THE GRADUATE INSTITUTE GENEVA

INSTITUT DE HAUTES ÉTUDES INTERNATIONALES ET DU DÉVELOPPEMENT

GRADUATE INSTITUTE OF INTERNATIONAL AND DEVELOPMENT STUDIES

Electrifying Nigeria

The impact of access to electricity on education

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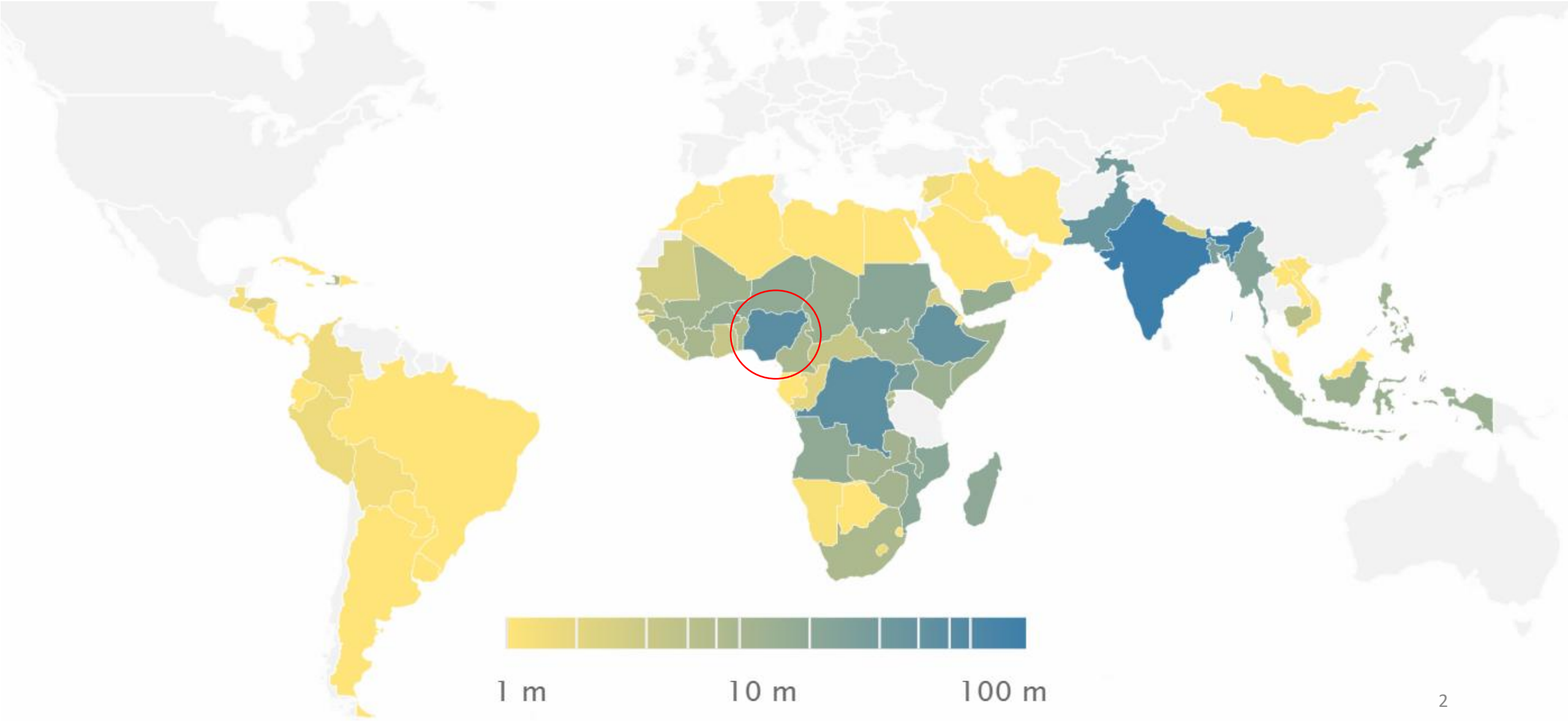
The Graduate Institute Geneva (IHEID)

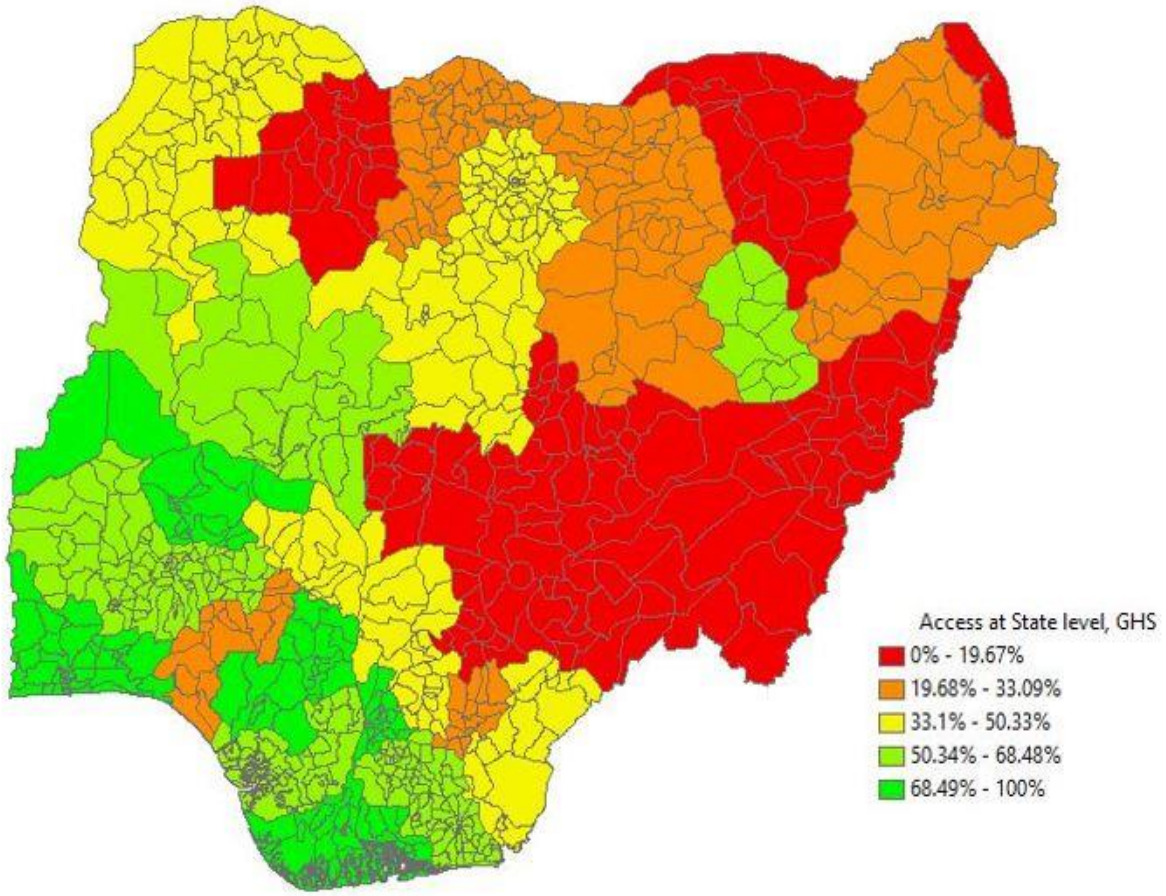
IAEE 43rd Annual Conference

07 June 2021

Motivation

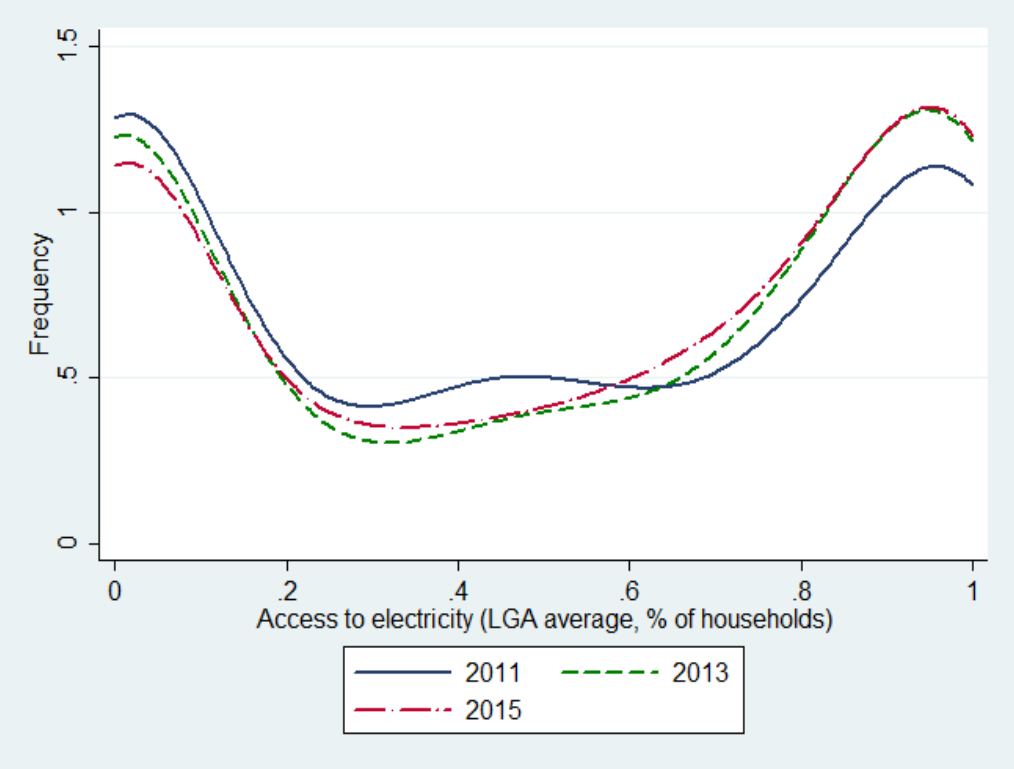


Access to electricity is highly heterogeneous and quality is important



- **98 million** people lacked access to electricity → 2nd largest country worldwide, after India
- National electrification rate: 45% (2016)
  - **Rural average: 36%**; urban: 55%
- **> 77% of firms** experienced ≥ 1 power outage during the previous year (WBES 2014)
  - avg number of black outs: **23/month**
  - avg length: **> 11 hours**
  - avg loss due to outages: **> 15% of annual sales**

Who gets access to electricity and who benefits from it?



- **Grid expansion**, **rural electrification programs** (mini-grid and off-grid solutions) and **autonomous solutions**
- Largest source of electricity is National Electric Power Authority: **>80%** of connected households
  - NEPA privatized between 2010 and 2013
- Grid expansion is **not random**
  - driven by technical feasibility, expansion costs, political reasons and expected returns
- Access to electricity as a **household's investment**:
  - (mini-/off-) grid expansion to an area/village requires **connection fee** by a household
  - **Solar panels** and **generators** are an investment in itself
- Not-connected households in connected villages may still **partially benefit** from neighboring connected households
  - Sharing, stealing, employment spillovers…

Existing evidence

	Average effect	Significance
Welfare/consumption	+++	High
School enrolment	**++**	**Medium**
HH employment	+	Medium
Business	+/-	Low

Reference	Year(s)	Country/ region	Methodology/ type of study	Outcome variable	Estimated effects
Barron and Torero (2014)	2009-2013	El Salvador	RCT	Female employment	Women 45.8% more likely to be engaged in non-farm employment
Bernard and Torero (2013)	2-period survey (1 year)	Ethiopia	Panel RCT	Labour supply	No short run effect of rural electrification on time spent on income generating activities
Burlig and Preonas (2016)	2001-2011	India	Regression discontinuity design	Labour supply	Reject changes in male labour allocation larger than 1.3%
Chowdhury (2010)	2004-2005	Bangladesh	Cross-sectional dataset with IV and structural model to cope with endogeneity	Female employment rate and labour supply	Availability of electricity has large and statistically significant influence on women's paid work and a negative effect on unpaid work burden. No statistically significant effect of employment rate.
Dasso and Fernandez (2015)	2006-2012	Peru	DID and FE	Labour supply	Small increase in hours worked for men, no effect on women. Decrease in probability to be self-employed for women (nothing for men). Decrease in the likelihood of having more than one job among males
Dinkelman (2011)	1996 and 2001	South Africa	DID with IV	Employment rate	+9-9.5% increase for women; no significant effect for men
Grogan (2008)	2000	Guatemala	Cross-sectional OLS and probit	Employment rate	Mostly for women, being younger at the time of community electrification has a strong positive effects on labour force participation
Grogan and Sadanand (2013)	1998-2005	Nicaragua	Panel data with IV, tobit regression, recursive bivariate probit	Labour supply	+23% propensity of rural Nicaraguan women to work outside the home. No impact on male employment.
Khandker et al. (2012)	2005	India	Cross-sectional with IV	Labour supply	+ 17 % employment hours for women and only +1.5% percent for men
Libscomb et al. (2013)	1960-2000	Brazil	FE – IV	Employment rate	A county that goes from 0 to full electrification would experience a 17–18% increase in probability of employment
Rathi and Vermaak (2017)	-	India and South Africa	Cross-sectional with IV; PSM; panel data with FE	Employment rate and labour supply	In India access decreases the probability of being employed for men by a 0.2 margin, while it increases that for women. However, annual earnings increase only for men and increased paid employment hours for both genders.
Salmon and Tanguy (2016)	2010-2011	Nigeria	Panel-data with IV, copula-based bivariate hurdle model	Labour supply	Electrification increases working time of both household spouses when assessment is separated; however, joint HH-level analysis highlights a positive effect only for men
Van de Walle et al. (2017)	1981-1999	India	Panel data with IV	Labour supply	Growth in regular wage work for men and more casual wage work for women

The paper in a nutshell

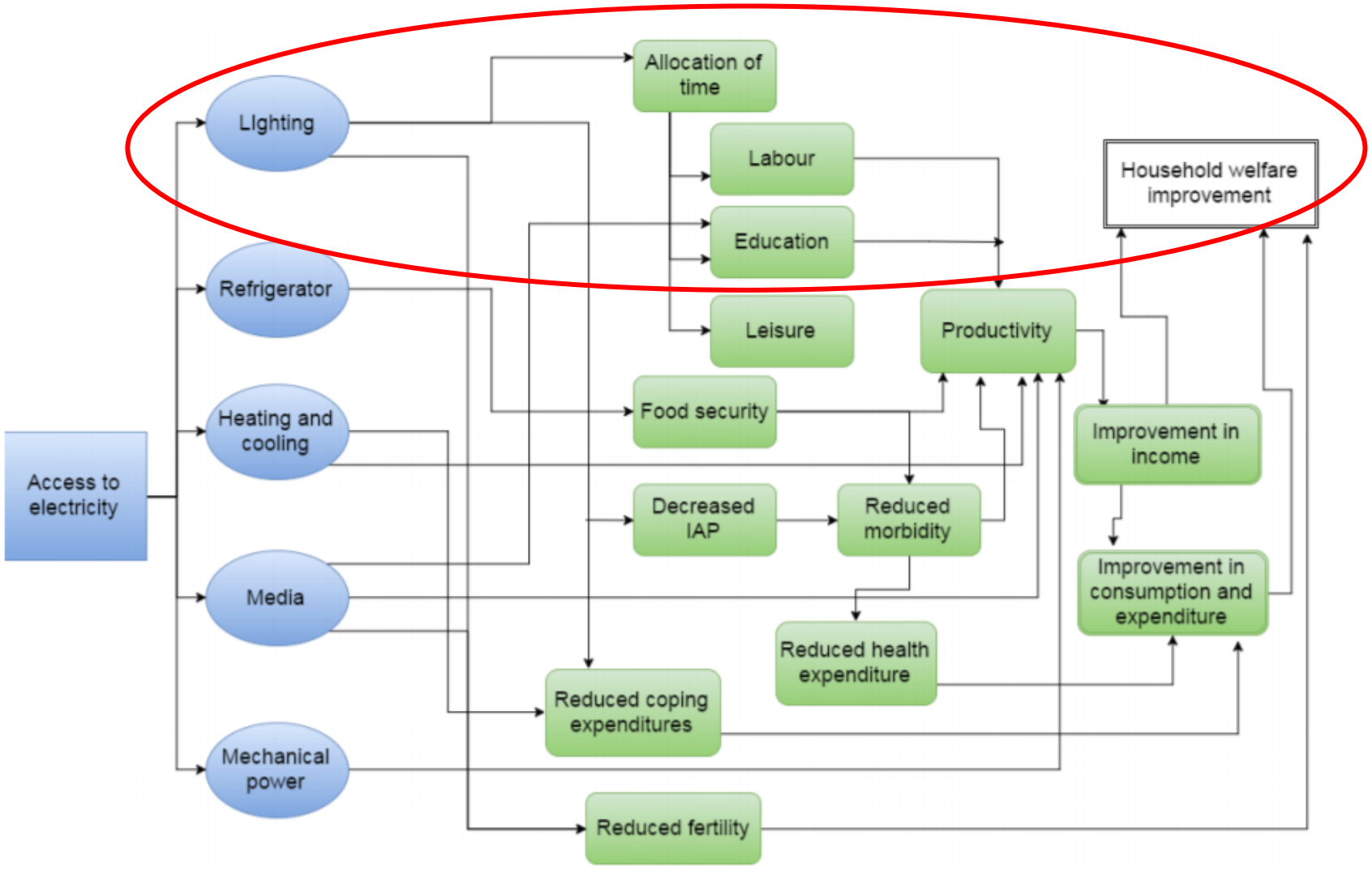
Research question: what is the micro-level impact of access to electricity on kids' education in rural Nigeria?

- Study the impact on both school enrolment (extensive margin) and grade-for-age gap (intensive margin)
- Measure outcomes at household level to incorporate intra-household dynamics
- Measure access to electricity at village level to incorporate spillover effects
- Instrument access to electricity with lightning strikes intensity in the area surrounding the household
- Quantify the effects of the quality of electricity received (blackouts) controlling for sample selection
- Employ panel regression methods controlling for household and year fixed effects
- Control for both demographics, other household-level, geographic and meteorological variables

Main findings:

- Access to electricity increases the proportion of household kids enrolled at school by ~28-56%
- Access to electricity decreases the grade-for-age gap by about 2.8 years
- Estimated impact is larger when focusing on connected households
- Larger point estimates for girls, but only significant for boys
- The enrolment effects are larger for poorer household, but no differences for the grade-for-age gap
- Blackouts negatively impact school output (intensive margin) but not enrolment (extensive margin)
- Both lightning intensity and higher distance from powerplant negatively affect access and quality of electricity

Conceptual framework

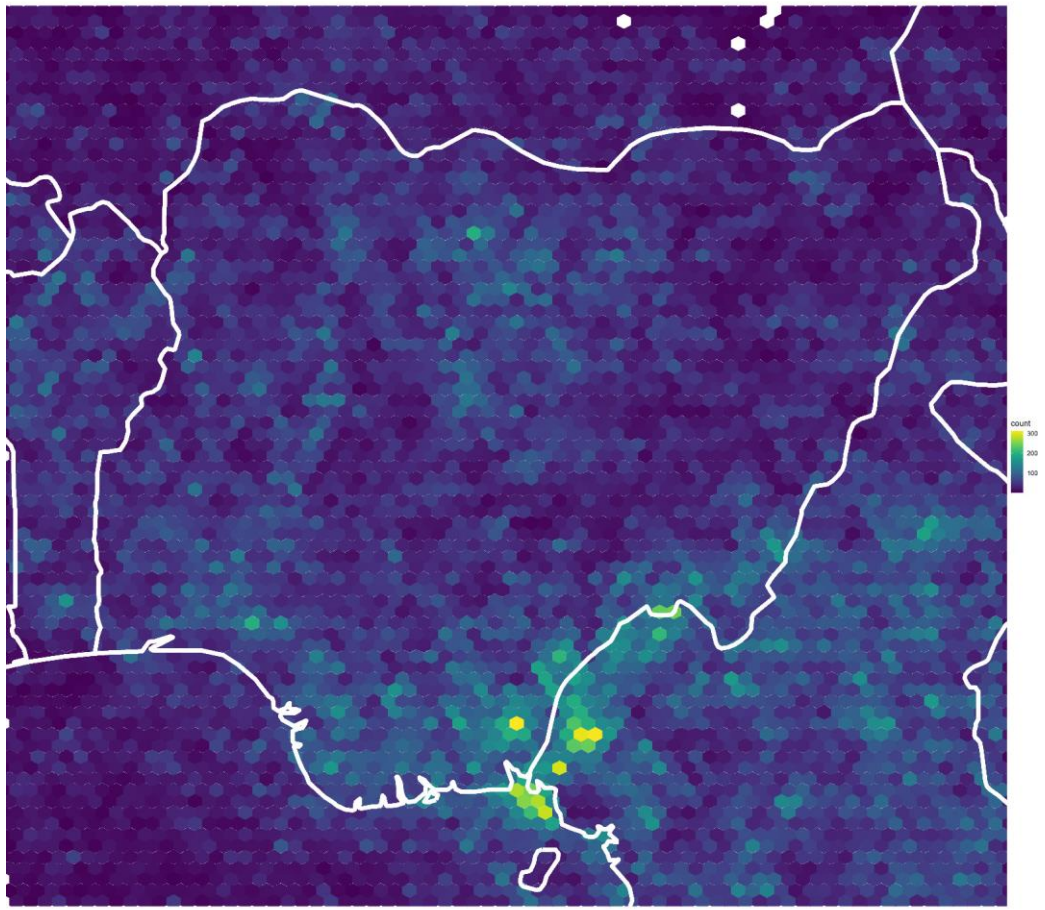


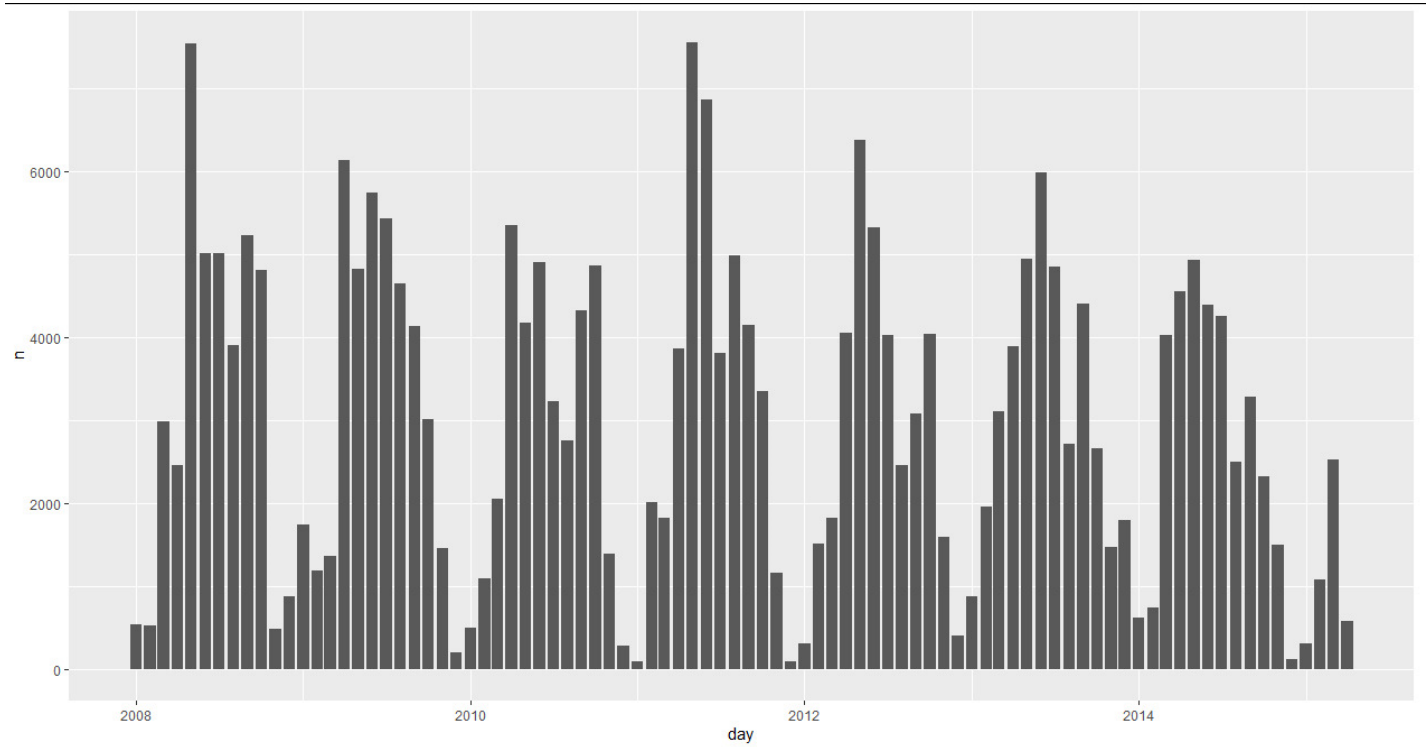
Data

- Nigeria's General Household Survey – WB LSMS
- Panel of 5000 (~3300 rural) households in 2011, 2013, 2015
- Representative at national, urban-rural and geopolitical zone levels
- Low attrition rate (3.9%)
- Lightning data with 0.05°x0.05° spatial resolution from NASA's Lightning Imaging Sensor (LIS) on TRMM Science Data
- Average monthly number of lightning events in the area of 30 km radius around household geolocation over the period of 2 years before the survey

	Obs	Mean	SD	Min	Max
Village electricity access	9,738	0.46	0.50	0	1
HH electricity access	9,736	0.36	0.48	0	1
Enrolled ratio	6,672	0.81	0.36	0	1
Grade-for-age gap	5,327	1.43	1.58	0	10
Blackouts	3,490	2.69	0.62	1	3
Lightnings	9,812	5.42	3.03	0.08	17.6
Distance to grid	9,812	24.5	24.6	0.01	133.3
Distance to powerplant	9,812	130.3	97.0	2.13	465.6
Number of kids	9,742	2.90	2.42	0	19
Wealth quintile	9,592	-0.34	0.84	-1.67	3.31

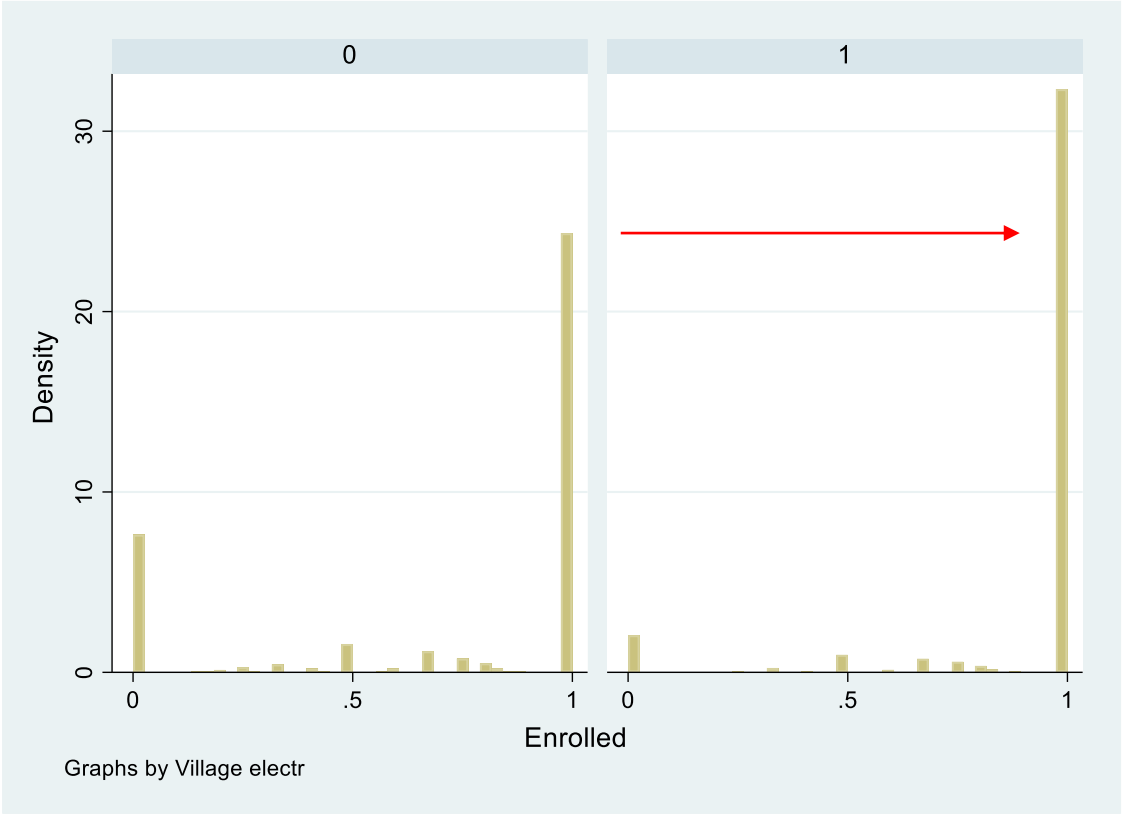
Lightnings distribution



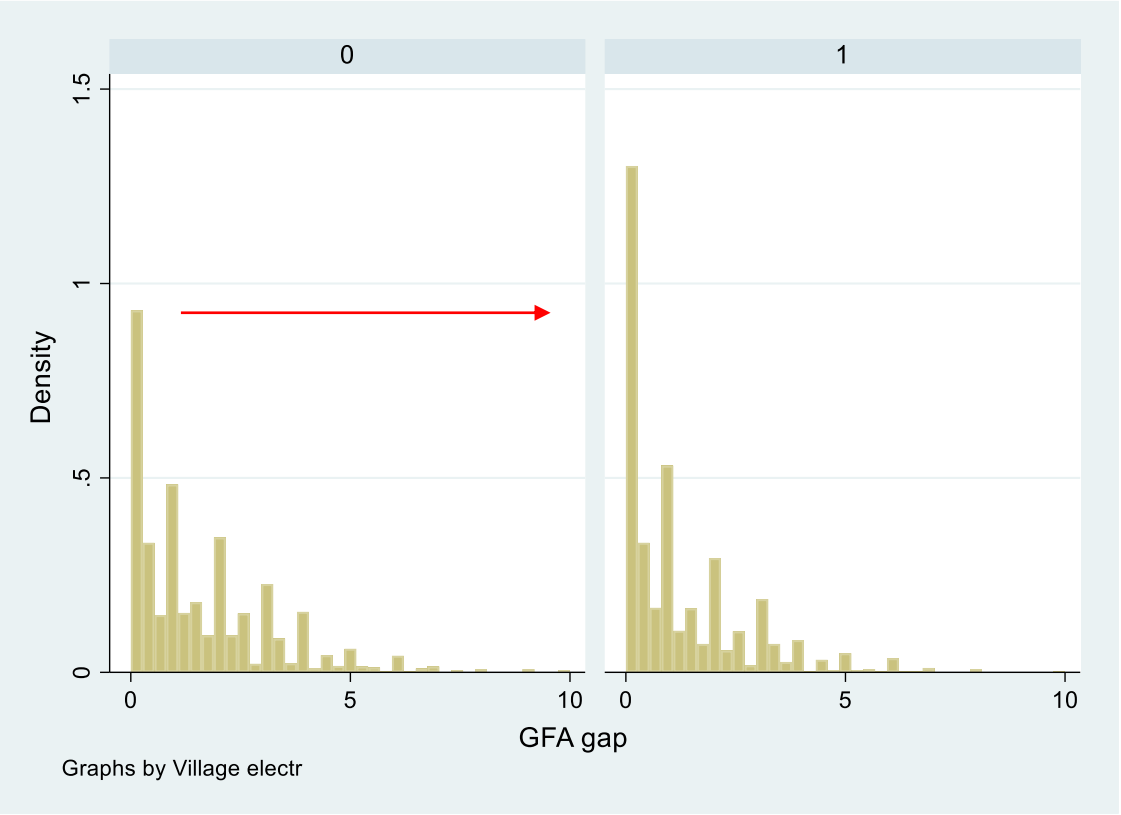


Main outcome variables

School enrolment



Grade-for-age gap



Empirical model: the basics

Random effects: $$y_{it} = \alpha + \beta E_{it} + \gamma' \boldsymbol{x_{it}} + \underbrace{\mu_i + \vartheta_t + u_{it}}_{v_{it}}$$

y_{it} = {enrolment, grade-for-age gap} of household *i* in year *t*

E_{it} = Electricity access {1, 0} of household *i*'s village in year *t*

$\boldsymbol{x_{it}}$ includes: household head age, female share, number of kids, wealth quintile, distance to nearest market, distance to nearest population center, annual mean temperature, annual precipitations, potential wetness index

μ_i and ϑ_t are household and year fixed effects

Fixed effects: $$(y_{it} - \bar{y_i}) = \beta(E_{it} - \bar{E_i}) + \gamma'(\boldsymbol{x_{it}} - \bar{\boldsymbol{x}_i}) + (\vartheta_t - \bar{\vartheta}) + (u_{it} - \bar{u_i})$$

Hausman test rejects RE in what percentage of regressions?

100%.

Empirical model: endogeneity

Problem: Access to electricity is not random (OV & RC)

Reason: Grid extension & household decision may depend on outcome variable

Solution: Instrumental Variable strategy

- Land gradient (Dinkelman, 2011)
- Distance to the grid (Grogan and Sadanand, 2013)
- Distance to nearest power plant (Van de Walle et al., 2017)

→ Lightning strikes intensity (Andersen et al., 2012; Andersen & Dalgaard, 2013; Millien, 2017)

Explanation: Exogeneity & relevance (-)

Results: school enrolment

	(1)	(2)	(3)	(4)	(5)
Dependent Variable			Enrolled		
Village access	0.587**	0.575**	0.544**	0.557**	0.278**
	(0.246)	(0.246)	(0.231)	(0.233)	(0.139)
First stage - DV: village access					
Lightnings	-0.008***	-0.008***	-0.008***	-0.008***	-0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Demographics	NO	YES	YES	YES	YES
Other household covariates	NO	NO	YES	YES	YES
Meteorological covariates	NO	NO	NO	YES	YES
Average hh education	NO	NO	NO	NO	YES
Observations	6,217	6,191	6,059	6,059	4,975
Number of hhid	2,329	2,324	2,292	2,292	1,885
R-squared	0.007	0.011	0.018	0.021	0.039
KP F-stat	17.1	16.8	18.4	18.3	15.5

Note: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Results: grade-for-age gap

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Grade-for-age gap				
Village access	-2.753**	-3.077**	-2.816**	-2.783**	-2.818**
	(1.391)	(1.459)	(1.309)	(1.297)	(1.296)
First stage - DV: village access					
Lightnings	-0.008***	-0.008***	-0.008***	-0.008***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Demographics	NO	YES	YES	YES	YES
Other household covariates	NO	NO	YES	YES	YES
Meteorological covariates	NO	NO	NO	YES	YES
Average hh education	NO	NO	NO	NO	YES
Observations	4,782	4,760	4,667	4,667	4,667
Number of hhid	1,817	1,812	1,790	1,790	1,790
R-squared	0.007	0.012	0.021	0.023	0.034
KP F-stat	13.9	13.1	15.5	15.6	12.0

Note: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Rob check: village vs household access

Panel A: village access to electricity

	(4)	(5)	(6)	(4)	(5)	(6)
Dependent Variable	Enrolled		Village access	Grade-for-age gap		Village access
Village access	0.557**	0.278**		-2.783**	-2.818**	
	(0.233)	(0.139)		(1.297)	(1.296)	
Lightnings			-0.009***			-0.008***
			(0.002)			(0.002)
Avg hh education	NO	YES	YES	NO	YES	YES
Observations	6,059	4,975	4,975	4,667	4,667	4,667
Number of hhid	2,292	1,885	1,885	1,790	1,790	1,790

Panel B: household access to electricity

	(4)	(5)	(6)	(4)	(5)	(6)
Dependent Variable	Enrolled		HH access	Grade-for-age gap		HH access
Household access	0.711**	0.411*		-4.657*	-4.718*	
	(0.334)	(0.233)		(2.708)	(2.720)	
Lightnings			-0.006***			-0.005**
			(0.002)			(0.002)
Avg hh education	NO	YES	YES	NO	YES	YES
Observations	6,057	4,973	4,973	4,666	4,666	4,666
Number of hhid	2,291	1,884	1,884	1,790	1,790	1,790

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Rob check: radius for lightnings IV

	Enrolment						Grade-for-age gap					
	20k		30k		50k		20k		30k		50k	
Village access	0.582*		0.557**		1.030**		-3.240*		-2.783**		-3.215	
	(0.329)		(0.233)		(0.454)		(1.966)		(1.297)		(3.403)	
Lightnings		-0.011***		-0.009***		-0.004***		-0.010***		-0.008***		-0.003***
		(0.004)		(0.002)		(0.001)		(0.004)		(0.002)		(0.001)
R-squared		0.024		0.027		0.024		0.020		0.023		0.020
Observations	6,059	6,059	6,059	6,059	6,059	6,059	4,667	4,667	4,667	4,667	4,667	4,667
Number of hhid	2,292	2,292	2,292	2,292	2,292	2,292	1,790	1,790	1,790	1,790	1,790	1,790

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Rob check: two instruments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Enrolled	Village access	Enrolled	Village access	GFA gap	Village access	GFA gap	Village access
Village access	0.653***		0.250*		-2.051*		-2.260**	
	(0.248)		(0.134)		(1.086)		(1.108)	
Lightnings		-0.008***		-0.009***		-0.009***		-0.009***
		(0.002)		(0.002)		(0.002)		(0.002)
Distance to powerplant		-0.010		-0.020		-0.026**		-0.025*
		(0.009)		(0.012)		(0.013)		(0.013)
Avg hh education	NO	NO	YES	YES	NO	NO	YES	YES
Sargan-Hansen p-value	0.212		0.605		0.188		0.310	
R-squared		0.021		0.028		0.024		0.024
Observations	6,059	6,059	4,975	4,975	4,667	4,667	4,667	4,667
Number of hhid	2,292	2,292	1,885	1,885	1,790	1,790	1,790	1,790

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Heterogeneity: gender

	Enrolment			Grade-for-age gap		
	All kids	Boys	Girls	All kids	Boys	Girls
Village access	0.557**	0.479*	0.699	-2.783**	-2.926*	-3.215
	(0.233)	(0.245)	(0.481)	(1.297)	(1.590)	(3.403)
Observations	6,059	4,613	4,237	4,667	3,364	2,905
Number of hhid	2,292	1,786	1,676	1,790	1,321	1,155

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Heterogeneity: wealth

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Enrolled	Village electr	Connected*Wealth	GFA gap	Village electr	Connected*Wealth
Village connected	0.547**			-2.781**		
	(0.236)			(1.295)		
Village connected*Wealth	-0.094**			-0.108		
	(0.042)			(0.268)		
Lightnings		-0.008***	0.012***		-0.008***	0.009***
		(0.002)	(0.002)		(0.002)	(0.003)
Lightnings*Wealth		0.001	0.036***		0.002	0.037***
		(0.002)	(0.003)		(0.002)	(0.003)
R-squared		0.021	0.305		0.023	0.350
Observations	6,059	6,059	6,059	4,667	4,667	4,667
Number of hhid	2,292	2,292	2,292	1,790	1,790	1,790

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Quality of electricity: blackouts

	(1)	(2)	(3)
Dependent Variable	Enrolled	GFA gap	Village access
Blackouts	0.085	2.484*	
	(0.112)	(1.451)	
Lightnings			-0.100***
			(0.019)
Distance to powerplant			-0.210**
			(0.104)
IMR	-0.069*	0.009	
	(0.039)	(0.372)	
Observations	1,890	1,666	2,053
Number of hhid	754	679	707

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Migration, time use & item ownership

Migrated	2011	2013
No	-	4,927 (98.5%)
Yes	-	73 **(1.5%)**
Total	5,000	5,000

Electricity	Firewood	Fridge	TV
No	69.1%	3.3%	12.6%
Yes	**43.3%**	**26.9%**	**64.6%**
Total	56.2%	15.2%	38.9%

Conclusions

- Electricity is still a big concern in developing countries such as Nigeria
- Having electricity access *does* make a difference for kids' education, even in the **short-medium term** (2-4 years), after controlling for both time-invariant specific effects and endogeneity bias
  - Large impact on both **school enrolment (+)** and the **grade-for-age gap (-)**
  - Effects are larger for girls but **only significant for boys**
  - Results are **robust** to varying the IV's radius and the use of a second IV
- Evidence in favor of the presence of **spill over effects** from neighbors having access to electricity, but results are larger for households actually connected to electricity
- Access to electricity favors everybody, but seems to be a **pro-poor** policy along the wealth axis, particularly for enrolment
- Key role played by the **quality of electricity** (proxied by blackout frequency) for school output (grade-for-age gap)
- Next steps: better explore mechanisms, interactions and role of other covariates (e.g. energy sources and number of schools) and outcome variables

Thank you for your attention!

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Appendix

School enrolment

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable			Enrolled			Village access
Village access	0.587**	0.575**	0.544**	0.557**	0.278**	
	(0.246)	(0.246)	(0.231)	(0.233)	(0.139)	
Lightnings						-0.009***
						(0.002)
HH head age		-0.000	-0.000	-0.000	0.000	0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HH female share		-0.043	-0.028	-0.025	-0.020	0.151*
		(0.106)	(0.107)	(0.107)	(0.082)	(0.090)
Kids number		0.006	0.006	0.006	-0.004	-0.015***
		(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
Wealth quintile			-0.017*	-0.017*	-0.011	0.030***
			(0.010)	(0.010)	(0.007)	(0.008)
Distance to market			0.001	0.001	-0.001	0.004***
			(0.002)	(0.002)	(0.002)	(0.001)
Distance to popul center			0.000	0.000	0.000	-0.001**
			(0.000)	(0.000)	(0.000)	(0.000)
Annual mean temperature				-0.000	0.001	0.000
				(0.005)	(0.004)	(0.008)
Annual precipitation				-0.001**	-0.001**	0.001***
				(0.000)	(0.000)	(0.000)
Potential wetness index				-0.004	-0.004*	0.001
				(0.002)	(0.002)	(0.002)
HH avg education					-0.009***	-0.003
					(0.002)	(0.003)
Year (1=2013)	-0.021**	-0.019*	-0.018*	-0.018*	-0.020***	0.018*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.007)	(0.010)
Year (1=2015)	0.093***	0.097***	0.093***	0.092***	0.030***	0.030***
	(0.011)	(0.011)	(0.012)	(0.012)	(0.009)	(0.012)
Observations	6,217	6,191	6,059	6,059	4,975	4,975
Number of hhid	2,329	2,324	2,292	2,292	1,885	1,885
KP F-stat	17.1	16.8	18.4	18.3	15.5	
R-squared						0.027

Note: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Grade-for-age gap

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Grade-for-age gap					Village access
Village access	-2.753**	-3.077**	-2.816**	-2.783**	-2.818**	
	(1.391)	(1.459)	(1.309)	(1.297)	(1.296)	
Lightnings						-0.008***
						(0.002)
HH head age		0.021***	0.021***	0.022***	0.022***	0.000
		(0.006)	(0.006)	(0.006)	(0.006)	(0.001)
HH female share		0.081	-0.045	-0.068	-0.142	0.170*
		(0.641)	(0.623)	(0.619)	(0.618)	(0.099)
Kids number		-0.194***	-0.184***	-0.184***	-0.184***	-0.014***
		(0.036)	(0.034)	(0.034)	(0.034)	(0.005)
Wealth quintile			0.033	0.031	0.035	0.031***
			(0.059)	(0.059)	(0.059)	(0.008)
Distance to market			0.032**	0.029***	0.027***	0.004***
			(0.013)	(0.010)	(0.010)	(0.001)
Distance to popul center			-0.006**	-0.006**	-0.006**	-0.001
			(0.002)	(0.002)	(0.002)	(0.000)
Annual mean temperature				-0.015	-0.016	0.000
				(0.034)	(0.034)	(0.008)
Annual precipitation				0.005**	0.005**	0.001***
				(0.002)	(0.002)	(0.000)
Potential wetness index				0.000	-0.001	0.001
				(0.015)	(0.015)	(0.002)
HH avg education					-0.081***	-0.003
					(0.016)	(0.003)
Year (1=2013)	0.356***	0.275***	0.251***	0.252***	0.286***	0.011
	(0.059)	(0.059)	(0.058)	(0.058)	(0.058)	(0.010)
Year (1=2015)	0.234***	0.084	0.127*	0.123*	0.192***	0.031**
	(0.067)	(0.067)	(0.071)	(0.071)	(0.074)	(0.012)
Observations	4,782	4,760	4,667	4,667	4,667	4,667
Number of hhid	1,817	1,812	1,790	1,790	1,790	1,790
KP F-stat	13.9	13.1	15.5	15.6	12.0	
R-squared						0.023

Note: robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1