



Impacts of Rural Electrification Programs – Ex-ante Evidence from Rwanda

Gunther Bensch

Jochen Kluge

Jörg Peters

RWI Essen, Germany

**International Conference on Infrastructure Economics and
Development**

Toulouse, France, 15 January 2010



Today's presentation

- [1.] Survey background and sample design
- [2.] Descriptive analysis: The data, "access" vs. "connected"
- [3.] Impact prediction through "hypothetical treatments"
- [4.] Impact evaluation using statistical matching
- [5.] Concluding remarks

[1.] Evaluation project background

Framework: Dutch-German Energy Access Partnership “Energizing Development (EnDev)” (2005-2012)

EnDev activities

- MDG-oriented
- focused on partner countries of the Netherlands, particularly in Africa

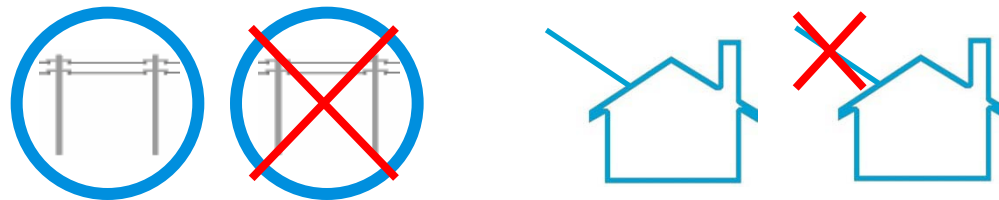
Micro-hydro Power Project of GTZ in Rwanda

- launched in May 2006
- objective: electrification of 5 rural villages (“Project villages”) via mini-grids
- private sector participation approach – government willing to create enabling environment for private investors
- RWI assigned by GTZ to establish impact assessment concept

[1.] Basic impact assessment concept

Study design enabling impact assessment

- both (i) ex post and (ii) ex ante
- of both the treatment **“access”** and **“connection”**

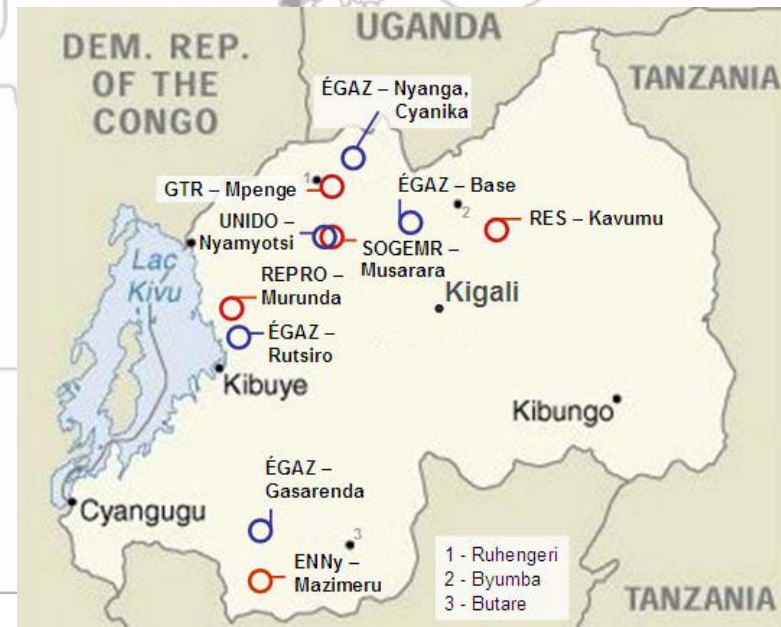


Survey conducted among households in (yet non-electrified) project villages and (already electrified) control villages

Today's presentation: Ex ante






[1.] The survey

- conducted May-June 2007 and Nov-Dec 2008
- in cooperation with local NGO
- sample comprises ~700 households in 5 project and 5 comparable control regions
- Comparability criteria:
 - Geographical location
 - Electrification date
 - Rural agricultural structure
 - Access to tarmac roads
 - Access to markets
 - Unrestricted access to electricity
 - Metered billing



[1.] Sample selection for ex ante analysis



Control regions

-  Kavumu
-  Mpenge
-  Musarara
-  Mazimeru
-  Murunda

Treatment regions

- Gasarenda
- Nyanga / Cyanika
- Rutsiro
- Base
- Nyamyotsi

Survey conducted in villages that were included for project reasons only

-  semi-urban
-  no metering

One project village (rehabilitation) could be classified as already electrified

[2.] Summary statistics



	Variable	Mean		t-test t
		Treatment	Control	
	N households	273	269	-
	N connected	129	6	
	N not connected	143	259	
HOUSE- HOLD	household size	5,18	5,57	2,08
	age father	40,94	42,51	1,30
	age mother	38,66	39,06	0,36
	sex hh head	0,22	0,19	0,79
	education father, years	8,22	5,92	5,53
	education mother, years	6,53	4,54	5,69
	HOUSING	property status	0,84	0,92
material walls		0,33	0,12	6,13
material floor		0,49	0,33	3,75
window fitted with glass		0,52	0,23	7,2
means of transportation		0,16	0,15	0,4

	Variable	Mean		t-test t
		Treatment	Control	
EMPLOY- MENT	N(sample)	269	273	-
	subsistence farming (head of hh)	0,42	0,65	5,53
	civil service (head of hh)	0,26	0,14	-3,19
OUT- COMES	services (head of hh)	0,17	0,06	-4,09
	lighting hours	13,15	4,14	2,88
	kids studying home (1ary school)	0,84	0,69	1,59
	income per work-age adult	367300	176800	-3,91

[2.] Correlates of being connected

	Coeff.	t	Coeff.	t	Coeff.	t
HHsize	0.032	2.32	0.013	1.08	0.016	1.25
Age household head	0.010	3.85	0.004	1.77	0.003	1.46
Education household head	0.050	7.38	0.020	2.9	0.018	2.31
Female head	-0.051	-0.71	-0.012	-0.19	-0.026	-0.4
Own house			0.081	1.13	0.081	1.11
Stone wall			0.183	2.9	0.184	2.91
Glass window			0.164	2.68	0.158	2.51
Cement floor			0.344	5.95	0.342	5.86
No transport			-0.016	-0.23	-0.021	-0.29
Subsistence farmer					-0.039	-0.4
Civil service: head					-0.023	-0.22
Services: head					-0.102	-1
Constant	-0.456	-3.08	-0.275	-1.63	-0.192	-0.96
N	255		249		249	
R-squared	0.21		0.43		0.44	

[3.] Impact prediction



- i** Step 1: estimate Probit-Model for treatment sample of electrified villages

$$\Pr(Y = 1|X = x) = \Phi(x'\beta)$$

- *Treatment Y*: connection
- Kovariate *X*: household (HH) variables, *predetermined*
= *non-responsive to treatment*

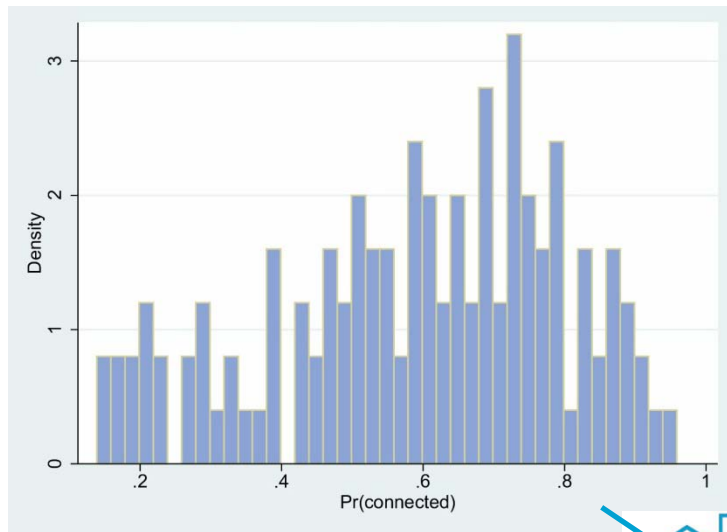
	Variable
	N(sample)
HOUSE-HOLD	household size
	age(hh head)
	sex(hh head)
	education(hh head)

- i** Step 2: calculate expected connection probability $Pr(\text{connected})$ (\rightarrow *propensity score*) for treatment AND control sample (HH in electrified AND non-electrified villags)
- i** Step 3: determine different groups that serve in “hypothetical treatments” for an impact prediction

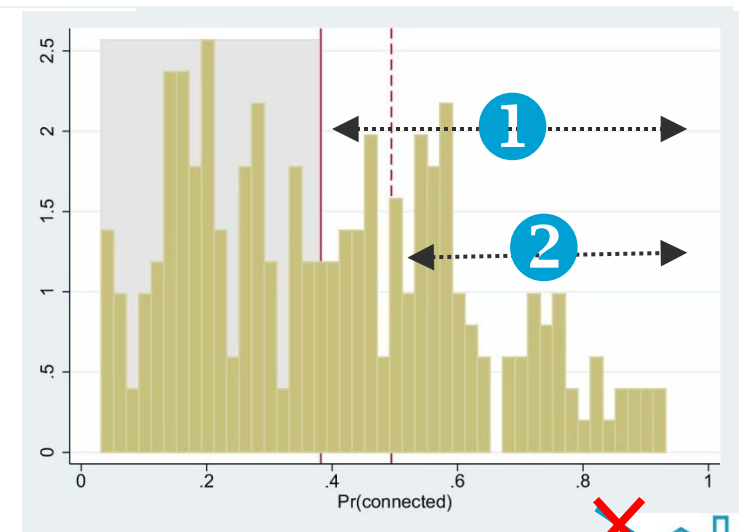
[3.] Hypothetical treatments

Obs: connection rate in electrified villages of roughly one half (46.5 %)

- **i** Step 3a: “treated”: connected households in treatment group
 “control”: households in control villages with
 $\text{Pr}(\text{connected}) > \text{Median}_i(\text{Pr}(\text{connected}))$ for
1: $i = 0$ (treatment group), **2**: $i = 1$ (control group)



Treatment



Control



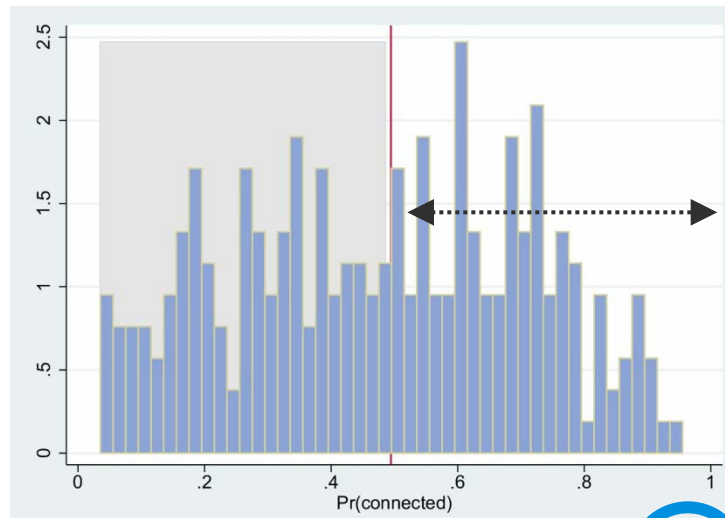
[3.] Hypothetical treatments



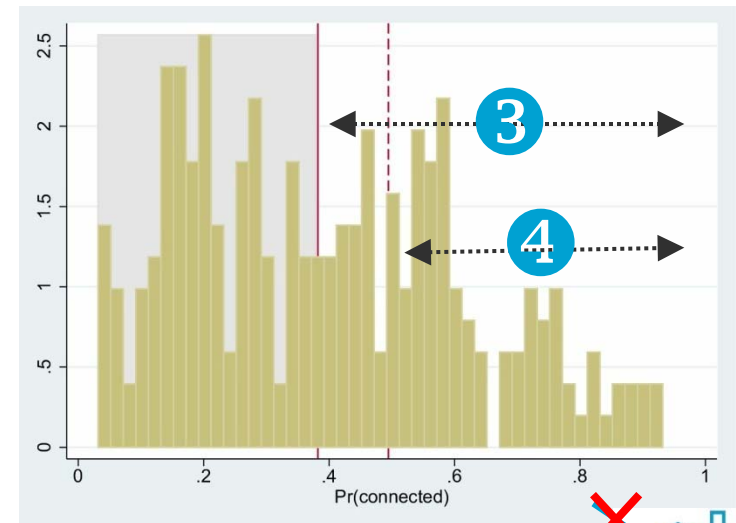
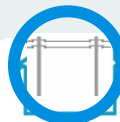
i Step 3b: “treated”: households in treatment group with $\text{Pr}(\text{connected}) > \text{Median}_0(\text{Pr}(\text{connected}))$

“control”: same as in step 3a with

3: $i = 0$ (treatment group), **4**: $i = 1$ (control group)



Treatment

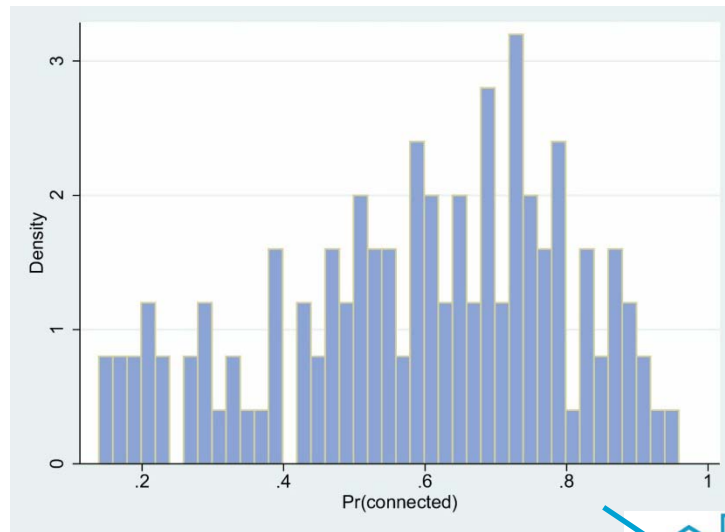


Control

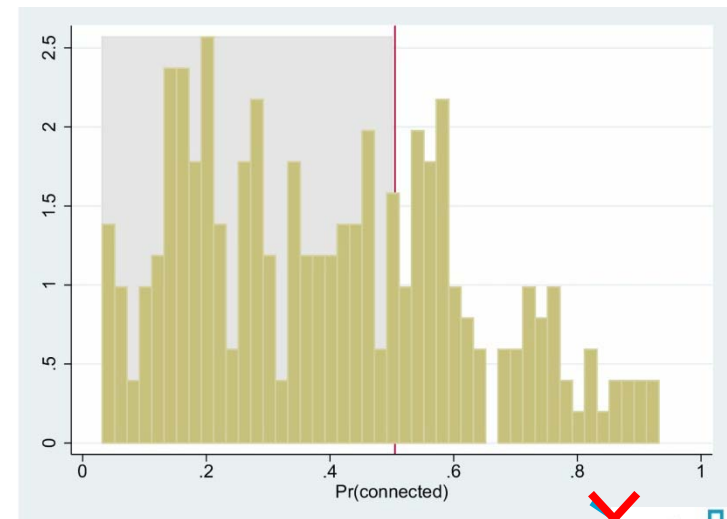


[3.] Hypothetical treatments

- Step 3c: "treated": same as in step 3a
"control": households in control villages with $\text{Pr}(\text{connected}) > 50\%$



Treatment



Control



[3.] Impact prediction using hypothetical treatments



i Step 4: regression analysis with control variables

		lighting hours	Kids studying home	Income work-age adult
Hypreat1	raw effect	9.25***	0.07	243756***
	plus HH variables	8.91***	-0.08	87642
	plus house variable	7.17***	-0.13	28841
	plus employment variables	7.08***	-0.14	9726
Hypreat2	raw effect	9.66***	0.12	326888***
	plus HH variables	8.04***	-0.13	91096
	plus house variable	6.67***	-0.19	42786
	plus employment variables	6.44***	-0.22	20049
Hypreat3	raw effect	15.09***	0.24*	290497***
	plus HH variables	15.34***	0.2	206039***
	plus house variable	12.85***	0	83824
	plus employment variables	12.91***	0	67899
Hypreat4	raw effect	8.61***	-0.03	285000***
	plus HH variables	8.45***	-0.12	140689**
	plus house variable	6.4***	-0.16	88727
	plus employment variables	6.26***	-0.18	68835

Significance levels indicated as *** 1%, ** 5%, * 10%.

[4.] Impact evaluation using statistical matching



- ❏ Step 3d: “treated”: connected households in treatment group
“control”: non-connected households in control villages
- ❏ Step 4: Matching individual observations of the two groups based on the propensity score
 - Causal effect of connection: what would have happened to treated units if they had not been exposed to the intervention?
-> counterfactual
 - ATET generally not identified. Unless -> Conditional independence
 - Matching: Replace non-treatment outcome for treated population with non-treatment outcome of non-treated

[4.] ATETs after matching

▪ Parsimonious specification

		N treated	N controls	lighting hours	Kids studying home	Income work-age adult
ATET Stratification	all observations	117	256	15.69***	0.16	259393***
	common support	117	253	15.69***	0.15	259190***
ATET Nearest Neighbor	all observations	129	81 ^a	16.02***	0.15	341646***
	common support	122	73 ^b	16.05***	0.18	336767***

▪ Full specification

		N treated	N controls	lighting hours	Kids studying home	Income work-age adult
ATET Stratification ^e	all observations	120	248	14.85***	0.03*	205043**
	common support	120	218	14.85***	0.03	204502**
ATET Nearest Neighbor	all observations	129	61 ^c	15.63***	0	163156
	common support	120	50 ^d	15.59***	-0.03	155693

[5.] Conclusion

- Study design of rural electrification project allows for ex ante impact assessment
- Findings: providing access results in use of electricity, access itself does not seem to have significant effects on other outcomes.
- Decision to connect is selective. Connection might reinforce studying hours of school children in the household.
- Predicted impacts suggest that those households in control (=not-yet-treated) villages that are likely to connect will benefit in terms of household income.