The World Bank Economic Review, 31(2), 2017, 385–411
doi: 10.1093/wber/lhv057
Advance Access Publication Date: October 14, 2015
Article

Long-term Gains from Electrification in Rural India

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Abstract

We know surprisingly little about the long-run impacts of household electrification. This paper studies the impacts on consumption in rural India over a 17-year period, allowing for both internal and external (village-level) effects. Under our identifying assumptions, electrification brought significant consumption gains for households who acquired electricity for their own use. We also find evidence of a dynamic effect of village connectivity for households without electricity themselves. This is suggestive of an external effect, which also comes with a shift in consumption spending suggestive of status concerns among those still without electricity. Labor earnings were an important channel of impact. This was mainly through extra work by men. There was no effect on average wage rates.

JEL classification: H54, O12, O13

A great many people still do not have electricity. In much of the developing world, households continue to rely on traditional sources of fuel for lighting, heating, and cooking. Indeed, it is estimated that 1.3 billion people in 2009 had no access to electricity.[1]

Rural households can spend a lot of time collecting and preparing fuel for domestic use. Many continue to cook with wood and biomass (mainly dung) with deleterious effects on the health of family members. Across countries, these time and health burdens are thought to be higher for women and the children under their care. Over recent decades, governments and donors have made a concerted effort to bring more efficient sources of energy, particularly electricity, to rural households.

It is often simply assumed that electrification will result in significant welfare gains for households and particularly for the women within them. Referring to policy discussions in the 1970s and 1980s,

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1 See World Energy Outlook (WEO) 2011, published by the International Energy Agency. The WEO estimates that in 2009 25% of the population of the developing world was still without electricity, and the proportion rises to 37% in rural areas. In South Asia, the corresponding proportions are 32% and 40%, while in Sub-Saharan Africa they were 69% and 86%. It is estimated that 70–77% of energy consumption in Sub-Saharan Africa over 1980–2005 comes from wood fuel (Kebede et al. 2010).

Barnes and Binswanger (1986, 26) note the "blind faith placed in rural electrification." Some observers have expressed skepticism on the claimed benefits of electrification over other energy sources.[2] There are concerns about both internal and external validity of past evidence. In an extensive review of the literature, the World Bank's Independent Evaluation Group (2008, xvii) concluded that "the evidence base remains weak for many of the claimed benefits of rural electrification." Similarly, Bernard (2010, 41) writes that "While funding for rural electrification programs often rests on their supposed impacts on such outcomes as health, education, or poverty level, there is still very little empirical evidence to substantiate them."

A number of issues make identification of the household welfare impacts of rural electrification difficult. Three stand out. First, there is the potential for electricity acquisition to be jointly determined with outcomes or correlated with omitted variables. Second, nonrandom placement is likely to entail sensitivity to the choice of regression controls. Third, there are likely to be external effects of electrification in the village, which could well bring benefits to an individual household even if it does not have electricity itself. Indeed, some part of the externality may also be asymmetric in that certain types of benefits accrue to those who do not already have electricity much more than to those who do. For example, the entertainment benefits of having a neighbor with an electricity-powered television and fans is likely to be considerably greater for a household without electricity than for one who has electricity. In contrast, lit village streets are likely to be advantageous to all local households.

Recent studies have recognized the endogeneity of placement issue, though sensitivity to controls and external effects are less often discussed. It has become common to exploit geographic variables for identification under conditional independence assumptions. Those assumptions appear to be more plausible in some applications than in others. Randomized approaches are difficult with rural electrification because of the large scale and political nature of these efforts.[3] Observational panel data studies help address these concerns, to the extent that the endogeneity can be fully accounted for in the correlation between placement and time invariant factors that can be differenced out using the panel data. However, the acquisition of electricity within the time period is still likely to be endogenous to changes in outcomes at the household level. This has been dealt with in the literature by either adding controls for initial conditions that are likely to be correlated with subsequent trajectories or by using an instrumental variables estimator. Both methods require a conditional independence assumption, namely that the error term in the outcomes regression must be conditionally independent of either placement or its instrumental variable (IV).

This paper studies the effects of India's large expansion in rural household electrification on household living standards as measured by consumption. A contribution is that we distinguish the internal effects of household electrification from the external effect of village electrification. Asymmetry in the external effects between households with and without their own electricity plays a role in our identification strategy, as does (time-varying) proximity to power generating plants. We find long-term consumption gains from household acquisition of electricity but also show that there are strong positive external effects of village connection to the grid for households without electricity themselves. Our estimated consumption gains are lower than the past estimates in this setting that addressed endogeneity. We argue that this reflects biases when ignoring these external effects, and latent geographic heterogeneity. In particular, the use of village placement as an instrument for household placement is also seen to be a source of sizeable bias.

2 See, for example, the discussion in Mathur and Mathur (2005) with regard to India's "Electricity for All" program. Also see the discussion in Barnes and Binswanger (1986).

3 Two recent exceptions are ongoing studies that look at specific features of new electricity programs in rural Sub-Saharan Africa, where only 5 percent of households on average have electricity connections. These are described in Bernard (2010).

There is only so far we can go in understanding the mechanisms linking electrification to household consumption. One potentially important mechanism (emphasized in some of the literature reviewed later) is through the labor market, notably labor supply and wage rates. To test whether this is an important mechanism, we also use labor supply and wage rates as the dependent variables.

After reviewing the literature in the following section, we discuss our data in section II; an online statistical addendum is also available with further details. The model and identifying assumptions are outlined in section III. Our results are presented in section IV, while section V summarizes the lessons learnt.

I. Arguments and Evidence from the Literature

The evidence on the economic gains from rural household level electrification is somewhat mixed. Some papers have reported evidence of seemingly large impacts on household consumption, income and other dimensions of welfare in developing countries (Khandker, Barnes, and Samad 2009, 2013; Khandker, Barnes, Samad, and Minh 2009; Khander et al. 2012). Using data for India, Khandker et al. (2012) claim proportionate impacts of household electrification on income of the order of 25–50%.[4] Also using data for India, the results of Chakravorty et al. (2014) suggest a 9% gain in rural nonfarm incomes. Other studies, including Bensch et al. (2011) using data for Rwanda, do not find such impacts.

Labor supply responses figure prominently in past arguments. World Bank (2004) and Mathur and Mathur (2005) point to large differences in time allocation between rural Indian households with electricity and those without it, although concerns about endogenous selection clearly cloud the inferences that can be drawn. One popular hypothesis on the benefits of household electrification is that by relieving the time burdens in collecting and preparing fuel, household electricity leads rural women to engage in market-based work (Dinkelman 2011; Kohlin et al. 2011). A number of studies show that the introduction of household electrical appliances—by raising women's productivity in domestic work—can account for a large share of the increase in married American women's labor force participation in the 20th century (see, for example, Greenwood et al. 2005; Coen-Pirani et al. 2010).[5] Dinkelman (2011) and Grogan and Sadanand (2012) find similar effects on female employment (and not on male employment) for South Africa and Nicaragua, respectively. Dinkelman attributes this to the use of electric stoves and other time-saving appliances.

Household electrification presumably increases the productivity of domestic production relative to other uses of time. However, this productivity effect may well be weak in poor rural economies. The evidence indicates that, with rare exceptions, rural households in developing countries use electricity first and foremost for lighting, followed by powering televisions and fans (Bernard 2010; Barnes 2007; IEG 2008). Southern Africa appears to be unusual among developing countries in that rural households commonly use electricity for cooking (IEG 2008). The relevance of the Dinkelman (2011) results for South Africa to other developing countries, where most women continue to use traditional fuels and technologies for domestic tasks, is thus unclear. In some contexts, electricity may reduce the cost of lighting and is certain to improve lighting quality over traditional kerosene lighting devices.[6] However, since biofuels and firewood continue to be used for cooking in most rural settings, collection time is unlikely to be hugely affected, contrary to some claims (ADB 2010; Mathur and Mathur 2005; Barnes and Sen 2004). In India, there is also evidence that, given erratic electricity supply, reliance on kerosene for lighting is maintained alongside electricity (Mathur and Mathur 2005; Rehman et al. 2005).

4 These are coefficients on household electrification in regressions for the log of income, using village electrification rates as the instrumental variable. Estimates vary with the conditional quantile. Impacts were somewhat lower for consumption but still sizable for the upper consumption groups.

5 Contrast the American view with that of a judge in Japan who famously said: "modern appliances are partly responsible for failed marriages because they give women time to contemplate" (Hendry 2010).

6 A typical device is a homemade or locally produced wick lamp. This is known to have low luminous efficiency and to generate smoke with potentially adverse health effects.

While the productivity effect may be weak in poor rural settings, there is another implication of household electrification that could well be more important. Electric lighting extends the time available for activities that need good lighting, thus enabling a rearrangement of tasks to evening hours. Household members can then continue their enterprise work, domestic duties, homework, and reading into the evening with potential positive effects on earnings and living standards. For example, studies for Bangladesh suggest that with lighting, people spend a greater share of their evening hours in household-based income-generating activities (see Barkat et al. 2002; Chowdhury 2010). Electrification may foster small home-based enterprises (such as ironing and sewing services) with longer hours for productive work. Constraints on electricity supply are believed to be a significant impediment to small-scale enterprise development and rural industrialization in this setting, and there is supportive evidence in the work of Alby et al. (2013).[7] Leisure activities too can be reallocated, and this may well matter as much for men as for women. Without electricity, a significant share of leisure time will no doubt be in daylight hours, in which case it competes with labor supply. With electric light, there can be a substitution of male leisure from daylight hours to night time; for example, instead of hanging out with the village men at the tea shop during daylight hours, men can sit at home and watch TV in the evening once electricity is available. By freeing up daylight hours for work outside the home or own-farm, household electrification may well make regular salaried work more feasible.

The literature has suggested other ways through which household electrification might increase welfare. Health benefits can arise as electric lighting reduces the pollution from using candles or kerosene (IEG 2008). Traditional biomass fuels for cooking and kerosene lamps generate indoor air pollution that is a recognized health hazard, with health costs that are disproportionately borne by women and children.[8]

The implications for household expenditure on energy have also been prominent in the literature, often with claims about benefits from lower energy expenditures due to electrification (see, for example, Mathur and Mathur 2005, in the context of rural India). However, while a lower price (per unit of energy consumed) can be expected to generate a welfare gain, there can be no presumption that total expenditure on energy provides an inverse welfare indicator. Spending on energy may increase due to electrification, and this can be a good thing.

Substitution amongst energy sources can also be expected. Heltberg (2004) documents evidence of a switch to modern (nonsolid) cooking fuels with rural electrification in eight developing countries including India. There is evidence that the highly subsidized kerosene ration that many Indian households receive is substituted for cooking once electricity is used for lighting (Heltberg 2004), although kerosene lamps and candles remain a common back-up given erratic electricity supply (Rehman et al. 2005). Such substitution can still entail welfare gains, of course; for example, even kerosene is considered a cleaner fuel for cooking stoves than traditional biomass.

The role of television is not well understood and may be more important than past economic analyses have allowed for. Television viewing may improve women's domestic productivity and welfare through greater knowledge (see, for example, Kohlin et al. 2011; ADB 2010). Research has documented significant effects on fertility from information about modern contraception gained from watching TV (IEG 2008; Peters and Vance 2011). By the same argument, other health related behaviors may alter and lead to better family nutrition, reduce child morbidity and result in overall health improvements.

Any improved productivity for one member is likely to have implications for other members through reallocations within the household. Schultz (1993), for example, discusses how changes in home-based

7 Evidence on the effects of electrification on rural industrialization in India can also be found in Binswanger et al. (1993) and Rud (2012).

8 See Dasgupta et al. (2006), using data for Bangladesh. Also see Duflo et al. (2008) for a review of the evidence on the health effects of indoor air pollution.

technology such as electricity can reduce household dependence on girls' labor and the opportunity cost of sending girls to school.

Past claims about the household-level impacts of electrification on employment are hard to reconcile with the classic characterization of an under-developed rural economy as having a large labor surplus—as in the famous Lewis (1954) model. In a setting with a large excess supply of labor one would not normally expect a purely supply-side change such as a household's electrification to directly increase employment. If the Lewis model is right, then the channel would have to involve relaxing the external quantity constraints on employment at the household level. However, it is important in this setting to distinguish formal (regular or casual) wage work from self-employment. The quantity constraints may well apply to the former but not the latter. For example, Dinkelman (2011) conjectures that the female employment effects (in a setting with unusually high unemployment rates) are through self-employment, although her data (from census employment questions) do not allow this type of work to be identified.

The main focus of past research has been on the "internal" effect of electrification within the household. There will also be external effects of village-level electrification. A few papers treat the community as the unit of analysis and estimate the total effect on all households, whether or not they have an internal electricity connection (Dinkelman 2011; Lipscomb et al. 2013). Here we separate out the internal from the external effect.[9] The external effect can be expected to operate through wages, prices, or other income and also through any quantity constraint on labor supply in a model with a labor surplus. We can distinguish two types of external effects. Symmetric external effects exist when village electrification gives similar gains to households who are themselves electrified and to those who are not. Examples include potential benefits such as safer streets, changing social norms, and general equilibrium effects on wages and employment opportunities.

By contrast, asymmetric external effects are substantially greater for households without electricity. An example is shared lighting. If your household already has its own lighting, it may matter rather little whether or not your neighbors have light, but if you do not have light yourself, having neighbors with light can make a big difference; for example, you can send your child to study there in the evening, watch the neighbors' TV, or store your perishables in their refrigerator. The village externality can also operate through domestic production possibilities. The domestic production activity need not be physically located within the household in question but might reside instead within a friend or neighbor's dwelling. Thus a household still without electricity can benefit by using the electric sewing machine (say) of a neighbor who has acquired an electric connection, possibly with some compensation to the neighbor. This is another example of an asymmetric external effect.

Village-level external effects can also arise through status-seeking behavior. Having electricity in one's home in a typical Indian village is conspicuous and conveys a sense of status. Those without electricity (for some exogenous reason) may then respond by changing their own consumption behavior, spending more on other status-conveying goods to compensate; Frank (1997) discusses such behavior and points to supportive evidence. These goods would clearly need to also be conspicuous goods, rather than (say) food consumed within the home. Spending on celebrations and festivals is a plausible example. The welfare implications of such behavior are unclear. As Frank (1997) argues, such social effects on consumption behavior may have little or no lasting effect on welfare because everyone keeps trying to keep up their relative status in a race that leaves everyone spending too much on such goods. Rao (2001) describes the importance of status-related spending in South Indian villages, though Rao emphasizes the more positive roles that such spending can play in building social capital, which can be welfare enhancing.

9 To our knowledge, the only other paper that does this is Khandker et al. (2013), which separates the internal from the external gains from connection to the electricity grid in Vietnam. It finds evidence of external effects on household consumption, labor earnings, and the schooling of girls (but not boys).

Geographic variables have often been treated as a source of exogenous variation in past efforts to identify the household-level impacts of electrification. Grogan (2012) uses distance to the power source, namely hydroelectric dams. Khandker, Barnes, and Samad (2009) use household proximity to an electricity line. Similarly, Chakravorty et al. (2014) use the density of transmission lines in the district of residence. Coen-Pirani et al. (2010) and Khandker et al. (2012) use the local geographic mean electrification (or appliance-ownership) rate as the IV for household electrification. A number of papers have been influenced by the identification strategy used by Duflo and Pande (2007) exploiting geological/topological features of the land; Duflo and Pande use local river gradient interacted with predicted district level dam construction as an IV (in their case for dam placement). Dinkelman (2011) and Grogan and Sadanand (2012) use local land gradient as the IV for electricity placement.[10] Lipscomb et al. (2013) use the time path of estimated electricity network expansion costs as the grid expands to more costly areas. Some of these papers also control for location fixed effects to control for time invariant factors that may affect both the generation of electricity and outcomes.

II. Setting and Data

India's early, post-independence, economic plans gave priority to the use of electricity for urban industry in an effort to develop capital-intensive domestic production. Efforts to bring electricity to rural households were delayed until the 1970s and initially focused on connections for irrigation pump sets. Based on India's National Sample Surveys, only around 18 percent of rural households had an electricity connection for household use in 1982, while close to 70 percent did so twenty years later, although with wide variation across regions. The expansion of the grid was initially influenced by population density (households in large cities were among the first to be connected) but also favored areas where natural resources were abundant for generating electricity (rivers for hydroelectric power, and coal for thermal power). Connections in dwellings expanded rapidly during the 1980s and 1990s. The bulk of rural households get their electricity from a wired connection to above-ground power lines, which in turn are connected to village transformers that are linked via a feeder (or medium-voltage) line to power substations further away on the grid.

According to official statistics, more than 90 percent of villages are currently electrified, in that they have a feeder connection to the grid (International Energy Agency 2002). However, far from all households in these villages are connected to the electricity grid, and the extent of household connections varies widely on a regional basis. Since the 1960s, five main regions (the North, East, West, Northeast, and South) have comprised and managed India's grid (Pandey 2007). Each state and union territory of India falls in one of these regions; power is also shared across regions.

A key question is how India's dramatic increase in household-level electrification impacted household economic behavior. The India Rural Economic and Demographic Survey (REDS) covers this key period of rising household level electrification and includes detailed information for a panel of households. This appears to be the only long-period household panel data set available for a rural economy that underwent extensive electrification. While providing a unique opportunity for assessing the long-term impacts of electrification, the use of the data for this purpose still requires a number of assumptions, which we outline later.

We use the 1981–82 and 1998–99 (henceforth 1982 and 1999) rounds of the REDS, conducted by the National Council for Applied Economic Research (NCAER).[11] The two rounds form a panel of 6,008 households across 242 villages in 15 states. The REDS was initially designed to be representative

10 Flatter land makes it cheaper to lay cables (Dinkelman 2011).

11 There was a first round of the REDS (called ARIS) in 1970–71 but its questionnaire was more restricted in scope than that for the subsequent rounds. There is also a more recent round for 2006, which is not yet for public access. However, for the questions of interest to us, the 1982–1999 panel covers the key period.

of rural India, excluding states in significant conflict.[12] Given the long time period covered by the panel, current representativeness of the survey data for rural India can be questioned and we can only make inferences for the baseline panel sample at subsequent dates.

In both rounds, the household survey collected data on education, health, marital status, labor supply (main and secondary occupations), and sources of farm and nonfarm income, access to infrastructure and facilities, consumption expenditure and assets, agricultural production, and land owned and inherited.[13] Accompanying village surveys for both rounds elicited community access to facilities, infrastructure, population characteristics, prices, and wage rates by activity for men and women.

For each round, we construct a binary indicator of whether the household has electricity. Only the 1999 survey directly asked whether the household had electricity in the home. In the earlier survey, households were asked about their ownership of consumer durables that use electricity and of electric irrigation pumps. We construct an indicator of household electrification over time that is equal to one in 1982 if the household reports having an electric appliance or pump, and equal to one in 1999 if the household reports having an electricity connection in the home, incurring consumption expenditures on electricity, or owning an electric pump.[14] In a few cases, it is unclear whether an appliance requires electricity to run. For example, early radios and sewing machines were run without electricity. The evidence for rural India in 1982 convinced us that such appliances were typically not electricity driven then. We constructed alternative definitions of household electrification—both conservative (assuming such appliances were not electricity dependent) and liberal (assuming they were). In this paper we will use the more conservative definition, which we believe is more likely to approximate the correct measure. However, we tested sensitivity to using the broader measure as well and found this made negligible difference to the main results.

We do not know from the survey whether the household's electricity was obtained from a private generator or through connection to the grid, although our expectation is that private generators were relatively rare. We include households that report having an electricity connection for purely agricultural purposes since it is not clear that we can separate out the effects of electricity in the home versus that on the household's farm. Irrigation connections may well also have ramifications for time use and allocation. However, we also tested the sensitivity of our results to excluding households whose only connection is for agricultural purposes; this made very little difference to the results.[15] Using our main electrification indicator, 24 percent of rural households had electricity in 1982, while 71 percent did in 1999. Our figures accord reasonably well with national trends as reported in other sources.[16]

12 The 1982 round surveyed a total of 4,979 households across 250 villages. (The survey excluded Assam because of an insurgency at the time. In the 1999 round, Jammu and Kashmir was excluded due to unrest there.) The 1999 round covered all surviving 1982 households and added a small random sample of new households from the same villages. Together with household division since 1982, this results in a sample of 7,474 households. The increase in the number of households with baseline information in 1982 and hence in the 1982–1999 panel is explained by household splits over time.

13 Both survey rounds also collected data from women on their time allocation and that of their children. This is likely to be quite noisy data, especially in measuring changes over time (not helped by changes in the questionnaire for reporting time allocation). We decided that the data were not usable for our purpose.

14 There are 122 households for which our electricity indicator is positive in 1982 and zero in 1999. Of these, 42 split off from a mother household that maintains its electricity status over time; 42 split off from an initial household with electricity to a number of households of which none have electricity in 1999. The remaining 38 households did not split between rounds and we can only conclude that they became un-electrified over the period studied, perhaps through loss of a private generator or an illegal connection.

15 The results are reported in table A2 of the online Statistical Addendum.

16 Using National Sample Survey (NSS) data for India, Pachauri and Muller (2008) estimate that 18% of rural households had electricity in 1981 (for both household and agricultural use). Restricting their sample to just those fifteen states in the REDS panel, the share is 20%. The comparable figure in our analysis is a bit higher at 24% for households with electricity connections for agriculture and owning an electric appliance. The 55th NSS round (1999–00) indicates

Table 1 presents the share of panel households with electricity across the fifteen states in both rounds. There is considerable regional variation. In 1982, household electrification was less common in the East than elsewhere, especially the North (where many hydropower stations are found). Although many more households had received electricity by 1999, access was still limited in the East, especially Bihar, eastern parts of Madhya Pradesh, and Uttar Pradesh.

Table 1. Proportion of Rural Households with Electricity by State

		1982		1999	
	N	Mean	Std. dev.	Mean	Std. dev.
Andhra Pradesh	350	0.23	0.42	0.76	0.43
Bihar	277	0.03	0.17	0.08	0.28
Gujarat	463	0.29	0.45	0.94	0.24
Haryana	353	0.26	0.44	0.87	0.34
Himachal Pradesh	94	0.32	0.47	1.00	0.00
Karnataka	500	0.11	0.32	0.86	0.35
Kerala	330	0.39	0.49	0.91	0.29
Madhya Pradesh	627	0.22	0.42	0.70	0.46
Maharashtra	310	0.30	0.46	0.79	0.41
Orissa	337	0.27	0.44	0.58	0.49
Punjab	228	0.68	0.47	1.00	0.00
Rajasthan	639	0.32	0.48	0.70	0.46
Tamil Nadu	458	0.36	0.40	0.90	0.30
Uttar Pradesh	783	0.08	0.27	0.38	0.49
West Bengal	259	0.05	0.22	0.54	0.50
Total panel	6008	0.24	0.43	0.71	0.45

Notes: There were two more households in Andhra Pradesh in 1999 and two less in Tamil Nadu. A household is defined as being electrified if it owned an unambiguously electricity-run appliance or an electric irrigation pump set in 1982 and if it reports having electricity, incurring expenditures on electricity, or owning an electric pump set in 1999.

Source: 1982 and 1999 REDS panel.

Table 2 gives a cross-tabulation of the numbers of households in the panel according to whether they have electricity. We see that 49% (2,929/6,008) of the sampled panel households went from being non-electrified in 1982 to being electrified by 1999. (Very few went in the other direction.) The share of households with electricity for their own use rose from 24% to 71%.

The table also gives the cross-tabulations with village electrification, as reported in the village survey for REDS, which asked what year the village was electrified. The latter is not defined precisely, but we presume this to imply that the village has a feeder connection to the grid. (Nor does "village electrification" mean it had a reliable flow of electricity.) The expansion in village electrification is evident; in 1982, 27% of sampled households lived in villages without electricity; this had declined to 5% by 1999. The bulk of households with electricity lived in villages deemed to be electrified at both dates, although "non-grid" sources appear to have been relatively more important in 1982; 90% of households with electricity in 1982 lived in electrified villages as compared to 99% in 1999. Also notable is that 86% of those who did not have their own electricity at either date lived in electrified villages. An external effect for such households could thus entail large gains.

Table 2 also suggests that household demand-side factors have been important in electricity expansion for residential use. Amongst those households without electricity in 1982, 64% had acquired electricity by 1999. However, it is clear that the acquisition of electricity by the village was not the only

that 66% of rural households across the fifteen states in the REDS panel use electricity for domestic lighting, while our figure based on the REDS 1999 is 71%.

Table 2. Change in Rural Household and Village Electrification between 1982 and 1999

			1982						
			Household has electricity?						
			No			Yes			Total
			Village has electricity?			Village has electricity?			
	Household has electricity?	Village has electricity?	Yes	No	Total	Yes	No	Total	
1999	No	Yes	880	518	1,398	83	34	117	1,515
		No	0	233	233	0	5	5	238
		Total	880	751	1,631	83	39	122	1,753
	Yes	Yes	2,223	658	2,881	1,223	102	1,325	4,206
		No	0	47	47	0	2	2	49
		Total	2,223	705	2,928	1,223	104	1,327	4,255
	Total		3,103	1,456	4,559	1,306	143	1,449	6,008

Source: 1982 and 1999 REDS panel households. Also see Table 1 notes.

reason; indeed, 76% of the 2,928 households who acquired electricity for their own use over the period lived in villages that were already deemed to be electrified, presumably through a grid connection. (As one would expect, the villages that were connected in 1982 all stayed connected.) And 32% of the 1,631 households who did not have electricity at either date lived in villages that acquired a connection over the period. The evident importance of household-demand factors from table 2 reaffirms the importance of treating household electrification as endogenous.

We are interested in the dynamic impacts of village electrification separately from the current impacts of household access. Past grid-connection may bring cumulative gains over time, including for households not directly connected to the electricity source. Using these data, we construct a variable for the years since the village has been electrified. Given a few discrepancies in dates across the two rounds, we rely primarily on the 1982 data, which we deem likely to be more reliable given recall bias, but we use information from the later survey when the information is missing in the baseline and whenever electrification occurred more recently.

We first examine the impact of electrification on real total consumption per capita expressed in 1998 rupees. We also consider impacts on components of spending including fuel expenditures per capita.[17] The consumption variables are fully comparable across the two survey rounds.[18] Whether electricity has an impact on the ownership of kerosene run stoves is of interest given the claims that subsidized kerosene is substituted for cooking when electricity powers lighting.

The survey contains information on the primary and secondary activities of adults. We construct household level variables for the average number of eight-hour work days per individual male or female adult member in casual wage work, regular wage work, and nonagricultural and agricultural self-employment during the year preceding the survey round.[19] For our purposes here, we define adults to be those aged between sixteen and fifty-five.

Table 3 presents summary statistics for our outcome variables.

17 We are not able to examine fuel expenditures net of that spent on electricity, as these expenditures were not disaggregated in the first survey round. Fuel expenditures include the imputed value of own-produced fuel.

18 The online statistical addendum provides more information on the construction of these variables.

19 There are some measurement errors as person-specific days worked in certain activities run in excess of 365 days in a year. We restrict the number of potential person-days to 365 for each activity as well as the total person-days spent in all activities combined for every individual household member.

Table 3. Summary Statistics for Household Level Outcome Variables, by Electricity Status and Year

Panel households only	1982				1999			
	No electricity		Electricity		No electricity		Electricity	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Consumption variables (1998 Rs.)								
Total consumption per capita	3,414.34	1,939.49	5,687.66	4,537.10	5,133.11	2,694.52	9,163.87	7,725.03
Log total consumption per capita	8.002	0.514	8.466	0.569	8.437	0.446	8.945	0.552
Food consumption per capita	2,079.66	1,217.14	3,222.68	2,421.59	2,755.13	1,211.84	3,784.94	1,779.25
Nonfood, no-fuel consumption per capita	1,144.17	967.55	2,158.66	2,822.53	2,039.29	1,701.03	4,846.63	6,381.94
Clothing & footwear expenditures per capita	377.11	271.93	626.16	562.58	458.89	296.24	745.90	606.00
Entertainment expenditures per capita	40.60	63.95	84.54	148.51	75.47	126.71	154.78	252.68
Ceremonies expenditures per capita	56.01	299.83	117.60	845.80	195.94	769.71	644.11	2,439.41
Travel expenditures per capita	55.58	79.83	100.82	134.70	105.87	139.25	230.25	335.64
Education expenditures per capita	43.12	108.22	124.75	320.10	77.32	194.52	290.05	757.58
Health expenditures per capita	97.29	155.06	147.10	207.81	205.59	248.82	364.34	634.46
Domestic help expenditures per capita	3.94	34.45	47.25	362.52	3.02	86.39	22.03	269.49
Repairs to housing expenditures per capita	0.81	10.44	2.04	21.66	0.99	13.21	8.69	76.46
Fuel expenditure per capita	190.51	175.19	306.33	318.88	338.70	286.16	532.30	418.19
Kerosene stove ownership share	0.16	0.36	0.41	0.49	0.28	0.45	0.56	0.50
Days of (nondomestic) work per adult (aged 16–55)								
Total days of work by women	78.39	79.18	69.23	72.51	72.73	78.28	69.23	77.83
Total days of work by men	149.75	98.23	129.60	96.74	172.04	93.13	165.77	106.54
Days of regular wage work women	0.95	12.39	3.93	29.80	0.87	15.27	5.18	39.24
Days of regular wage work men	21.41	64.22	35.03	78.74	19.25	68.46	48.70	108.99
Days of casual wage work women	28.57	64.17	6.65	32.89	42.29	71.32	23.14	57.00
Days of casual wage work men	62.33	93.92	15.41	48.89	104.62	98.82	50.36	86.52
Days of agricultural self-employment by women	45.08	53.12	55.45	58.34	28.03	41.25	39.90	50.92
Days of agricultural self-employment by men	57.07	59.59	63.47	65.60	38.09	46.36	52.82	59.28
Days nonagricultural self-employment by women	4.07	18.97	3.48	17.35	1.75	16.71	1.33	14.42
Days nonagricultural self-employment by men	11.66	45.74	18.16	61.99	11.44	47.36	17.29	60.12
Share panel households with electricity			0.24	0.43			0.71	0.45
Observations	4,557		1,449		1,753		4,253	

Notes: Consumption aggregates are expressed in 1998 prices using a deflator obtained from NCAER. A household is defined as being electrified if it owned an unambiguously electricity-run appliance or an electric irrigation pump set in 1982 and if it reports having electricity, incurring expenditures on electricity, or owning an electric pump set in 1999. A household is involved in an activity if at least one family member aged sixteen and over is involved in the activity either as their primary or secondary activity. The number of days worked in each activity is calculated based on the total hours reported in the activity during the last year, divided by eight. Days are then expressed as a household mean for male and female members aged sixteen to fifty-five. The data are unweighted.

Source: 1982 and 1999 REDS panel.

In choosing controls, we have been guided in part by past literature. In the closest prior study for India, Khandker et al. (2012) controls for household demographic characteristics, maximum education, land and nonland assets, and infrastructure. The REDS allows a similar set of controls. Our base-year household level controls include demographic characteristics (age, age squared, and marital status of the household head, disability/illness in the household, size and age/gender composition, religion, and caste); maximum years of schooling of any adult; and wealth variables (dummies for landownership and whether the house is built with bricks and inherited land amounts). Community variables include access to facilities and infrastructure, local agricultural and nonagricultural wages for men and women, the Muslim population share, characteristics of land tenure and cultivable land, a dummy indicating below normal crop yields in the preceding year and inequality as measured by the mean log deviation of household consumption in the community. We also include controls for some changes in household characteristics (including size and composition and the maximum education) and in community characteristics over time. There are endogeneity concerns about some of these controls to which we will return. We do not control for changes in whether the house is built with bricks, land inheritance amounts, or changes in village access to facilities that are all clearly affected by access to electricity. Finally we include a dummy variable to indicate whether the household split between the survey rounds.

Physical proximity to power generating plants is known to have influenced the placement of grid infrastructure (see, for example, Chaurey et al. 2004). For identification purposes, we use data on the location of power generating plants obtained from the 2004–5 CO2 Baseline Database for the Indian Power Sector, published by the Central Electricity Authority of India. This public database has detailed information on each power plant in India, across different types of power (hydropower versus thermal, for example) and generating capacity. The data include the date at which each power plant became active. Using the GPS locations of the REDS survey villages, we calculated the straight-line distance from each village to the nearest power plant for 1965 (as a benchmark before the REDS survey, during the time when rural electricity generation capacity was beginning to expand) and for 1975.

III. Specification and Identification

We postulate two distinct ways that a rural household can benefit from electrification. First, it can gain from village electrification, even if it does not have electricity itself, though the extent of that gain may depend on whether the household itself has electricity. Second, the household can gain directly from having electricity inside the home. We first outline the model specification and then discuss identification.

Model Specification

To quantify these two factors we exploit the unusually long time period in the REDS panel. This allows us to observe household consumption at a base date (1982), denoted C_{ij82} for household i in village j, and at the follow-up survey date seventeen years later (1999), denoted C_{ij99}.

To help motivate our model specification, consider first a standard difference-in-difference (DD) specification giving the change in (log) consumption for household i in village j as a function of the change in electrification:

$$\Delta \ln C_{ij99} = \ln(C_{ij99}/C_{ij82}) = \alpha + \gamma(E_{ij99} - E_{ij82}) + \epsilon_{ij} \quad (1)$$

Here E_{ij99} and E_{ij82} denote whether household i in village j has electricity in 1999 and 1982 respectively. This allows household electrification to yield a proportionate consumption gain represented by the term $\gamma(E_{ij99} - E_{ij82})$. Household fixed effects in the levels of log consumption are differenced out in deriving equation (1). The specification in (1) allows for a time effect in the levels of consumption, represented by α. In the simple DD set-up, the innovation error term, ϵ_{ij}, is assumed to be orthogonal to $(E_{ij99} - E_{ij82})$.

There are two groups of concerns about this specification in this context.

Dynamic Effects

The first concern is that there may be dynamic returns to electrification. There are two aspects to consider. One is that the returns to household electrification vary over time. This can be addressed by allowing for a vector of control variables (X_{ij}) that includes E_{ij82}. We test this, as described further below. If we cannot reject the null hypothesis that the coefficient on E_{ij82} in the vector X_{ij} is zero then the relationship between consumption growth and household electrification is said to be homogeneous, meaning that the effect is the same at the two dates.

Another possibility within this overall concern about dynamics is that this specification does not allow explicitly for a cumulative effect of electrification. In the underlying levels equation (for which equation 1 is the differenced model) current consumption only depends on current electrification. If there is also a cumulative gain from past access then this will depend on the time period in which the household had electricity. As a practical matter, we do not know from the data when the household gained electricity. What we do know is when the village was connected to the grid. Note also that village electrification can have both an internal (dynamic) gain for a household with electricity and an external gain to those who do not have electricity themselves.

To allow for a dynamic effect of past electrification we postulate that village electrification allows household consumption to grow at a higher rate. Let T_j denote the number of years that village j has been connected to the grid. We expect that the gain in consumption from village electrification will also depend on whether the household has electricity itself. Our prior here is that there will be a larger external effect for those who do not have their own electricity connection. Thus we would ideally augment equation (1) with an extra term of the form $(\beta_0 + \beta_1 E_{ij99-T_j})T_j$ where $E_{ij99-T_j} = 1$ if the household has electricity at the time of connection to the grid T_j years earlier and $E_{ij99-T_j} = 0$ otherwise. As a practical matter, however, we do not observe whether the household had electricity at the time of the grid connection, as we only observe this for the initial and the final survey dates. We replace E_{ij99-T_j} by E_{ij99}. (This will probably produce some attenuation bias in our estimates of β_1.) We considered the alternative of replacing E_{ij99-T_j} by E_{ij82}. However, since we will be using E_{ij82} as an instrumental variable for E_{ij99} this makes little difference—either one is using E_{ij82} or a predicted value based on E_{ij82}.

Notice that the dynamic gain becomes $\beta_0(1 - E_{ij99-T_j})$ under the restriction $\beta_0 + \beta_1 = 0$, in which case the private return to village grid connection is zero if one already has electricity privately. We do not assume that this is the case but rather test the null hypothesis that $\beta_0 + \beta_1 = 0$ as a restricted form.

Endogeneity of Electricity Acquisition

There are two reasons why one can question the assumption that $Cov[\epsilon_{ij}, (E_{ij99} - E_{ij82})] = 0$ in (1). The first relates to observable sources of endogeneity, while the second relates to unobservable ones. With regard to the first, there may be systematic heterogeneity in the observable baseline characteristics of households and in changes over time in exogenous characteristics that jointly influence consumption growth and the acquisition of electricity, implying that $Cov[\epsilon_{ij}, (E_{ij99} - E_{ij82})] \neq 0$ in (1). To address this concern we augment equation (1) to include a vector of household and community characteristics as controls, which include changes in exogenous characteristics.

Thus, on incorporating the dynamic effect, we have the following augmented DD model of consumption growth between the beginning and final survey dates:

$$\Delta \ln C_{ij99} = \alpha + (\beta_0 + \beta_1 E_{ij99})T_j + \gamma(E_{ij99} - E_{ij82}) + \pi X_{ij} + \epsilon_{ij} \quad (2)$$

(We use the same specification for labor supply.) In this equation we see the two distinct ways that electrification can matter. The first is through village electrification, the benefits of which can depend on own-electrification; this is the term $(\beta_0 + \beta_1 E_{ij99})T_j$. We interpret this as the external effect. The second (partial equilibrium) channel is the direct idiosyncratic effect of the household acquiring electricity within the period $(\gamma(E_{ij99} - E_{ij82}))$.

The second endogeneity concern is that there may well be latent characteristics (or changes in characteristics) in the error term that are correlated with electricity acquisition, again implying that $Cov[\epsilon_{ij}, (E_{ij99} - E_{ij82})] \neq 0$. We next turn to our identifying assumptions in addressing this concern.

Identifying Assumptions

While geographic variables are plausible predictors of electricity placement at the household level, the validity of the exclusion restrictions is never beyond question. Household electrification in the geographic area is a questionable IV since we postulate the existence of external benefits (including to non-electrified households), such as through greater employment opportunities or general equilibrium price effects on the village economy. Geographic proximity to an electricity line is also questionable given endogenous placement of those lines.[20]

We shall use instead long lags of proximity to the primary power generators source from which the transmission lines emanate. While the lines and substations that emanate from that source are endogenously placed, the source itself can be more plausibly treated as independent of household outcomes conditional on placement and other covariates. Of course, judgments on the plausibility of the identification strategy must also depend on what other control variables are used, given that the estimator is making a conditional independence assumption. By exploiting the relatively rich REDS data on village attributes and the (long) panel structure we believe that our exclusion restriction is defensible.

We make two identifying assumptions. The first assumption is as follows:

Identifying Assumption 1

The endogeneity of household electrification is confined to the acquisition of electricity over the time period, i.e., E_{ij99} is endogenous but E_{ij82} is exogenous and excludable from the vector X_{ij} in (2). Thus E_{ij82} is used as an IV for $E_{ij99} - E_{ij82}$.

We acknowledge that this assumption can be questioned. Although exogeneity of E_{ij82} is more plausible over a long period (seventeen years in our case), the length of the time period also makes it more likely that the returns to electrification may have changed (as noted already). This casts doubt on the homogeneity condition and (hence) the excludability of the initial value in a difference-in-difference specification. In view of this concern, we use a second IV to test the validity of assumption 1. Given an over-identifying IV, the homogeneity restriction is testable. The sequential structure to the identification plays an important role in that we do not estimate impacts unless the first assumption is deemed to be valid. For this purpose we draw on our second identifying assumption:

Identifying Assumption 2

Access to electricity depends in part on historical proximity to the primary power-generating plants, which does not influence outcomes independently of electrification or the other controls, including other exogenous geographic variables.

20 Chakravorty et al. (2014) argue that their use of the local density to federally placed transmission lines is a better instrument than the state-placed distribution systems, but the concern remains; as Chakravorty et al. note, the placement of the transmission lines from power generating plants is a matter of choice, and past placement is likely to have responded to the potential for local nonfarm development.

In implementing assumption 2, we use the distance in kilometers from the village to the nearest power generating plant within the state in 1965 and 1975. As compared to distance to the nearest power substation (which supplies feeder lines to villages and is hence located closer to villages), distance to the nearest power generating plant is more likely to be orthogonal to unobserved factors affecting household outcomes and electricity access. Villages do not shift location in rural India, and even by 1999, power-generating plants were often several hundred kilometers away from villages (with means of 177 km in 1965, and 139 km in 1999). Also, power generating plants are typically located on engineering criteria and do not appear to have any special economic salience beyond that. So it does not seem plausible that proximity to a power station (let alone 10–20 years ago) would have any lasting independent effect on household consumption. Nonetheless, to help relieve concerns about omitted geographic factors correlated with proximity to power generating plants we allow a complete set of district fixed effects, as well as control variables for village characteristics, in the vector X. We include initial conditions (1982 values) of the household and community characteristics detailed in Section II as well as changes in their value over time. We tested separate specifications dropping variables that are potentially endogenous (such as changes in household land and housing material and in community access to facilities[21]). Our preferred model and the one we will focus on omits these variables. The online addendum gives supplementary summary statistics including for the control variables.

Armed with the extra IV, we test the null hypothesis that electrification has the same effect at each date, conditional on other controls, that is, we test whether E_{ij82} should be included in the control vector X_{ij}. It is this homogeneity restriction that allows us to use E_{ij82} as an IV for E_{ij99}. In other words, this is the test of the exclusion restriction for this IV, which is only possible given that we have the second IV. If the test fails then we will not employ our estimator.[22]

IV. Results

We first discuss the results for consumption, before turning to the role of labor earnings as the channel of impact.

Total Consumption

The first stage regressions for electrification are given in table 4. As expected based on table 2, there are a number of significant demand-side factors in the expansion of household electrification over the period (including religion, caste, schooling, and wealth variables). Even so, the instruments perform well. Distance to the nearest power generating plant for the two years we examine has a strong significant impact on household electrification. The two distance variables enter with about the same coefficient but opposite signs, implying that the households living in villages for which the distance to a power station fell more (higher difference between the “1965 distance” and that for 1975) were more likely to gain access to electricity.[23]

21 Including these potentially endogenous household and community change variables results in a slightly higher IV estimate of the internal household effect but no difference to the external village effect.

22 Strictly, our model is still identified if the test fails. However, with only the second, geographic IV left, we naturally do not feel that this would adequately capture the exogenous variation in household electrification.

23 Note that the signs switch between columns (1) and (2) in table 4 since the dependent variable in (1) reflects whether a household is not electrified in 1999.

Table 4. First Stage Estimates

Variables	(1) Years of village elec. 99 * Household not electrified 99	(2) Change in HH electrification
Log household size (initial condition)	−0.064	0.001
	[−0.13]	[0.06]
Age of head (initial condition)	−0.128	0.006
	[−1.47]	[1.54]
Age sq. of head (initial condition)	0.001	−0.000
	[1.49]	[−1.55]
Head is divorced/widowed (initial condition)	0.519	−0.051*
	[0.75]	[−1.81]
A HH member 15+ has chronic illness/disability (initial condition)	−0.947**	0.035*
	[−2.10]	[1.81]
Head is Hindu (initial condition)	−1.432*	0.067**
	[−1.91]	[2.48]
Head is SC/ST (initial condition)	2.442***	−0.066***
	[5.19]	[−3.50]
Max yrs. of schooling of any adult 15+ (initial cond.)	−0.452***	0.020***
	[−3.75]	[4.39]
Max yrs. of schooling of any adult 15+ squared (initial condition)	−0.003	0.000
	[−0.46]	[0.86]
Share of women aged 16–55 (initial condition)	−1.144	0.037
	[−0.61]	[0.55]
Share of men aged 16–55 (initial condition)	2.241	−0.085
	[1.22]	[−1.38]
Share of girls aged 7–15 (initial condition)	0.986	0.011
	[0.42]	[0.13]
Share of boys aged 7–15 (initial condition)	0.224	−0.068
	[0.10]	[−0.81]
Share of girls aged 0–6 (initial condition)	0.213	−0.006
	[0.07]	[−0.05]
Share of boys aged 0–6 (initial condition)	1.586	−0.081
	[0.69]	[−0.90]
Head moved from outside village (initial condition)	1.167	−0.075*
	[1.35]	[−1.73]
HH owns land (initial condition)	−1.755***	0.089***
	[−3.18]	[4.15]
Inherited land (100s acres) (initial condition)	−0.023	0.001
	[−0.77]	[0.76]
House made from bricks/cement (initial condition)	−0.714*	0.038**
	[−1.86]	[2.19]
Mean log deviation of total village consumption (initial condition)	−6.488*	0.344**
	[−1.66]	[2.14]
Village crop yield below normal (initial condition)	1.434	−0.012
	[1.64]	[−0.29]
Share of Muslims in village (initial condition)	0.256	0.012
	[0.14]	[0.23]
Share of village area under cultivation (initial condition)	−2.465***	0.124***
	[−2.64]	[3.41]

Continued

Table 4. (continued)

Variables	(1) Years of village elec. 99 * Household not electrified 99	(2) Change in HH electrification
Large landowners lease out land (initial condition)	0.259	−0.008
	[0.40]	[−0.33]
Km to nearest pucca road (initial condition)	0.007	−0.001***
	[0.99]	[−2.60]
Km to block HQ (initial condition)	−0.002	0.000
	[−0.72]	[0.70]
Nearest market within 2 km of village (initial condition)	−1.068	0.022
	[−1.32]	[0.73]
Cooperative in village (initial condition)	1.352**	−0.022
	[2.18]	[−0.87]
Health facility within 5 km (initial condition)	−0.462	−0.009
	[−0.93]	[−0.50]
Primary school within 2 km (initial condition)	−0.152	0.007
	[−0.26]	[0.26]
Secondary school within 2 km (initial condition)	0.785	−0.015
	[1.27]	[−0.52]
Community has a public drinking water tap (initial condition)	−0.638	0.007
	[−1.08]	[0.35]
Ag. wage rate for women (initial condition)	−0.149	−0.003
	[−1.11]	[−0.60]
Non-ag. wage rate for women (initial condition)	−0.034	−0.004
	[−0.38]	[−1.37]
Agricultural wage rate for men (initial condition)	−0.046	0.007*
	[−0.46]	[1.83]
Non-ag. wage rate for men (initial condition)	0.139**	−0.002
	[2.44]	[−1.00]
HH split in 1998 (y = 1, n = 0)	−0.683**	0.033***
	[−2.28]	[2.66]
Log HH size, diff.	−0.765**	0.021
	[−2.18]	[1.29]
Age of head, diff.	−0.035	0.003
	[−0.69]	[1.57]
Age of head sq., diff	0.000	−0.000
	[0.69]	[−1.48]
Head is divorced/widowed, diff.	0.618	−0.028*
	[1.48]	[−1.66]
HH member 15+ has chronic illness/disability, diff.	−0.734**	0.022*
	[−2.11]	[1.83]
Max yrs of schooling of any adult, diff.	−0.270***	0.013***
	[−3.21]	[3.58]
Max yrs of schooling of any adult sq., diff.	−0.004	0.000
	[−0.88]	[1.04]
Share of women aged 16–55, diff.	−1.030	0.035
	[−0.89]	[0.79]
Share of men aged 16–55, diff.	1.039	−0.053
	[0.95]	[−1.44]
Share of girls aged 7–15, diff.	0.335	0.010
	[0.24]	[0.18]
Share of boys aged 7–15, diff.	−0.352	−0.027
	[−0.30]	[−0.55]

Continued

Table 4. (continued)

Variables	(1) Years of village elec. 99 * Household not electrified 99	(2) Change in HH electrification
Share of girls aged 0–6, diff.	1.442	−0.047
	[0.95]	[−0.78]
Share of boys aged 0–6, diff.	1.723	−0.079
	[1.21]	[−1.41]
HH owns land y = 1 n = 0, diff.	−2.527***	0.109***
	[−6.11]	[6.80]
Village mean log deviation of total consumption, diff.	−0.864	0.149
	[−0.38]	[1.55]
Crop yield below normal, diff.	1.408**	−0.066**
	[2.41]	[−2.18]
Share of Muslims in village, diff.	1.101	0.103**
	[0.72]	[2.30]
Distance to block headquarters, diff.	0.003	−0.000
	[0.91]	[−0.23]
Years in 1999 since village was electrified	0.367***	0.003***
	[11.63]	[3.13]
Interaction: years in 1999 of village electrification* HH is electrified in 1982	−0.083***	−0.003***
	[−2.75]	[−2.89]
Identifying instruments		
Distance to power plant in 1965	−2.132**	0.138***
	[−2.50]	[4.74]
Distance to power plant in 1975	1.880***	−0.081***
	[2.66]	[−3.71]
HH is electrified in 1982 y = 1, n = 0	1.099	−0.894***
	[1.22]	[−23.19]
Constant	3.493	0.049
	[0.90]	[0.35]
Observations	5,954	5,954
R-squared	0.440	0.606
F-test of excluded instruments F (5,241)	28.80	913.04
Prob.	0.0000	0.0000

Notes: Robust t-statistics in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. A household is defined as being electrified if it owned an unambiguously electricity-run appliance or an electric irrigation pump set in 1982 and if it reports having electricity, incurring expenditures on electricity, or owning an electric pump set in 1999.

Source: Authors' calculations using 1982 and 1999 REDS panel.

Table 5 provides the detailed total consumption regression results for the various specifications, as well as the homogeneity tests. The simple DD method attributes a 17.7% increase in consumption to the household acquisition of electricity (1.0% per annum).[24] Evaluated at the mean consumption of those households who did not have electricity in 1982, this represents a gain of Rs. 604.30 per person per year. However, the simple DD method appears to greatly over-estimate the consumption gains attributable to electrification. Our IV estimator gives an implied consumption gain of 8.8% (0.5% per annum), representing a gain of Rs. 300.3 per person per year. These numbers suggest sizeable bias due to endogenous acquisition of electricity by more (latently) wealthy families.

24 Note that the regression coefficient of 0.163 is the change in log consumption. Then the ratio of consumption in 1999 to 1982 is exp (0.163) = 1.177

Table 5. Detailed Results for the Panel Data Regressions for Household Consumption

Variables	(1) OLS Simple DD	(2) OLS	(3) OLS with restriction imposed	(4) IV	(5) IV with restriction imposed
Years village has been electrified 1999		0.001		0.024*	
		[0.60]		[1.96]	
Interaction: years village electrified in 99* HH electrified in 99		0.002		−0.034*	
		[1.14]		[−1.80]	
Interaction: years village electrified in 99* HH not electrified in 99			−0.001		0.008**
			[−0.79]		[2.00]
Change in HH electrification between 99 and 82	0.163***	0.100***	0.105***	0.051	0.084***
	[6.85]	[4.51]	[4.93]	[1.31]	[2.97]
Log HH size (initial condition)		0.047	0.045	0.046	0.047
		[1.51]	[1.45]	[1.25]	[1.50]
Age of head (initial condition)		0.001	0.001	0.006	0.002
		[0.16]	[0.20]	[0.91]	[0.39]
Age sq. of head (initial condition)		−0.000	−0.000	−0.000	−0.000
		[−0.12]	[−0.15]	[−0.90]	[−0.37]
Head is divorced/widowed (initial condition)		−0.012	−0.012	−0.031	−0.017
		[−0.34]	[−0.34]	[−0.65]	[−0.47]
HH member 15+ has chronic illness/disability (initial condition)		−0.052*	−0.051*	−0.014	−0.042
		[−1.95]	[−1.92]	[−0.41]	[−1.60]
Head is Hindu (initial condition)		0.039	0.041	0.090*	0.051
		[1.10]	[1.17]	[1.77]	[1.45]
Head is SC/ST (initial condition)		−0.027	−0.030	−0.114**	−0.049*
		[−0.96]	[−1.09]	[−1.98]	[−1.69]
Max yrs. of schooling of any adult 15+ (initial condition)		−0.009	−0.009	0.008	−0.005
		[−1.43]	[−1.35]	[0.66]	[−0.77]
Max yrs. of schooling sq of any adult 15+ (initial condition)		0.001**	0.001**	0.001**	0.001**
		[2.51]	[2.53]	[2.51]	[2.59]
Share of women aged 16–55 (initial condition)		0.032	0.032	0.071	0.042
		[0.32]	[0.33]	[0.54]	[0.41]
Share of men aged 16–55 (initial condition)		0.021	0.018	−0.066	−0.001
		[0.24]	[0.21]	[−0.59]	[−0.01]
Share of girls aged 7–15 (initial condition)		−0.017	−0.015	−0.056	−0.028
		[−0.14]	[−0.12]	[−0.38]	[−0.22]
Share of boys aged 7–15 (initial condition)		−0.050	−0.046	−0.060	−0.053
		[−0.43]	[−0.40]	[−0.46]	[−0.47]
Share of girls aged 0–6 (initial condition)		0.284**	0.290**	0.276	0.281*
		[1.98]	[2.02]	[1.44]	[1.88]
Share of boys aged 0–6 (initial condition)		−0.080	−0.075	−0.132	−0.095
		[−0.63]	[−0.59]	[−0.90]	[−0.75]
Head moved from outside village (initial condition)		0.050	0.051	0.000	0.037
		[0.83]	[0.84]	[0.00]	[0.61]
HH owns land (initial condition)		−0.089***	−0.088***	−0.017	−0.070**
		[−3.27]	[−3.25]	[−0.33]	[−2.32]
Inherited landownings (100s acres) (initial condition)		−0.014***	−0.014***	−0.013***	−0.013***
		[−3.54]	[−3.52]	[−2.98]	[−3.41]
House made from bricks/cement (initial condition)		−0.127***	−0.126***	−0.099***	−0.120***
		[−3.74]	[−3.73]	[−2.72]	[−3.57]

Continued

Table 5. (continued)

Variables	(1) OLS Simple DD	(2) OLS	(3) OLS with restriction imposed	(4) IV	(5) IV with restriction imposed
Village mean log deviation of total consumption (initial condition)		−0.184	−0.132	0.007	−0.148
		[−0.74]	[−0.52]	[0.02]	[−0.60]
Crop yield below normal (initial condition)		0.084*	0.091**	0.026	0.067
		[1.88]	[2.05]	[0.42]	[1.45]
Share of Muslims in village (initial condition)		−0.076	−0.052	−0.064	−0.079
		[−0.77]	[−0.53]	[−0.54]	[−0.80]
Share of village area under cultivation (initial condition)		−0.217***	−0.215***	−0.135*	−0.196***
		[−3.26]	[−3.21]	[−1.71]	[−2.93]
Large landowners lease out land (initial condition)		−0.094**	−0.094**	−0.100**	−0.096**
		[−2.14]	[−2.12]	[−2.11]	[−2.19]
Km to nearest pucca road (initial condition)		−0.000	−0.000	−0.000	−0.000
		[−0.51]	[−0.62]	[−0.75]	[−0.57]
Km to block HQ (initial condition)		−0.000	−0.000	0.000	−0.000
		[−0.22]	[−0.10]	[0.15]	[−0.15]
Nearest market within 2 km of village (initial condition)		−0.020	−0.027	0.024	−0.006
		[−0.38]	[−0.53]	[0.38]	[−0.12]
Cooperative in village (initial condition)		−0.056	−0.058*	−0.101*	−0.068*
		[−1.64]	[−1.66]	[−1.90]	[−1.91]
Health facility within 5 km (initial condition)		0.042	0.044	0.061	0.047
		[1.51]	[1.60]	[1.64]	[1.63]
Primary school within 2 km (initial condition)		0.071	0.067	0.079*	0.075
		[1.53]	[1.41]	[1.69]	[1.64]
Secondary school within 2 km (initial condition)		−0.039	−0.039	−0.066	−0.046
		[−1.03]	[−1.00]	[−1.49]	[−1.25]
Community has a public drinking water tap (initial condition)		−0.011	−0.012	0.012	−0.005
		[−0.27]	[−0.28]	[0.27]	[−0.12]
Ag. wage rate for women (initial condition)		0.009	0.009	0.012	0.010
		[1.33]	[1.32]	[1.61]	[1.48]
Non-ag. wage rate for women (initial condition)		0.005	0.006	0.006	0.005
		[0.78]	[0.94]	[0.88]	[0.79]
Ag. wage rate for men (initial condition)		0.004	0.006	0.005	0.004
		[0.73]	[0.99]	[0.77]	[0.68]
Non-ag. wage rate for men(initial condition)		0.009**	0.009**	0.003	0.008*
		[2.22]	[2.18]	[0.65]	[1.90]
HH split in 1998 (y = 1, n = 0)		−0.050***	−0.050***	−0.022	−0.042**
		[−2.98]	[−2.99]	[−0.87]	[−2.42]
Log HH size, diff.		−0.428***	−0.429***	−0.400***	−0.420***
		[−21.35]	[−21.38]	[−14.10]	[−20.27]
Age of head, diff.		0.004	0.004	0.006	0.004
		[1.31]	[1.34]	[1.55]	[1.43]
Age of head sq., diff.		−0.000	−0.000	−0.000	−0.000
		[−1.03]	[−1.05]	[−1.29]	[−1.15]
Head is divorced/widowed, diff.		−0.012	−0.012	−0.035	−0.018
		[−0.59]	[−0.57]	[−1.16]	[−0.85]
HH member 15+ has chronic illness/disability, diff.		0.058***	0.059***	0.086***	0.065***
		[3.59]	[3.64]	[3.41]	[3.98]
Max yrs of schooling of any adult, diff.		−0.011***	−0.011***	−0.001	−0.009**
		[−2.67]	[−2.61]	[−0.12]	[−2.04]

Continued

Table 5. (continued)

Variables	(1) OLS Simple DD	(2) OLS	(3) OLS with restriction imposed	(4) IV	(5) IV with restriction imposed
Max yrs of schooling of any adult sq., diff.		0.002***	0.002***	0.002***	0.002***
		[6.20]	[6.21]	[5.84]	[6.34]
Share of women aged 16–55, diff.		0.162***	0.162***	0.202***	0.172***
		[3.04]	[3.03]	[2.60]	[3.03]
Share of men aged 16–55, diff.		0.231***	0.231***	0.193***	0.221***
		[4.51]	[4.52]	[3.07]	[4.41]
Share of girls aged 7–15, diff.		−0.046	−0.040	−0.052	−0.049
		[−0.67]	[−0.59]	[−0.60]	[−0.70]
Share of boys aged 7–15, diff.		0.067	0.069	0.078	0.069
		[0.99]	[1.03]	[0.98]	[1.02]
Share of girls aged 0–6, diff.		−0.112	−0.109	−0.161	−0.126
		[−1.35]	[−1.31]	[−1.55]	[−1.48]
Share of boys aged 0–6, diff.		−0.200***	−0.196***	−0.258***	−0.217***
		[−2.72]	[−2.67]	[−2.68]	[−2.86]
HH owns land y = 1 n = 0, diff.		0.084***	0.084***	0.179***	0.108***
		[4.30]	[4.32]	[3.10]	[4.61]
Village mean log deviation of total consumption, diff.		0.136	0.170	0.116	0.122
		[0.79]	[0.97]	[0.63]	[0.71]
Crop yield below normal, diff.		0.003	0.003	−0.047	−0.010
		[0.10]	[0.10]	[−1.03]	[−0.30]
Share of Muslims in village, diff.		0.050	0.052	0.015	0.040
		[0.52]	[0.54]	[0.14]	[0.42]
Distance to block headquarters, diff.		0.000	0.000	−0.000	−0.000
		[0.12]	[0.25]	[−0.44]	[−0.07]
Constant	0.607	−0.162	−0.094	−0.159	−0.181
	[25.80]	[−0.83]	[−0.50]	[−0.74]	[−0.94]
District fixed effects	No	Yes	Yes	Yes	Yes
Homogeneity test:					
F (1,241)		2.90		2.04	
Prob.		(0.090)		(1.154)	
Observations	6,006	5,954	5,954	5,954	5,954
R-squared	0.019	0.466	0.466	0.209	0.449

Notes: A household is defined as being electrified if it owned an unambiguously electricity-run appliance or an electric irrigation pump set in 1982 and if it reports having electricity, incurring expenditures on electricity, or owning an electric pump set in 1999. Robust t-statistics in brackets. Clustering is at the village level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. District fixed effects are included. Identifying IVs are as in table 4.

Source: Authors' calculations using 1982 and 1999 REDS panel.

Continuing to focus on our IV estimator, we could not reject the null hypothesis that $\beta_0 + \beta_1 = 0$ in all but one of the regressions (entertainment expenditure per capita), so we give results with this restriction imposed (or note its rejection). This implies that village electrification had no significant effect on our household level outcomes if the household already had electricity (beyond the internal effect captured by the term $\gamma(E_{ij99} - E_{ij82})$). The dynamic benefits of village electrification are largely confined to those households without electricity. Given that we cannot reject the null that $\beta_0 + \beta_1 = 0$, we are justified in using E_{ij82} as an IV.

However, the dynamic effect is not estimated with much precision; the 95% confidence interval includes the possibility that it is virtually zero. Comparisons between the magnitudes of the external and internal effects are thus of uncertain veracity.

There are also possible concerns with these results related to the other control variables. In particular, we have included controls for the change in (log) household size and the change in the maximum years of schooling. The assumption that these variables are exogenous can be questioned. And it could be argued that these are also channels of influence for electrification, leading us to underestimate the impact. Against these concerns, there is a potential omitted variable bias in excluding these controls.

We tried dropping the control for the change in log household size and instead using the change in log consumption per equivalent single person as the dependent variable, where the number of equivalent persons was assumed to be the square root of household size. This assumption was motivated by the fact that the coefficient on the change in log household size was close to -0.5.[25] This made little difference to the results for electrification; the coefficient on the change in household electrification in the IV estimate fell slightly (to 0.083 with a t-ratio of 2.98), while the coefficient on the village effect and its standard error were almost identical.

There was greater sensitivity to dropping the controls for changes in the household's maximum education. Then the coefficient on household electrification fell to 0.065 with a t-ratio of 2.22, while the coefficient and standard error for the village effect increased (0.009; $t = 2.41$). Not controlling for education (a key factor in other income sources) may well be imparting a downward bias on the estimated impact of household electrification. This bias stems from a "catching up" process in the spread of electrification, whereby it tended to be the less well educated households in 1998 who had become electrified—the relatively well-off having already acquired electricity in the base year.[26]

We found no sign of village effects until we use our IV estimator with homogeneity imposed. Then a significant effect emerges for those households without their own electricity. The annualized consumption gain from village electrification for households who are not electrified is 0.8%. (Note that β_0 can be interpreted as the annual growth rate of consumption attributed to village electrification for a household that is not electrified. By contrast, the coefficient on the household becoming electrified gives the total impact over the period.)

We also estimated a specification with extra controls for changes in village characteristics related to village accessibility, infrastructure, and institutions.[27] There are concerns about the possible endogeneity of these extra controls, but there are also concerns about omitted variable biases. This specification shows a somewhat stronger village externality of electrification (the coefficient rose to 0.009, $t = 2.34$). The coefficient and standard error for household electrification in this augmented model was 0.079, $t = 2.81$.

From a methodological perspective, it is notable that our IV estimator implies large selection biases in either single or double difference estimators.[28] From the difference in means of log consumption per capita the single difference estimate (log consumption for households with electricity less that for those without it) is 0.508, implying a selection bias of 0.424 (the difference between 0.508 and our IV estimate of 0.084). The selection bias accounts for 83% of the observed difference. The DD estimator reduces the bias considerably, bringing it down to 0.079 (the difference between 0.163 and our IV estimate of 0.084 from table 4). Nonetheless, even for the DD estimator, the selection bias is as large again as our impact estimate.

25 The coefficient in the restricted IV regression is -0.42 ($t = 20.3$); (see column 5 of table 5).

26 This is evident when we regress the change in the maximum years of education on the change in household electrification controlling for all other covariates used in the main regression. The regression coefficient is negative and significant (at the 1% level).

27 The extra variables included the changes in the distances to: a paved road, market, health clinic, and school and changes in the presence of a public water tap and an agricultural cooperative.

28 The following calculations use the fact that the observed difference between mean outcomes for those receiving a program and those who do not is identically equal to the true causal impact (the treatment effect for those treated) plus the selection bias (the difference in counterfactual outcomes between those receiving the program and those not).

Table 6. Impacts of Household and Village Electrification on Consumption and Its Components

	Simple DD	IVE: Allowing for external village effect, endogenous electrification and with controls	
	Change in household electrification	Change in household electrification	Years of village electrification in 1999 *times* household not electrified in 1999
Total consumption expenditure per capita (log)	0.163***	0.084***	0.008**
	(6.85)	(2.97)	(2.00)
Food expenditure per capita (log)	0.098***	0.095***	−0.0002
	(4.42)	(3.42)	(−0.06)
Fuel expenditure per capita (log)	0.174***	0.229***	−0.001
	(3.50)	(4.89)	(−0.06)
Nonfood, nonfuel expenditure per capita (log)	0.260***	0.084**	0.013***
	(8.01)	(2.26)	(2.77)
Of which: Clothing & footwear	0.228***	0.115**	0.004
	(5.56)	(2.34)	(0.55)
Entertainment	0.882***	–	–
	(2.85)		
Ceremonies	0.654*	−0.606*	0.099*
	(1.72)	(−1.80)	(1.77)
Travel	0.471**	−0.091	−0.072
	(2.52)	(−0.40)	(−1.45)
Education	0.454*	0.439	0.020
	(1.73)	(1.31)	(0.52)
Health	0.251**	0.056	−0.0004
	(2.09)	(0.43)	(−0.02)
Domestic help	0.320**	0.127	0.018
	(2.28)	(0.59)	(0.69)
Repairs to housing	0.147	−0.095	−0.009
	(1.28)	(−0.64)	(−0.48)
Owns a kerosene stove (1 = yes; 0 = no)	0.133***	0.131***	0.002
	(6.57)	(4.92)	(0.64)

Notes: The table gives the regression coefficients for electrification for each outcome variable. DD: "difference-in-difference." IVE: Instrumental variables estimates of a panel data model treating the acquisition of electricity as endogenous, using distances in 1965 and 1975 to the nearest power plant and whether the household was electrified in 1982 as IVs. Controls and district effects included. See text for further details. ***: 1%; **: 5%; *: 10%. The restriction passes in all cases but one (entertainment expenditure per capita). Also see notes to table 3.

Source: Authors' calculations using 1982 and 1999 REDS panel.

Components of Consumption

Table 6 gives results for the components of consumption. The table first gives the simple DD estimate of the effect of electrification for each outcome variable. Next, the table gives our estimates of the same parameter based on equation (2), allowing for the village-level external effect with controls and treating the household's acquisition of electricity by 1999 as endogenous. The last column of table 6 gives the corresponding estimates of the external effect from each regression.

We find a significant internal effect of electrification on each of the three main categories: food, fuel, and other (nonfood, nonfuel) expenditures. The impacts are robust to allowing for the endogeneity of household acquisition of electricity. When we break up nonfood, nonfuel spending further, we find significant internal effects on all components other than repairs to the house. However, only spending on clothing and on ceremonies (with a negative effect) are robust to allowing for endogeneity. The positive and strong internal effects on fuel expenditures imply about a 25.7% increase as a result of the household acquisition of electricity.

We find significant external effects on nonfood, nonfuel spending. This is suggestive of the social effects on consumption behavior discussed in section II, whereby households without electricity themselves shift their spending toward consumer goods that display affluence (unlike food, which is typically consumed in the privacy of one's home). We investigated this further using a finer breakdown of nonfood consumption. Most suggestive of such a social effect is a (just) significant and positive external effect on spending on ceremonies (a coefficient of 0.099, $t = 1.77$); in contrast, the (just) significant internal effect is negative (-0.606, $t = -1.80$), suggesting a substitution away from such spending for households who acquire electricity. There were no significant external effects on clothing and footwear, entertainment, domestic help, housing repairs, health, or education spending.[29] We would not expect a village effect on fuel spending and that is confirmed by our results in table 6.

So the external, village-level, effect for nonelectrified households entailed a change in the composition of spending away from food and fuel toward other goods, while the internal (household-level) effects were distributed across food and nonfood expenditures. The households who do not have electricity themselves spend on more conspicuous consumption, while those acquiring electricity for their own use tend to divert their spending toward less conspicuous food and nonfood items.

While these point estimates are suggestive of large effects of village electrification on conspicuous consumption by households who do not have electricity themselves, we should flag again a cautionary note that this external effect is not estimated with the same level of statistical precision as the internal effect.

Electrification also increased the ownership of kerosene stoves (table 6), consistent with the claim that subsidized kerosene rations are switched to cooking when electricity becomes available for lighting (Heltzberg 2004). Here too we would probably not expect a village external effect, and this is borne out by the results (table 6).

Labor Supply and Wage Rates

Turning to labor supply, a more complex picture emerges, involving the substitution of some activities for others. Table 7 gives the results (in the same format as table 6) for the various categories of labor supply that can be identified in the REDS survey data and compared over time. (Again the homogeneity restriction performed well and so was imposed.)

Casual wage work decreases for both men and women, though with a larger impact on men. Using our IV estimator, an extra 14.6 days per year of regular wage work for men is attributed to household electrification. This extra work came mainly from reduced casual wage work (8.4 days). Thus our results indicate a significant substitution in male labor supply from casual to regular work attributed to electrification. Using the IV estimator there is no significant effect of "own electrification" on self-employment in either farm or nonfarm activities for either men or women. There is evidence of a significant switch out of agricultural self-employment through the external dynamic effect. One interpretation of these findings is that electricity allows men to switch leisure time from daylight hours to night time, allowing a more regular supply of labor, as required by salaried work.

For women, there are no significant labor supply impacts. The only positive effect, and the largest effect at 4.2 days (although still not significant), is on casual wage work, suggestive of women taking up the casual work that was displaced by men. There are signs that this came in part from reduced days of regular wage work and of farm and nonfarm self-employment, although again, these displacement effects are not statistically significant.

In summary, we find that household electrification increased male labor supply. Men's regular wage work increased, much of it coming from casual wage work, and some from other activities, including leisure.

29 This is with the homogeneity restriction imposed.

Table 7. Impacts of Household and Village Electrification on Labor Supply

Labor supply in days per year	Simple DD: Change in household electrification	IVE: Allowing for external village effect, endogenous electrification and with controls: Change in household electrification	IVE: Years of village electrification in 1999 *times* household not electrified in 1999
Days of regular wage work women	−0.026	−2.389	0.113
	(−0.03)	(−1.17)	(0.62)
Days of regular wage work men	10.384***	14.581**	0.320
	(3.33)	(2.72)	(0.54)
Days of casual wage work women	−5.374**	4.230	−0.075
	(−2.13)	(1.25)	(−0.19)
Days of casual wage work men	−21.140***	−8.415*	−1.162*
	(−5.45)	(−1.66)	(−1.71)
Days of agricultural self-employment by women	2.252	−2.668	−0.899*
	(0.96)	(−0.89)	(−1.86)
Days of agricultural self-employment by men	9.503***	−2.841	−1.261**
	(3.07)	(−0.73)	(−2.46)
Days nonagricultural self-employment by women	−1.859**	−1.834	0.292*
	(−2.42)	(−1.23)	(1.79)
Days nonagricultural self-employment by men	1.848	3.319	0.524
	(0.83)	(0.88)	(1.60)

Note: See table 6.
Source: Authors' calculations using 1982 and 1999 REDS panel.

Using the wage rates reported in the village survey we can also test whether there is any sign that village electrification affected wage rates. We used the data on harvest wage rates to compare the changes in mean wage rates for those villages that became electrified between the two survey rounds with those for the villages that already had electricity in 1982. The DD estimate gave a small gain of Rs. 4.19 per day (in 1999 prices) for women and a small loss for men of Rs. −0.93; however, neither is significantly different from zero (standard errors of Rs. 3.87 and 3.68). We also repeated this analysis using the number of years the village was electrified as the treatment effect; again, there was no significant impact on wages. We find no evidence in these data that village electrification increased real wage rates. This does not, of course, rule out impacts on the demand for labor.

When our IV estimates of the impacts on days of labor supply are valued at the sample mean wage rates, the implied impact on total labor earnings in 1999 is Rs. 2,230 per household.[30] The mean impact on household consumption implied by our IVE results is Rs. 1,721. So the implied aggregate consumption gain is 77% of the implied income gain. The remaining gap has two possible explanations. The first is the existence of foregone income from market labor supply due to displaced activities within the household. In terms of the model in section II, this would entail that the extra market labor supply comes from domestic work in producing marketable commodities. The second explanation is savings; by this interpretation, about one quarter of the income gain was saved or invested directly. We cannot say which of these explanations is the right one. However, some support for the first explanation can be

30 The online addendum provides details on the wage rates used for imputation. A potentially contentious assumption we make is in using the casual wage rate for agricultural work in valuing the income effect of the impacts on days of self-employment in agriculture. As a sensitivity test we also tried using 50% of the casual wage rates; the impact on total earnings rose to Rs. 2,406.

found in past estimates of the income foregone in taking up new employment opportunities provided by public works in India. Datt and Ravallion (1994) estimate a foregone income of about one quarter of the gross wage rate in Maharashtra. Dutta et al. (2014) estimate a mean forgone income of about one third of the gross wage rate in Bihar. These observations suggest that our gap between the mean earnings gain and the gain in consumption could be explained by foregone income even if there is no impact on savings.

Turning now to the effects of village level electrification, we find a small increase in women's non-farm self-employment due to village electrification. The effect is only a third of a day; but recalling that it is annualized, it would add up to an extra week of such work over the period. We also find somewhat larger, but still small, significant decreases in men's casual wage work and in agricultural self-employment by both men and women attributable to village electrification. On the whole, the estimated village effects on labor supply of connecting the village to the electricity grid are small.

V. Conclusions

While positive claims are often heard in the literature and policy discussions about the consumption and income gains from household electrification in developing countries, there is surprisingly little rigorous evidence on the long-term impacts, as required for assessing the economic benefits of public investment in expanding access to electricity for the great many people in the world today who do not have such access. The literature has also largely ignored the distinction between internal (household-level) impacts and external, village-level, effects.

This paper has tried to fill these gaps in knowledge by studying the household-level impacts on consumption and labor supply of a period of huge expansion in rural electrification in India in the 1980s and 1990s. We have distinguished the dynamic growth effect of village electrification from the direct, idiosyncratic, household effect on consumption and labor supply. It is hoped that this study of the long-run impacts of expanding household access to electricity will have salience not only for India's continuing efforts to expand electrification but for the many other developing countries where this is still ahead.

We find a significant "internal" impact on consumption of household acquisition of electricity during the period. Under our identifying assumptions, the consumption gain is not as large as some past estimates, but it is still sizeable at around 0.5% per annum. We also find evidence of a dynamic effect of village electrification, which is asymmetric in that it favors households without electricity. This is suggestive of an external effect, which also comes with a shift in consumption spending away from food toward goods such as ceremonies—possibly associated with an attempt to maintain status among those without their own electricity.

In exploring the channels of impact, we find evidence of effects on labor supply, with electrification resulting in extra regular wage work for men. Our findings on the direct, household-level, impact on labor supply do not support the idea of a rural economy in labor surplus, whereby only the demand side matters to employment. Assuming that the income gains are fully consumed, our imputations of the income gains generated by the labor supply effects using gross wage rates suggest that about one quarter of the impact of electrification on gross earnings is lost due to foregone incomes stemming from displaced activities within the household. However, we cannot rule out the possibility that a share of the income gain from electrification is saved or directly invested.

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