

How Large Are the Economic Benefits of Rural Electrification?

Fiona Burlig and Louis Preonas

Universal access to energy is a policy goal for many countries around the world, but little is known about the economic impacts of connecting rural villages to the electricity grid. We estimate the effects of a policy that expanded energy access in over 400,000 villages in India. Contrary to previous evidence, we find that electrification yields at most only modest economic benefits.

Approximately 1.1 billion people around the world still lack access to electricity. These people are overwhelmingly rural, and live almost exclusively in Asia and Sub-Saharan Africa. In recent years, developing

countries have made large investments to extend the electricity grid to the rural poor. This is not surprising, given that electrification is widely touted as an essential tool to help alleviate poverty and spur economic progress. While access to electricity is highly correlated with GDP at the national level, there exists limited evidence on the causal effects of electricity access on rural economies.

Our study examines the effects of India's national rural electrification program, which expanded electricity access in over 400,000 villages. We find that the program caused statistically significant and economically meaningful increases in electricity consumption, which are measurable from space. However, we find, at most, small changes to economic outcomes, including employment, asset ownership, the housing stock, household wealth, and school enrollment, and can statistically reject even modest effects.

Taken together, these results suggest that the causal impact of large-scale

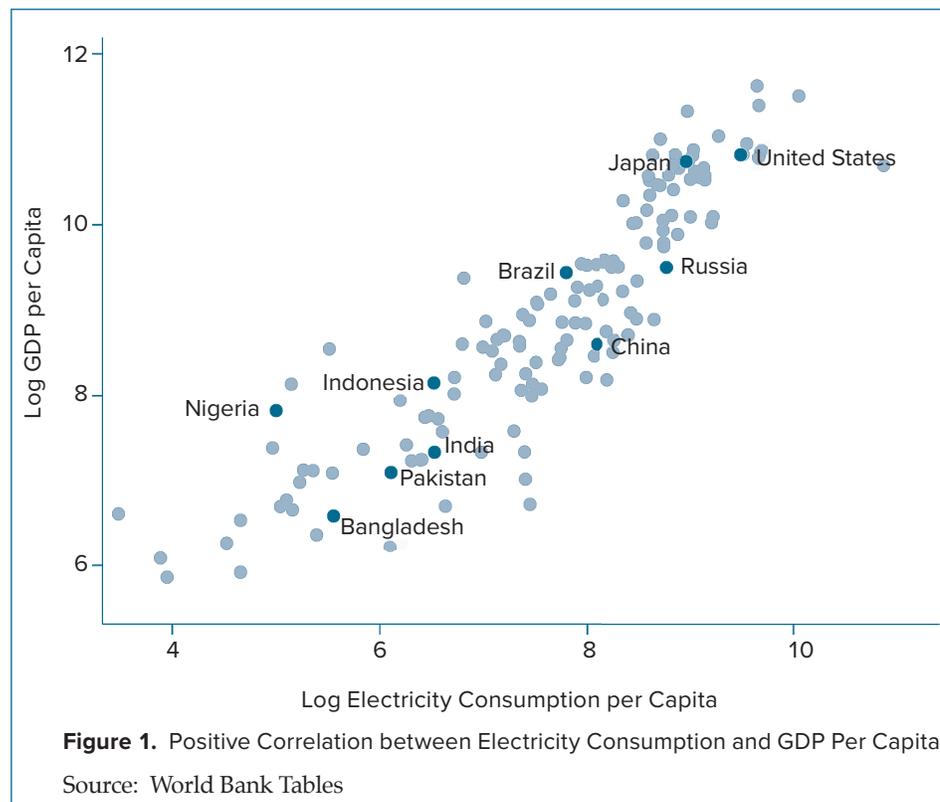
rural electrification on economic development may be substantially smaller than previously thought. This contrasts with previous research that has tended to attribute large economic impacts to rural electrification, in part because it is difficult to disentangle the impacts of electricity access from general economic growth.

India's National Electrification Program

In this study, we leverage a unique "natural experiment" – India's electrification program had a built-in cutoff, whereby villages with 300 or more inhabitants were eligible for electrification, and villages of fewer than 300 people were ineligible. This enables us to compare outcomes in villages just below this arbitrary cutoff to villages just above the cutoff, which are similar along all other dimensions, to estimate the causal effects of electrification on development.

We first demonstrate that the electrification program led to meaningful increases in electricity access among eligible villages. To do this, we use data from satellite images of nighttime brightness, which serve as a well-known proxy for electricity consumption. Figure 2 compares the average nighttime brightness of barely eligible villages to that of barely ineligible villages. Average brightness is noticeably greater for villages to the right of the 300-person eligibility threshold, and this result is robust and statistically significant.

We use nighttime brightness data from at least three years after most electrification projects were completed. This shows that the program yielded sustained increases in electricity consumption. Our estimates are consistent with changes in brightness associated with the addition of nine new streetlights – a sizeable increase in 300 person villages, especially since

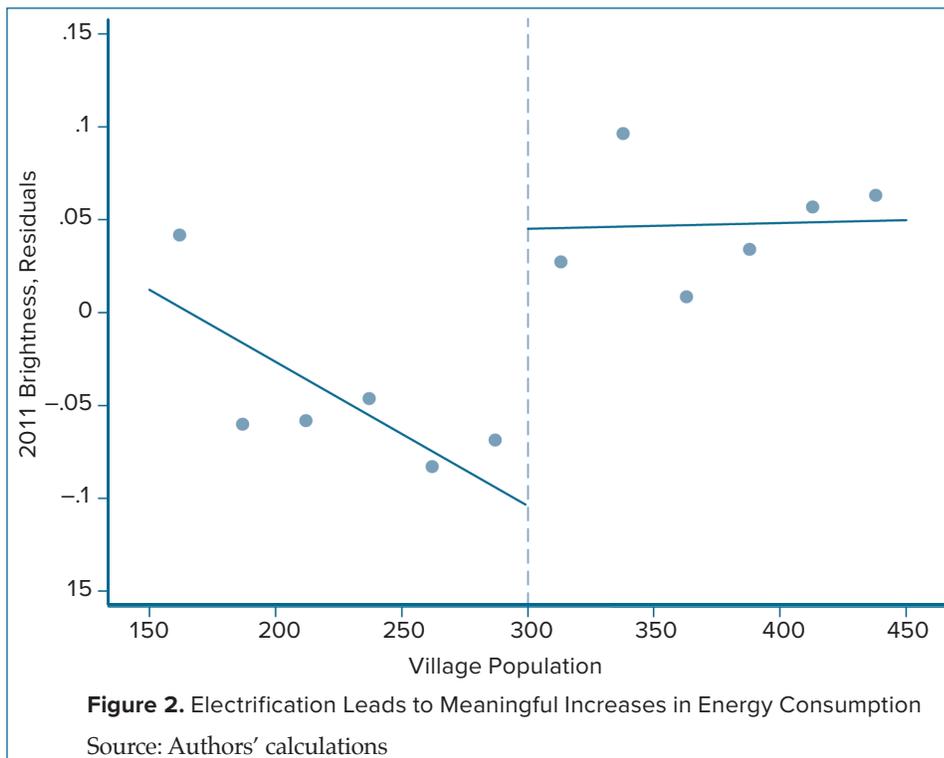


the electrification program did not add new outdoor lighting. Instead, these increases in luminosity come from lighting in public spaces, households, and businesses consuming more electricity. If this effect were driven by household electrification alone, these results would be consistent with 68% of households receiving new electric connections under the program. This suggests that the electrification program led to meaningful increases in electricity access throughout eligible villages.

Electricity and Economic Outcomes

Next, we use the same strategy to test for the effects of electrification on economic outcomes. We collect detailed administrative data on a wide range of economic indicators, and we test a variety of channels through which electrification might be expected to produce economic impacts. We test whether electrification led to changes in:

- Employment in microenterprises, if electrification spurs entrepreneurship and new business growth
- Employment in agriculture, if electrification increases farm productivity or mechanization
- Female employment, if electrification improves women's empowerment
- Asset ownership, if electrification causes households to purchase new appliances
- Housing stock, if electrification causes households to invest in improved roof or floor materials
- Poverty rate, if electrification helps to move households out of poverty
- Household income, if electrification yields new income-generating opportunities



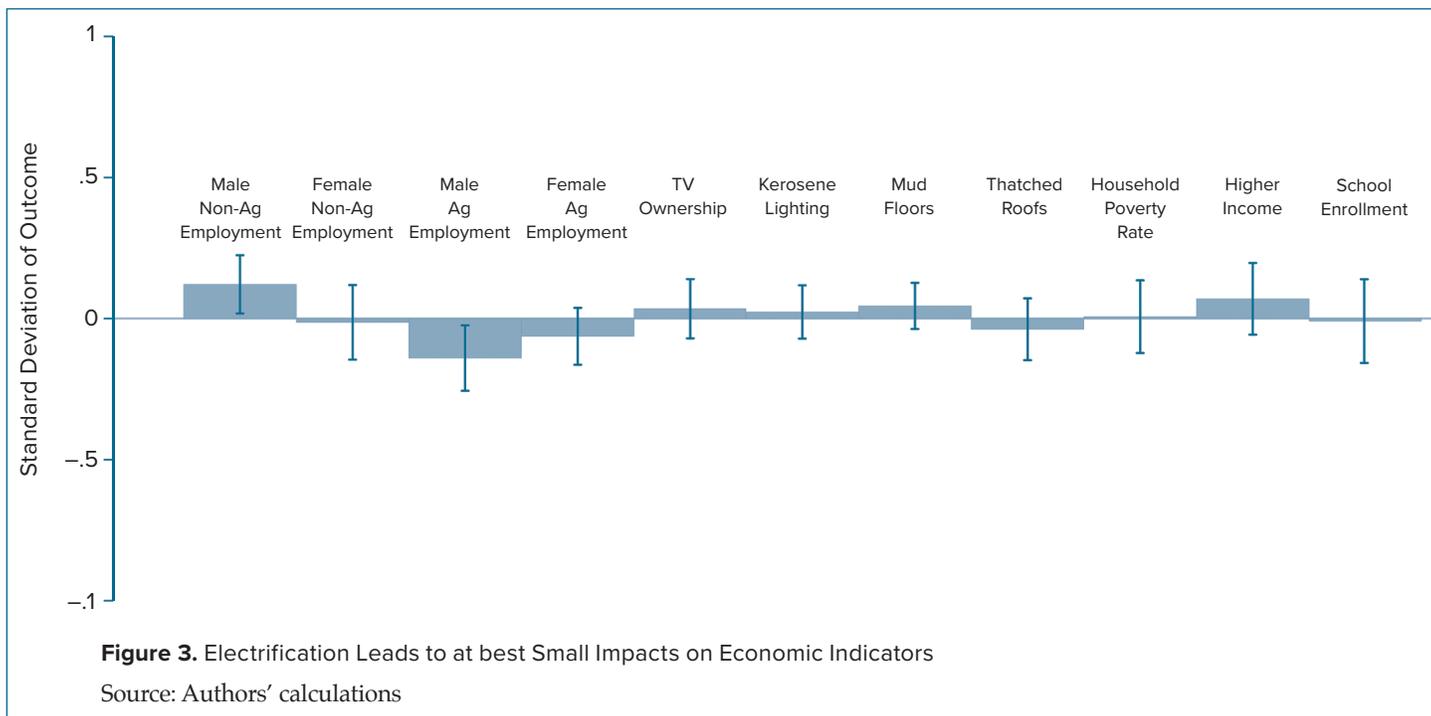
- School enrollment, if electrification facilitates better study habits, improves in-classroom learning, or affects the number of years of schooling children receive.

Figure 3 summarizes the results for 11 selected economic outcomes. We find that electrification led to only modest changes in employment for both men and women; ownership of a variety of household assets; poverty and household income; and school enrollment. The bars represent the effect size for each outcome, in units of standard deviations of each variable, while the solid line in the center of each bar represents the 95% confidence interval for each estimated effect. We can statistically reject improvements greater than 0.26 standard deviations, across all economic indicators that we observe.

Taken together, these results suggest that while the Indian electrification program substantially increased the provision and consumption of electricity, electrification did not lead to economically meaningful impacts among the wide range of outcomes that we can measure.

India is subject to major electricity shortages, and any benefits of electrification could potentially be undermined by low-voltage electricity or frequent power outages. In order to confirm that poor power quality is not driving our results, we separate states into two groups: those with above-average vs. below-average power reliability. As expected, the increase in nighttime brightness is much stronger in states with above-average reliability. However, our estimated economic impacts remain very similar across both groups. This suggests that even in states with relatively high-quality electricity supply, the economic impacts of electrification remain small.

It is also possible that the benefits of electrification take many years to accrue. Our main results rely on economic data from between three and five years after villages were targeted by the electrification program. If we restrict our analysis to include only the earliest villages to receive treatment, we find very similar economic impacts. This suggests that even in the medium-term, the economic effects of electrification are quite small.



We might worry that our analysis of small villages close to the program's 300-person eligibility cutoff are not representative of the full range of Indian villages. However, we expand our analysis to include all villages within the scope of the electrification program, by using a second natural experiment: Indian districts were split into two largely arbitrary groups, and villages in the first group received electrification before villages in the second group. This allows us to compare "treated" villages in the first group to "control" villages of similar size in the second group. We find remarkably consistent results, with substantial increases in electricity consumption but only modest changes in economic indicators.

Policy Implications

What do these results mean for policy? We find that even though rural electrification led to meaningful improvements in energy access and consumption that are measurable from space, it caused at most modest changes in labor, income, household wealth, asset ownership, and education. These results come from the world's largest

unelectrified population, and they likely apply to over 400,000 villages across rural India. They suggest that rural electrification may not be a silver bullet for reducing poverty or jumpstarting economic activity, and that medium-run economic outcomes alone likely do not justify the expensive investments required to electrify rural villages.

Nevertheless, electrification may still have large economic benefits that we cannot measure. In particular, while our study considers medium-run outcomes, we cannot observe long-run impacts. The economic benefits of electrification may only manifest after 10 or 20 years, and additional research is needed to evaluate these long-term effects. Furthermore, due to data limitations, we do not evaluate the impacts of electrification on "non-market" outcomes, such as happiness and stress. Some anecdotal evidence suggests that electrification may in fact have made rural Indians happier. We encourage future researchers to study such non-market impacts of rural electrification.

AUTHORS' BIOS

Fiona Burlig and Louis Preonas are PhD candidates in the Department of Agricultural and Resource Economics at UC Berkeley, and graduate student researchers at the Energy Institute at Haas. They can be reached at fiona.burlig@berkeley.edu and lpreonas@berkeley.edu, respectively.

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