The Adverse Effects of Electrification: Evidence from India

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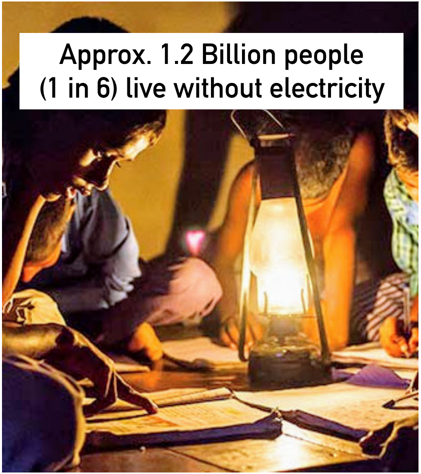
Motivation



Electrification programs have attracted policy support and billions of dollars

SUSTAINABLE DEVELOPMENT GOALS

7 AFFORDABLE AND CLEAN ENERGY

Programa LUZ para todos

POWER AFRICA

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% $\uparrow$
   - 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

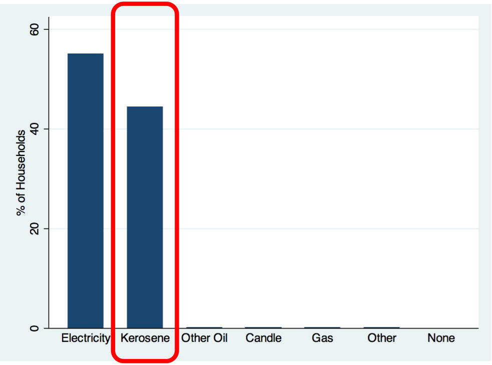
- Speaks to ongoing debate in many countries on removing kerosene subsidies
- Relates to a bigger theme on the potential negative consequences of the introduction of new technologies

Motivating Facts

Motivating Facts

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

Figure: Main Lighting Energy Sources of Rural Households

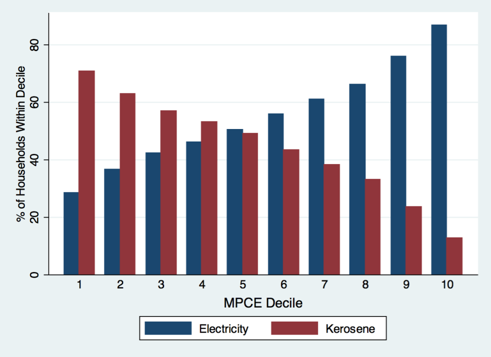


→ Kerosene markets in rural areas are tightly linked with power sector reforms.

Motivating Facts

2. **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")
- Nation-wide program **launched in 2005**, implemented during 10th (2002-2007) and 11th (2007-2012) Five-Year Plans
- 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)
   - Annual data from 2001-2007, 2009, 2010
   - HH-level consumption of kerosene (past 30 days) $\rightarrow$ unit value (total expenditure $\div$ 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

Empirical Method

Differences-in-Differences: 3 District-level Regressions

1. Discrete Treatment Variable

$$y_{dt} = \beta RGGVY_{dt} + \gamma_d + \lambda_t + \delta \mathbf{X}_{d2001} t + \epsilon_{dt}$$

- $RGGVY_{dt}$: dummy turning on when the program is implemented in district d at time t
- District fixed effects: γ_d; Time fixed effects: λ_t
- $\mathbf{X}_{d2001} t$: vector of 2001 baseline district characteristics interacted with time trend

2. Continuous Treatment Variable

$$y_{dt} = \beta Connections_{dt} + \gamma_d + \lambda_t + \delta \mathbf{X}_{d2001} t + \epsilon_{dt}$$

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

Differences-in-Differences: 3 District-level Regressions

3. Event Study

$$y_{dt} = \sum_{k=-4}^{5} \beta_k D_{dt}^k + \gamma_d + \lambda_t + \delta \mathbf{X}_{d2001} t + \epsilon_{dt}$$

- D_{dt}^k: dummy variable indicating in district d at time t, RGGVY was implemented k periods ago
- First lead D_{dt}^{-1} is excluded, so β'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

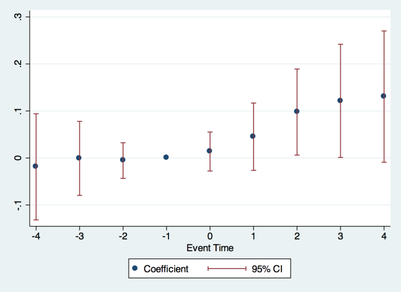
Table: Dependent Variable: Proportion of HHs in the District using Electricity or Kerosene as Main Source of Lighting

	Electricity		Kerosene	
	(1)	(2)	(3)	(4)
RGGVY Dummy	0.012*		–0.014**	
	(0.007)		(0.007)	
RGGVY BPL Connections		0.137***		–0.153***
		(0.029)		(0.029)
District FEs	Yes	Yes	Yes	Yes
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

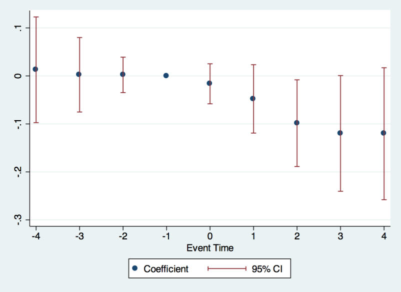
Year prior to government's launch of RGGVY: Ave. proportion of rural HHs using electricity as main source of lighting: 0.62; kerosene: 0.44. Median treatment intensity: 14% BPL Coverage

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).

Empirical Results

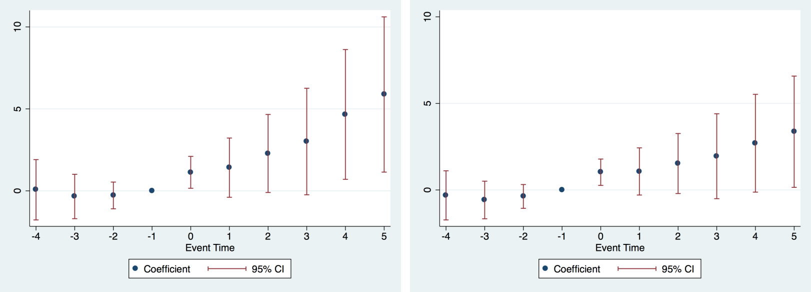
Table: Dependent Variable: Kerosene Prices (Rupees, unit values)

	Nominal Kerosene Price		Real Kerosene Price	
	(1)	(2)	(3)	(4)
RGGVY Dummy	0.809***		0.436**	
	(0.272)		(0.207)	
RGGVY BPL Connections		2.358*		1.282*
		(1.258)		(0.711)
District FEs	Yes	Yes	Yes	Yes
NSS Round FEs	Yes	Yes	Yes	Yes
2001 District Vars × Linear Time	Yes	Yes	Yes	Yes
Adj. R-squared	0.672	0.671	0.491	0.491
N	5122	5122	5122	5122

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).

Empirical Results

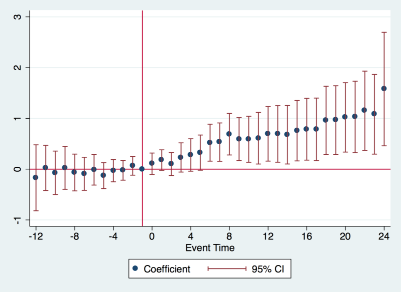
Table: Dependent Variable: Kerosene Prices (Rupees, CPI micro-data)

	Nominal Kerosene Price		Real Kerosene Price	
	(1)	(2)	(3)	(4)
RGGVY Dummy	1.295***		0.919***	
	(0.363)		(0.336)	
RGGVY BPL Connections		4.962***		1.802**
		(1.664)		(0.872)
Market FEs	Yes	Yes	Yes	Yes
Month FEs	Yes	Yes	Yes	Yes
2001 District Vars × Linear Time	Yes	Yes	Yes	Yes
Adj. R-squared	0.834	0.835	0.799	0.798
N	27361	27361	27361	27361

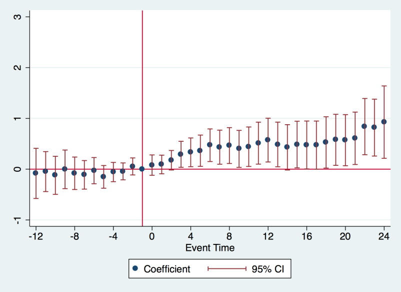
Dependent variable is kerosene price from the CPI micro-data, at the market-month level. Average pre-program kerosene price: Rs. 15 (nominal), Rs. 14.5 (real). Median treatment intensity: 14% BPL Coverage

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

Conclusion

- 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 $\downarrow$ market size $\implies$ $\uparrow$ average costs and thereby prices.

Thank you!