Returns to Grid Electricity on Firewood Consumption and Mechanism

Ngawang Dendup

Faculty of Political Science and Economics
Waseda University - Tokyo

Australian Conference of Economists 2021

Introduction

Global Policy Debates

- Reducing CO2 (and GHG) emission from our activities
- Reducing the stock of CO2 currently in the atmosphere

Traditional Role of Forest

- Resources for consumption (e.g. logging, firewood, recreation etc.)

Role of Forest Today

- Carbon Sink and Carbon Sequestration

Household Energy and Forest in DC

- Unsustainable harvesting of firewood (deforestation)
- 6-17% of global carbon emission is linked with forest degradation (van der Werf et al., 2009)

Firewood Extraction in DC

- About 2.7 billion people depend on solid fuel (IEA, 2015).
- Firewood extraction is primary reason for deforestation in Nepal (Baland et al., 2018)
- About 59% of total firewood is collected from common forest in India (Heltberg et al. 2000)
- Firewood and Charcoal production is responsible for about 31% of global forest degradation (Hosonuma, 2012)
- Charcoal production and firewood harvesting is primary cause of forest degradation in Africa (Kissinger et al. 2012)
- Health of forest near human settlement is poor due to timber and firewood extraction in India (Chettri et al., 2002)

Solution

Possible Solution

- Provide access to alternatives, such as electricity.
- Does household responds such (supply side) interventions?

Objective

- Effect of grid electricity on firewood consumption
- Investigate the mechanisms behind firewood-electricity relationship

Study Area: Bhutan

- Per capita firewood consumption is 1.3 tons annually (UNDP, 2012)
- Electricity is generated through hydropower plants

Literature Review: Effect of Electricity

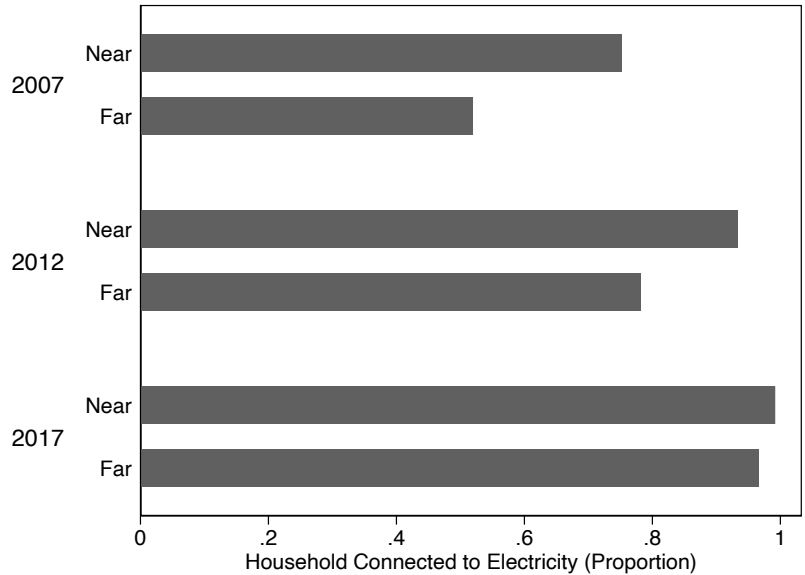
Author	Outcome Variable	Method	Main Findings
Dinkleman (2010), AER	Employment	IV	+ female employment but no effect on male employment outcome
Lipscomb et al. (2013), AEJ	HDI & House Price	IV	+ house price and HDI and no effect on Longevity
Van de Walle et al. (2015), WBER	Household Expenditure	IV	+ consumption expenditure
Barron et al. (2017), JEEM	PM2.5	RCT	PM2.5 reduced by 33-66 % in treated group
Khander et al. (2013), EDCC	Income & Expenditure	FE	Income & Expenditure increased by 28 %
Bernard et al. (2015), EDCC	Social Interactions	RCT	+neighbors' decision effects its neighbors

Reseach Design

Who receives electricity provision?

- Random assignment is almost impossible
- Utility may target rich households for cost recovery reasons
- Political importance matters (Dinkelman, 2011)
- Cost of building infrastructure matters and depends on:
  - Distance to (the nearest) substation
  - Proximity to powerplants

Did Distance Mattered in Bhutan Rural?



Econometric Model

$$FW_{hd} = \beta Electricity_{hd} + \gamma X_{hd} + \epsilon_h \quad (1)$$

$$Electricity_{hd} = \alpha_1 Substation_d + \alpha_2 Plant_d + \theta X_{hd} + \nu_h \quad (2)$$

Where:

- Firewood=Firewood consumption per month in cubic meter
- Electricity= 1 if a household is electrified, 0 otherwise
- Substation= Distance from nearest substation to centroid of subdistrict d
- Plant= 1 if a power plant is located in subdistrict d

Data

Effect of Grid Electricity:

- BLSS 2007: 6856 (6711)
- BLSS 2012: 4986 (3531)
- BLSS 2017: 6854 (5260)
  (Rural-Subsample only: N=15502)

Instrument: Administrative Data (from BPC)

- Location of substations
- Location of power plants

Others

- Census Data: PHCB 2005
- Administrative Data: MOAF

Summary Statistics of Pooled Data (N=15,502)

				Mean Comparison		
Variables	Definition	Mean	SD	W/out	With	Diff
Firewood	Firewood consumption in m^3	1.748	1.544	2.3	1.57	0.731***
Electricity	1 if connected to electricity	0.753	0.431			
LPG	1 if LPG is used for cooking	0.328	0.470	0.07	0.41	-0.347***
Television	1 if household owns television	0.34	0.474	0.05	0.44	-0.387***
Loan	1 if availed loan from bank	0.227	0.419	0.12	0.26	-0.145***
Cattle	Number of cattle ownerships	4.379	7.787	5.06	4.16	0.902***
Expenditure	Per capita expenditure	4,170	3,998	2815	4613	-1798***
Market	Distance to market in hours	1.956	5.696	4.88	1.00	3.886***
Forest	Distance to forest in hours	1.245	2.185	1.33	1.22	0.114***
South	1 if located in southern belt	0.295	0.456	0.35	0.28	0.0757***
Density	Household density	7.17	8.688	5.11	7.84	-2.734***
Substation	Distance to substation in KM	18.2	12.92			
Plant	1 if powerplant in sub-district	0.148	0.355			

Results: LATE

	(1)	(2)	(3)	(4)	(5)
			2SLS		
	OLS		1st Stage		2nd Stage
Variables	Firewood	Firewood	Electricity	Electricity	Firewood
Electricity	-0.656***	-0.522***			-1.512***
	(0.071)	(0.068)			(0.581)
Substation			-0.058***	-0.052***	
(x10)			(0.01)	(0.01)	
Plant			0.091***	0.082**	
			(0.031)	(0.025)	
Year D	Y	Y	Y	Y	Y
Controls	N	Y	N	Y	Y
N	15,502	15,502	15,502	15,502	15,502

Further Check on IV

Variables	Mean (SD)	Dep Var: Substation (0/1)		Dep Var: Plant (0/1)	
		No District	District	No District	District
Panel A					
Forest	78.177	-0.001	-0.001	0.001	0.002
	(18.933)	(0.001)	(0.001)	(0.001)	(0.001)
Observations		205	205	205	205
Panel B					
Middle	0.234	-0.022	-0.019	0.029	0.039
	(0.426)	(0.046)	(0.056)	(0.053)	(0.050)
Rich	0.049	0.002	0.080	0.002	0.083
	(0.216)	(0.109)	(0.136)	(0.109)	(0.121)
Observations		205	205	205	205

Mechanism: Change in Household Technology

Change in Household Technology:

- Household must shift from traditional fuel
  - Shift from traditional cooking fuel to electricity
  - Shift from traditional lighting fuel to electricity
  - Induce adoption of basic electrical appliances
- Does does electricity provision induces the households behavioral change in terms of above three outcomes?

Bivariate Probit Model

$$y^*_{hd} = \theta Electricity_{hd} + X_{hd}\beta + \epsilon \tag{3}$$

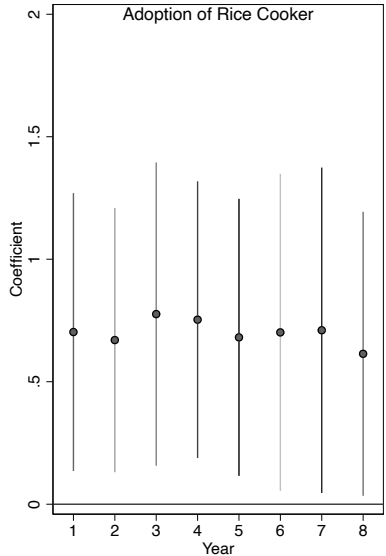
$$Electricity^*_{hd} = \alpha_1 Substation_d + \alpha_2 Powerplant_d + X_{hd}\delta + \nu \tag{4}$$

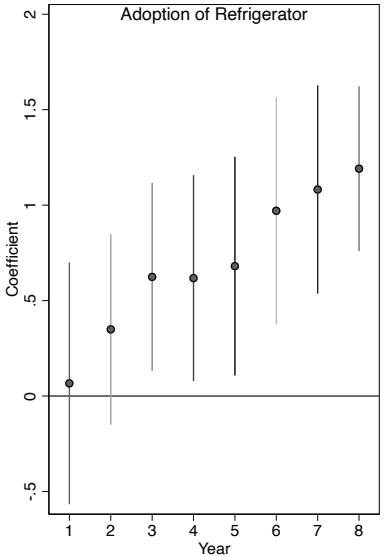
[Outcome variables (y): Cookingfuels (electricity and firewood), lightingfuel (electricity and kerosene) and appliances (rice cooker, curry cooker, water boiler)]

Mechanism: Results 1

	Electricity Is Cooking Fuel	Firewood Is Cooking Fuel
Electricity	2.503***	-1.820***
	(0.252)	(0.172)
APE	0.613***	-0.353***
	(0.024)	(0.019)
Mean (SD)	0.596(0.491)	0.514(0.500)
	Electricity is Lighting Fuel	Kerosene is Lighting Fuel
Electricity	3.475***	-1.811***
	(0.126)	(0.565)
APE	0.864***	-0.377***
	(0.018)	(0.048)
Controls	Yes	Yes
Observations	15,502	15,502
Mean (SD)	0.758(0.428)	0.195(0.396)

Mechanism: Results 2





Conclusion

- Electricity provision is helpful firewood conservation
  - Firewood consumption reduces by about 1.52 cubic meters per month
- Mechanism: Change in household technology
  - Households shifts to electricity for cooking and lighting (Electrified are more likely to use electricity for cooking and lighting and less likely to firewood and kerosene for cooking and lighting respectively)
  - Increases in adoption of electrical cooking appliances

THANK YOU

Questions/Comments

I will be grateful if comments can be email to: ngawangdendup(at)gmail.com