rural electrification in India indirectly increases household per capita income through increases in labor supply of men and women, schooling of boys and girls and reduced poverty.

This study examines the casual effects of differential effects of connectivity (access) and quality (intensity) of electricity on consumption expenditure, income, assets and poverty status. Since the extent of electricity utilization is endogenous to the household is dependent on household's ability to afford the slack in the electricity distributed, we use a geographic instrumental variable. Mean access and hours of electricity at the village level are used as instruments as they directly affect

[1] See Appendix Table A4.

household demand for electricity through peer effects but is exogenous to household's consumption demand for other goods, income, assets or status of poverty.

We use a panel fixed effects instrumental variable (FE IV) and cross sectional two stage least square IV regression to examine the causal effect and explain between variations of access and quality of electricity. In order to check for robustness, we compare the FE IV results with FE and OLS results. In order to analyse the effect of electrification on poverty status we use a logistic fixed effect regression to obtain reliable estimates of the extent to which electrification affects movement out of poverty. The model uses controls including social networks of households, age, education, sex, household size, membership in credit and savings group, and access to banks which are believed to affect overall welfare of the household (Bisrat et al., 2012; Davies, 1999; Montgomery, 1991; Morgan & David, 1963). We find positive causal effect of service reliability on household consumption, income, assets, and additional hours of electricity has differential impacts in the transition out of poverty at differential margins of electricity availability.

Electrification in India - The Context

Over 1/3 of the 840 million people lacking access to electricity globally reside in India (United Nations Economic and Social Council, 2019). This figure underlines the scarcity and bottlenecks of energy supply and the inability of various households to afford electrification for the whole day. With only 5.4% electricity generated from renewable sources[2], the supply gap is highest in India among the developing economies. India is dependent on the use of biomass in rural areas. Further, the country has the highest share of world annual consumption of biomass – 22% – significantly higher than that of other continental-size countries with similar social inequality. For the poor the demand for energy is limited and cooking accounts for 90% of the demand for energy.

In 2005, the Government of India under the Ministry of Power launched the "Power for All" (National Electricity Policy) programme as a joint initiative of Government of India and all states (Nouni et al., 2008). The objective was to connect the unconnected in a phased manner by FY 2018-19. The objective was also to ensure 24x7 quality, reliable and affordable power supply to all domestic, commercial and industrial consumers, and provide adequate supply to agriculture consumers as per the state policy within a fixed time frame. Progress was laid out by a report from

[2] Data derived from World Development Indicators, World Bank, 2015. The estimate excludes electricity generated from hydroelectric source. See https://data.worldbank.org/indicator/EG.ELC.RNWX.ZS

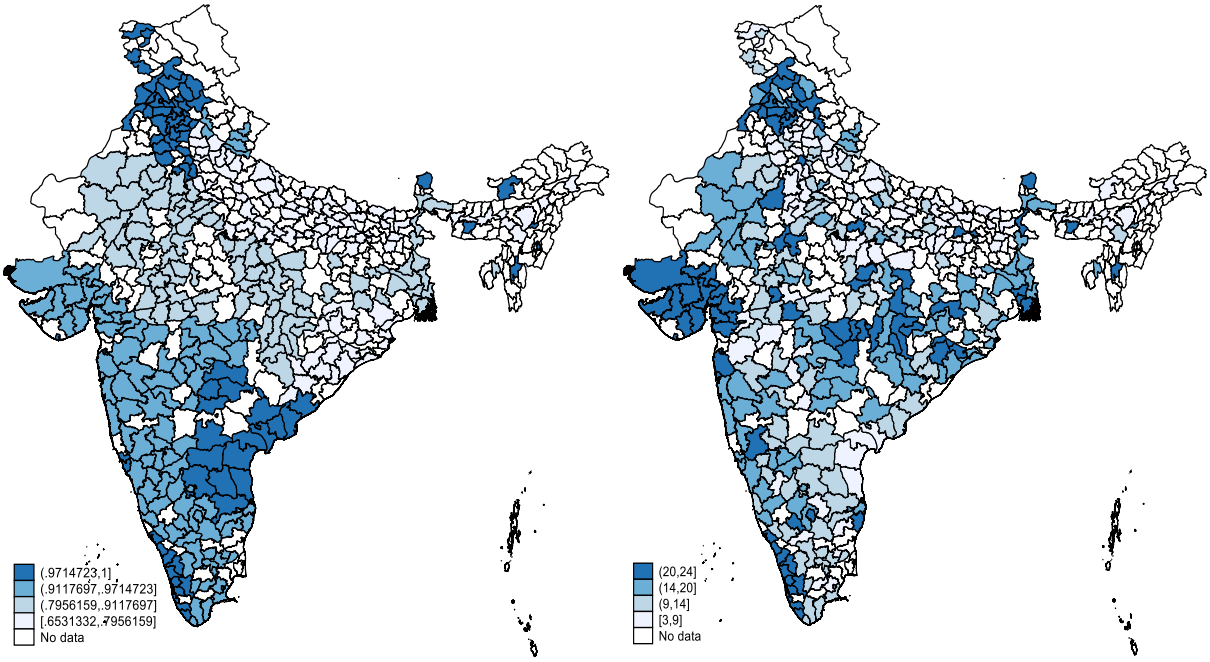
Smart Power India (2019) which stated, between 2000-2016, "half a billion people gained access to electricity in India, increasing the share of grid-electrified households from 43% to 82%.[3]

On April 22, 2018, the Prime Minister tweeted "I am delighted that every single village of India now has electricity" (Doshi, 2018). As per the Government the problem of electrification is over with 99.8% of villages being electrified in 2019 (Saubhagya Report, 2019). However, the official Government definition is: "a village is electrified if the basic infrastructure is in place; power is being supplied to schools, health centers and other public places; and at least 10% of households are receiving electricity" (Nouni et al., 2008; Singh & Sundria, 2017). It may be argued that the policy focus has been on the extensive margin with a lack of impetus at the intensive margin, or a market failure in tapping the potential demand.

Figure 1 panel (a) shows access and panel (b) shows hours of electricity in India in 2012[4] at the district level. Southern and Western India, along with Punjab in the North and Sikkim in the North East have high access (over 90% households electrified). In comparison to the data for 2005 (see Appendix Figure 1), there seems to be a considerable improvement in access to electricity in the Southern and Western States in India. However, in terms of hours only electricity only Kerela and Gujarat have had major improvements.

There are large variations between and within states at the district level in terms of the hours of electricity. This is intriguing given that State governments, and not the district level authorities, are responsible for electricity dissemination in India. Figure 1 and 2 motivate our question of how access is different from quality of supply and how this could household welfare. Note that the states with highest access and hours of electricity have also been the fastest growing states in terms of the growth rate of gross state domestic product from 2005-2012 (Planning Commission, 2013), as also shown by Rao (2013) for non-farm incomes in these states. In states such as Rajasthan, Jharkhand, Jammu & Kashmir and Madhya Pradesh, access was lower, but the hours of electricity were higher than the average of other states hinting to inequality and theft in electric supply in these otherwise poorer states of India. In 2005, Jharkhand, access is available 85%-95% of the population only, but whoever has access has over 80% of electricity hours in a day.

[3] In 2005, the govt. of India launched the Rajiv Gandhi Grameen Vidyutikaran Yojana, it is believed to have increased village electrification from 74 % to 91% between 2005 and 2011.
[4] For comparison of the variables with 2005 data, see Appendix Figure 2.



(a) (b)

Figure 1: Access and hours of electricity in India at the district level, 2012
Source: India Human Development Survey 2012

There is no official data on the intensity of electricity supply or electricity theft in India, hence having access to electricity is a poor measure of actual supply given the amount of illegal use. Subsidy and theft have also led the public run SEBS to operate with precarious financial positions, rendering them incapable of investing in needed infrastructural improvements, and thus unable to keep up with growing demand (Joseph, 2010). The first study by Rao (2013) on electricity intensity in India shows that the mean hour of electricity was at 15 hours a day in 2012, and almost 40% of the power generated is stolen or leaked away from poorly insulated lines, because of decades of underinvestment in the grid (Denyer & Lakshmi, 2012). For instance, in the village of Fateh Nagla in Uttar Pradesh, India's most-populated state and one of its poorest, about 250 kilometers east of New Delhi, a dairy shop runs on a combination of solar power and a battery, while its three flour mills use diesel generators. In the afternoons, men wait their turn to charge their mobile phones off a wire rigged up to an electric water pump.

Public private partnerships in electricity generation have not moved hand in hand. For example, Dabhol power plant near Mumbai in Maharashtra, established in 1992, as an FDI by Enron in the energy sector, failed and was closed down in 2001. The plant supplied to Maharashtra State Electricity Board (SEB), the board responsible for electricity distribution, but according to Joseph (2010) pricing issues rose as the charge for the power from the plant was higher than what the SEB paid to other state-run generating facilities. FDI agreement ended abruptly as the board had to supply electricity to agriculture and households at a subsidized rate it had to buy from other agencies. This has affected the business, trade and investment environment in India.

Despite the efforts to provide access to all, India's power supply has remained inadequate and unreliable. In 2014, more than 300 million Indians lived without electricity, of which 200 million lived in villages which were considered 'electrified' (World Bank, 2014). One might presume that in a vast country such as India, these numbers are a small market failure and along the path of progress, this issue will be automatically solved through electrification. However, a glance at India Human Development Index (IHDS) 2012 shows that the mean hours of electricity supply in rural India is approximately 13.5 hours a day, and exacerbated by major outages during peak periods (Joseph, 2010).[5]

Table A4 summarises the previous studies on the nexus of electrification and economic growth and points to the lack of a longitudinal estimation on the effect of the reliability of electricity on household welfare. The gap in the examination of household electrification and its impact on households who gained more hours of electricity post the power sector reforms (2003) warrants an empirical study on the longitudinal effects of electrification and its quality on variables of household welfare.

Section 2 describes the methodology and estimation strategy of the models used in the paper. Section 3 describes the data used in the study. Section 4 presents and discusses the results of the analysis. Section 5 is conclusion.

[5] For a detailed pictorial representation of the hours of electrification at the state level in 2005 using the IHDS survey, see appendix figure A1, and Rao (p. 4, 2013).