The Adverse Effects of Electrification: Evidence from India

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Nordic Conference on Development Economics
June 11, 2018
Approx. 1.2 Billion people (1 in 6) live without electricity

Electrification programs have attracted policy support and billions of dollars.
Existing Evidence on the Effects of Electrification

Positive Effects

- Increased female employment (e.g., Dinkelman, AER 2011)
- Reduced poverty rates (e.g., Lipscomb et al., AEJ:A 2013)
- Improved health (e.g., Barron and Torero, JEEM 2017)

Negative Effects

- Relatively unexplored

This paper

- Rural India
- Electrification increases price of alternative lighting fuel
- Negatively impacts those who do not adopt electricity
This paper: Electrification adversely affects non-adopters

1. **Descriptives:** Lighting is one of the main uses of electricity
   - Electrification impacts the market for alternative lighting
   - Main alternative: kerosene (paraffin)

2. **Empirics:** Diff-in-diff using India’s National Rural Electrification Program
   - *Main result:* electricity entry $\rightarrow$ kerosene prices 5-10% ↑
   - Higher kerosene prices hurts electricity non-adopters
   - Non-adopters also the poorest HHs

3. **Theory:** Construct a model extending Salop (1979)
   - *Potential mechanism for price increase:* $\downarrow$ market size
   - Kerosene retailers incur fixed costs
   - In equilibrium, price = average cost
   - Electrification causes the pool of kerosene buyers to shrink
This paper: Contributions

Research

- Development Economics: Fills a knowledge gap on the impact of electrification on markets

- IO: Contributes to small but growing literature on the price-increasing effects of competition (e.g., Stiglitz, 1987; Schulz and Stahl, 1996)

Policy

- Speaks to ongoing debate in many countries on removing kerosene subsidies

- Relates to a bigger theme on the potential negative consequences of the introduction of new technologies
Motivating Facts
Motivating Facts

Next to electricity, kerosene is the second most common energy source for lighting among rural households.

Figure: Main Lighting Energy Sources of Rural Households

→ Kerosene markets in rural areas are tightly linked with power sector reforms.
Kerosene use is more prevalent among the poor.

Figure: Kerosene/Electricity use by expenditure deciles

→ The poor are more vulnerable to kerosene price increases.
Empirical Context
India’s National Rural Electrification Program

- Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) or the Prime Minister’s Rural Electrification Scheme ("the program")
- Electrification projects were executed at the district-level, two main components:
  1. **Electricity distribution infrastructure:** substation in each subdistrict; install distribution transformers in each village
  2. **Free household connections:** provided to Below Poverty Line (BPL) HHs; above poverty line are required to pay connection fee (about Rs. 3000)

**Implementation/Treatment Date** in this paper: when project funds are first disbursed to the district.
Data
Main Outcome of Interest: **Kerosene Prices**

1. National Sample Survey (NSS) Consumer Expenditure
   - Socio-economic survey, all of India (except inaccessible areas)
   - HH-level consumption of kerosene (past 30 days)
     → unit value (total expenditure ÷ qty consumed)
   - Proxy for price: **median unit value, by district-year**

2. Rural Price Collection Data
   - **Actual prices** (micro-data for CPI)
   - Covers 603 markets in 26 states, but only 1/2 of all districts
   - Market-level, monthly data from 2001-2011
Differences-in-Differences: 3 District-level Regressions

1 Discrete Treatment Variable

\[ y_{dt} = \beta RGGVY_{dt} + \gamma_d + \lambda_t + \delta X_{d2001} t + \epsilon_{dt} \]

- \( RGGVY_{dt} \): dummy turning on when the program is implemented in district \( d \) at time \( t \)
- District fixed effects: \( \gamma_d \); Time fixed effects: \( \lambda_t \)
- \( X_{d2001} t \): vector of 2001 baseline district characteristics interacted with time trend

2 Continuous Treatment Variable

\[ y_{dt} = \beta Connections_{dt} + \gamma_d + \lambda_t + \delta X_{d2001} t + \epsilon_{dt} \]

- \( Connections_{dt} \): 0 in pre-program years; then, BPL HH connections as a proportion of total HHs in Census 2001
Event Study

\[ y_{dt} = \sum_{k=-4}^{5} \beta_k D^k_{dt} + \gamma_d + \lambda_t + \delta X_{d2001t} + \epsilon_{dt} \]

- \( D^k_{dt} \): dummy variable indicating in district \( d \) at time \( t \), RGGVY was implemented \( k \) periods ago

- First lead \( D^{-1}_{dt} \) is excluded, so \( \beta \)'s estimated relative to year before implementation

- Direct test of identifying assumption of diff-in-diff

- Shows dynamic effects of RGGVY over time
Empirical Results
### Empirical Results

**Table:** Dependent Variable: Proportion of HHs in the District using Electricity or Kerosene as Main Source of Lighting

<table>
<thead>
<tr>
<th></th>
<th>Electricity</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>RGGVY Dummy</td>
<td>0.012*</td>
<td>-0.014**</td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>RGGVY BPL Connections</td>
<td>0.137***</td>
<td>-0.153***</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.029)</td>
</tr>
</tbody>
</table>

|                      | Yes           | Yes          | Yes        | Yes        |
| District FEs         |               |              |            |            |
| NSS Round FEs        | Yes           | Yes          | Yes        | Yes        |
| 2001 District Vars × Linear Time | Yes | Yes | Yes | Yes |
| Adj. R-squared       | 0.828         | 0.829        | 0.831      | 0.832      |
| N                    | 5399          | 5399         | 5399       | 5399       |

Year prior to government’s launch of RGGVY: Ave. proportion of rural HHs using electricity as main source of lighting: 0.62; kerosene: 0.44. Median treatment intensity: 14% BPL Coverage.
Empirical Results

Figure: Event Study on Electricity and Kerosene Use

(a) Electricity

(b) Kerosene

Regression sample restricted to districts treated during the 10th Plan to achieve a balanced panel of districts before/after RGGVY implementation. Coefficient at event time $t = -1$ is zero by construction (omitted category in the regression).
### Table: Dependent Variable: Kerosene Prices (Rupees, unit values)

<table>
<thead>
<tr>
<th></th>
<th>Nominal Kerosene Price</th>
<th>Real Kerosene Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4)</td>
</tr>
<tr>
<td>RGGVY Dummy</td>
<td>0.809***</td>
<td>0.436**</td>
</tr>
<tr>
<td></td>
<td>(0.272)</td>
<td>(0.207)</td>
</tr>
<tr>
<td>RGGVY BPL Connections</td>
<td>2.358*</td>
<td>1.282*</td>
</tr>
<tr>
<td></td>
<td>(1.258)</td>
<td>(0.711)</td>
</tr>
<tr>
<td>District FEs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>NSS Round FEs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2001 District Vars × Linear Time</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.672</td>
<td>0.671</td>
</tr>
<tr>
<td>N</td>
<td>5122</td>
<td>5122</td>
</tr>
</tbody>
</table>

Dependent variable is the median unit value of kerosene from the NSS, for each district-year. Pre-program kerosene prices: Rs. 15 (nominal), Rs. 13.7 (real). Median treatment intensity: 14% BPL Coverage.
Empirical Results

Figure: Event Study on Kerosene Prices, Rupees (unit values)

(a) Nominal Price
(b) Real Price

Regression sample restricted to districts treated during the 10th Plan to achieve a balanced panel of districts before/after RGGVY implementation. Coefficient at event time $t = -1$ is zero by construction (omitted category in the regression).
### Table: Dependent Variable: Kerosene Prices (Rupees, CPI micro-data)

<table>
<thead>
<tr>
<th></th>
<th>Nominal Kerosene Price</th>
<th>Real Kerosene Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>RGGVY Dummy</td>
<td>1.295***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.363)</td>
<td></td>
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<tr>
<td>RGGVY BPL Connections</td>
<td>4.962***</td>
<td></td>
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<td></td>
<td>(1.664)</td>
<td></td>
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<tr>
<td>Market FEs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Month FEs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2001 District Vars × Linear Time</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.834</td>
<td>0.835</td>
</tr>
<tr>
<td>N</td>
<td>27361</td>
<td>27361</td>
</tr>
</tbody>
</table>

Dependent variable is kerosene price from the CPI micro-data, at the market-month level. Average pre-program kerosene price: Rs. 15 (nominal), Rs. 14.5 (real). Median treatment intensity: 14% BPL Coverage.
**Empirical Results**

**Figure:** Event Study on Kerosene Prices, Rupees (CPI micro-data)

(a) Nominal Price

(b) Real Price

Regression sample restricted to a balanced panel of districts before/after RGGVY implementation. Coefficient at event time $t = -1$ is zero by construction (omitted category in the regression).
Robustness Checks

- **Placebo Tests**
  - Urban areas (not covered by the program) electricity/kerosene use, kerosene prices
  - Rural price of rice
  - Rural price of subsidized kerosene

- **Functional Form**
  - Log kerosene prices

- **Control Variables**
  - No controls
  - Alternative: quartiles of baseline chars. interacted w/ time
Why do kerosene prices increase?
Why do kerosene prices increase?

- Electricity and kerosene are close substitutes.
- Standard supply/demand framework would predict prices fall.
- To better understand how electrification would affect kerosene prices, I adapt the Salop (1979) circular model.
  - Monopolistically competitive model, used in retail settings
  - Captures spatial differentiation across kerosene retailers
- Basic intuition:
  - Kerosene sellers have fixed costs
  - In equilibrium, price equals average cost
  - When market size falls, prices may increase
Rural electrification is increasingly being used as a policy tool for boosting development.

But their negative consequences are unclear.

Studying India’s national rural electrification program, I show that electricity provision leads to higher kerosene prices.

These higher prices negatively impact the welfare of poor households, who continue to rely on kerosene.

Higher kerosene prices can be explained by a model where ↓ market size $\Longrightarrow$ ↑ average costs and thereby prices.
Thank you!