Contracting structures in public procurement: Evidence from donor-funded electrification in Kenya

On-line Appendix

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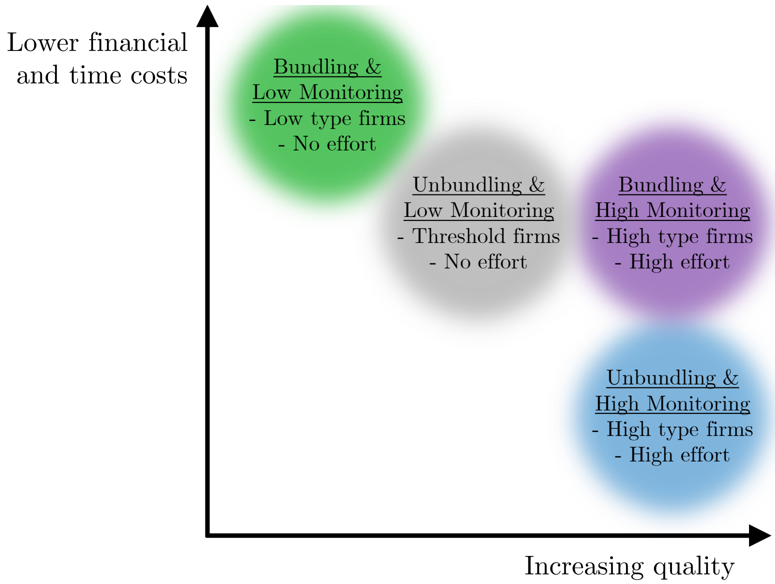
Authors are in ⓡCertified Random order. Wolfram: Massachusetts Institute of Technology and NBER. Miguel: University of California, Berkeley and NBER. Hsu: Yale University. Berkouwer: University of Pennsylvania and NBER. Paper available here.

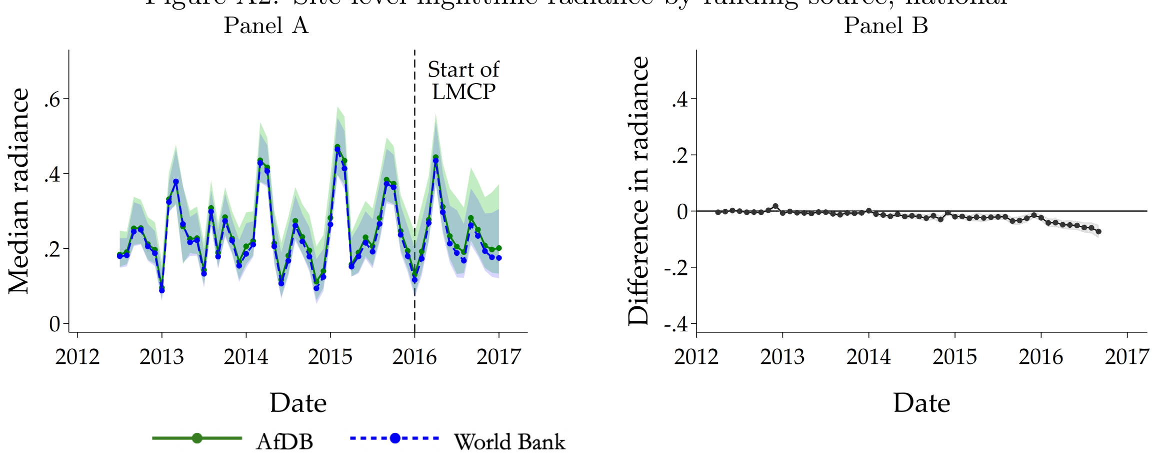
A Appendix Figures

Figure A1: Schematic of monitoring and bundling structures



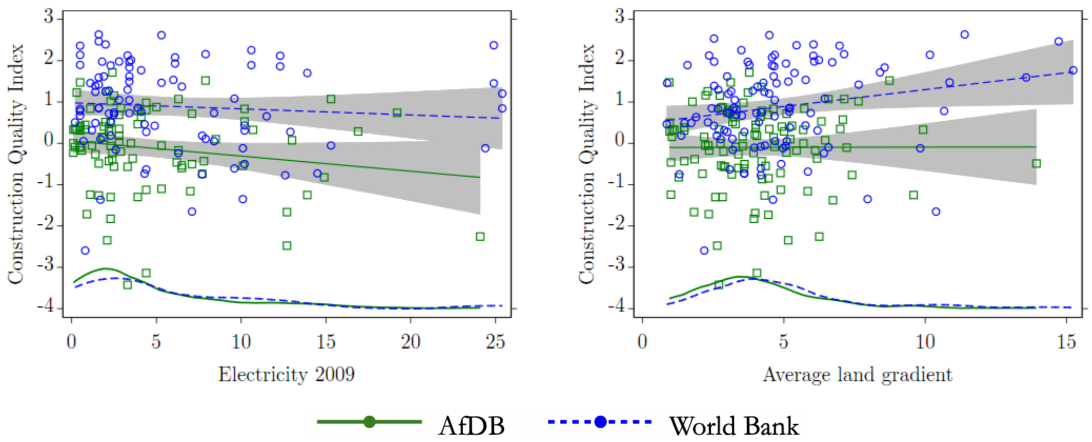
Notes: A graphical representation of how different monitoring levels (low or high) and contracting structures (unbundled or bundled components) affect quality and costs through the lens of the framework presented in **??**. Aggregate net benefits generally increase as financial and time costs decrease and quality increases, but the exact indifference curves depend on how the principal values cost and timeliness vis-a-vis quality, which is determined by, for example, their intertemporal discount rate. The green area (top left) approximates the structure used by the African Development Bank for the LMCP in Kenya. The blue area (bottom right) approximates the structure used by the World Bank for the LMCP in Kenya. The model suggests that combining bundled contracts with high monitoring can generate similar quality as unbundled contracting but with significantly fewer delays and administrative costs. The purple area (middle right) approximates this structure, which we empirically evaluate this using a randomized audits experiment. The gray area is unobserved in our context; placement reflects the model's predictions.

Figure A2: Site-level nighttime radiance by funding source, national



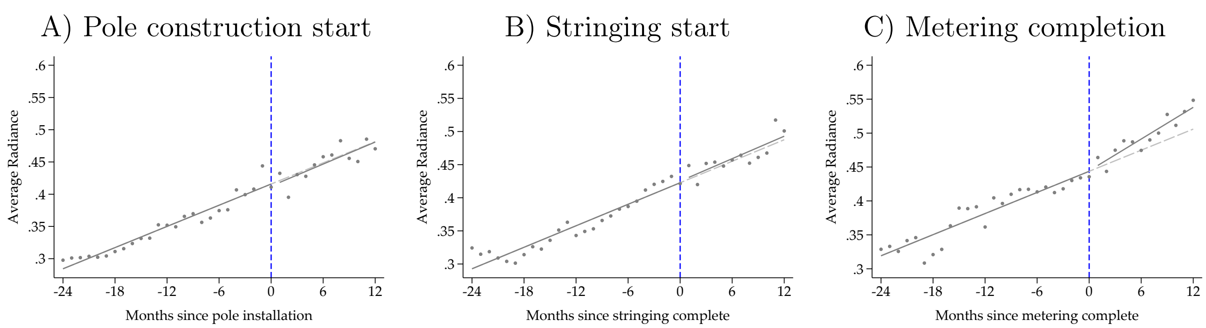
Notes: Panel A presents median monthly nighttime radiance from the Visible Infrared Imaging Radiometer Suite (VIIRS) between 2012-2017 per month, with bands showing the 25th to 75th percentile across sites, before and after the start of the Last Mile Connectivity Project (LMCP). Panel B shows imbalance that is statistically significant in later years, but economically small across World Bank and African Development Bank-funded sites (estimates include constituency fixed effects). **??** demonstrates baseline balance using a pooled regression of these data. **??** performs the same analysis on the study sample of transformers and finds no statistically detectable relationship between radiance and funder assignment.

Figure A3: Construction Quality, Gradient, and Electricity Access



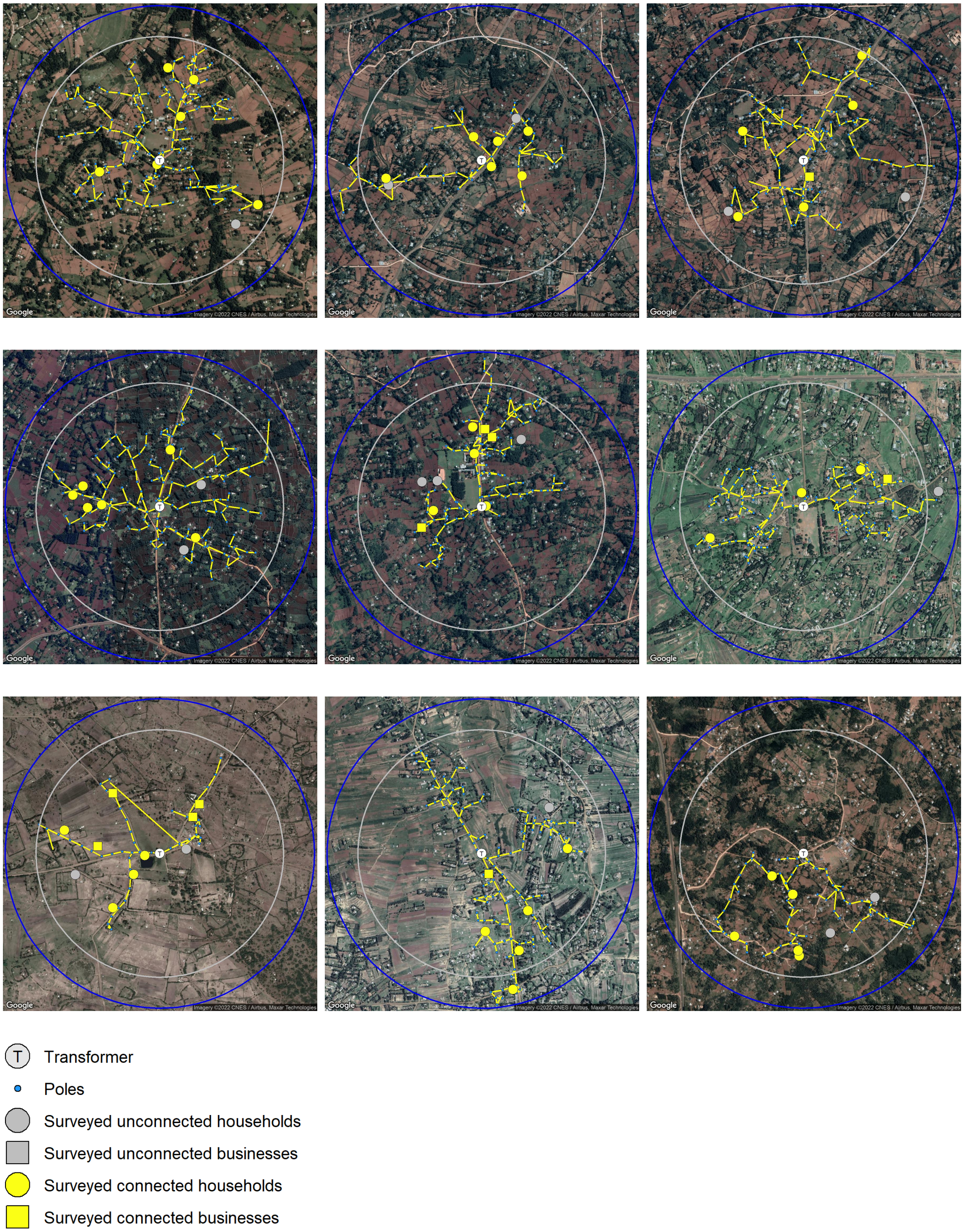
Notes: Differences in construction quality between WB and AfDB are approximately constant across the distribution of baseline electricity access and land gradient. Baseline electricity data from Kenya National Bureau of Statistics (2006; 2009). Average land gradient is calculated for each site over the 600 meter radius around its transformer using the 90-meter Shuttle Radar Topography Mission Global Digital Elevation Model.

Figure A4: Event study: nightlights after construction progress



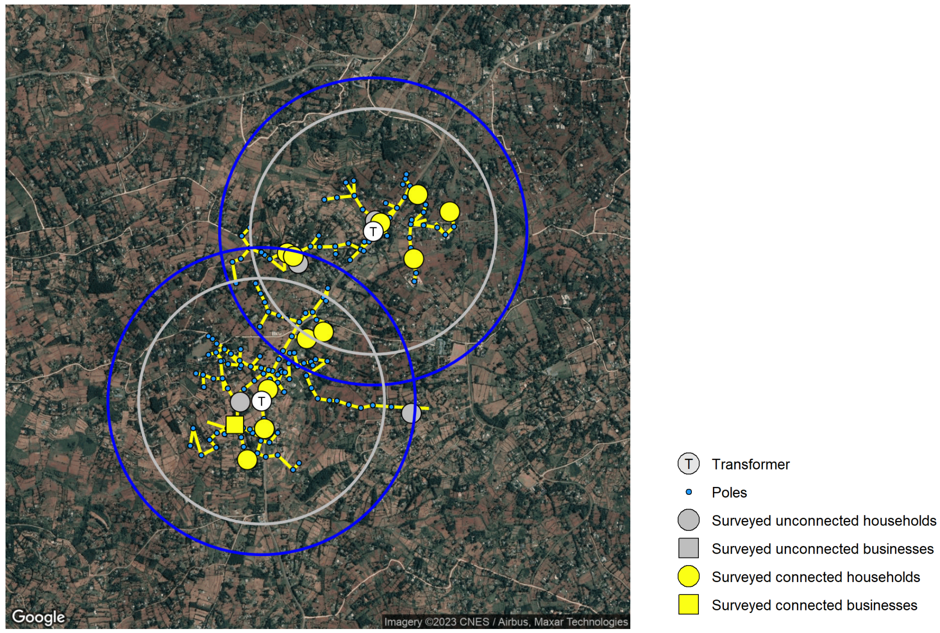
Notes: Data on construction progress collected through phone surveys with local village representatives. As expected, nighttime radiance data (Elvidge et al. 2017) increases after metering completion (when the electricity connection is activated) but not earlier.

Figure A5: Engineering data collected (additional example sites)



Notes: These maps display the construction data collected at example sites. The grey line denotes 600 meters and the blue line denotes 700 meters from the transformer ('T') at the center. **??** provides additional information on data collection. To preserve anonymity, random spatial noise has been added to household and business locations.

Figure A6: Two sites located less than 1,200 meters apart

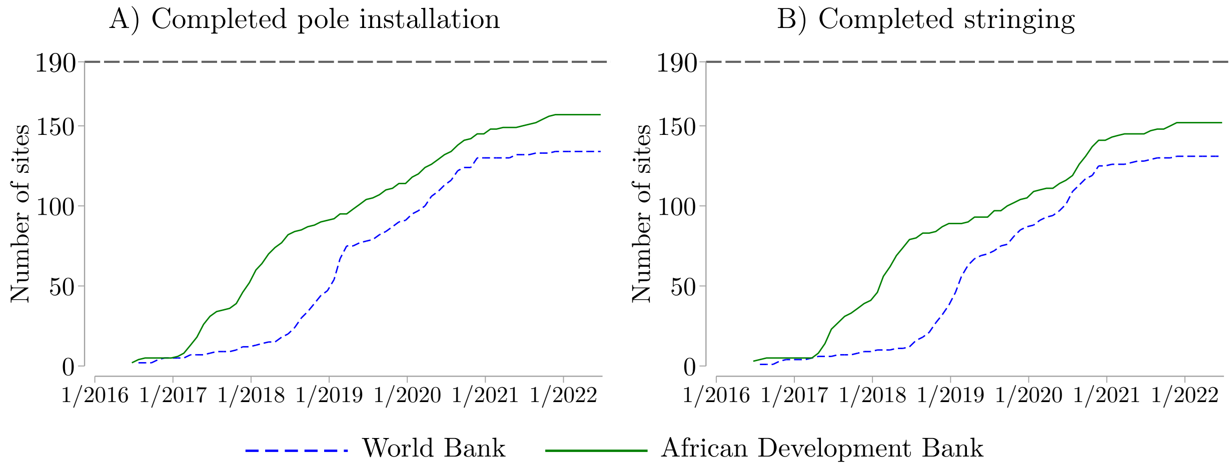


Notes: This map displays two sites whose transformers are located 990 meters apart, such that the 600 and 700 meter radius eligibility areas overlap. See **??** for a discussion on this issue. To preserve anonymity, random spatial noise has been added to household and business locations.

Figure A7: A PowerWatch device

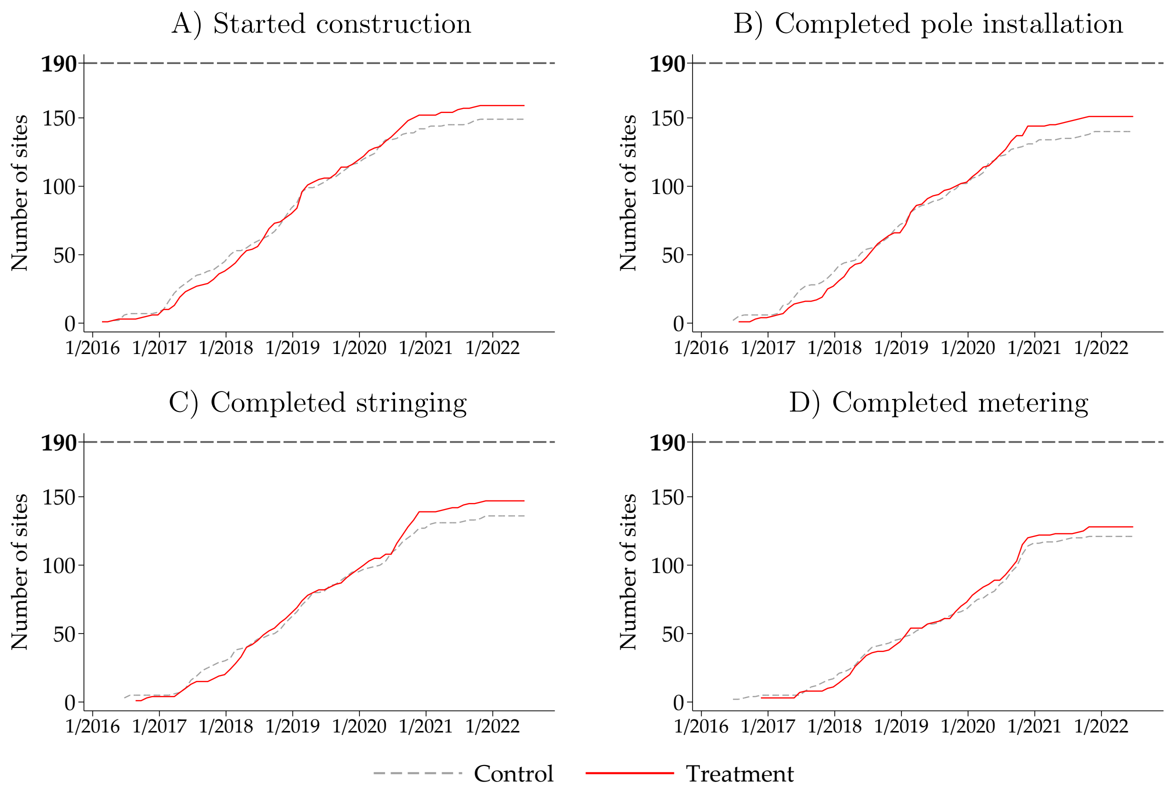
Notes: A PowerWatch device, part of nLine's GridWatch technologies used to measure household-level power outages and voltage. The device transmits data to the cloud in near real-time over the cellular network, and stores data locally to transmit later in the case of network failure. The GridWatch server consolidates data to detect patterns in power outages and reduce noisy signals.

Figure A8: Construction progress by funding source



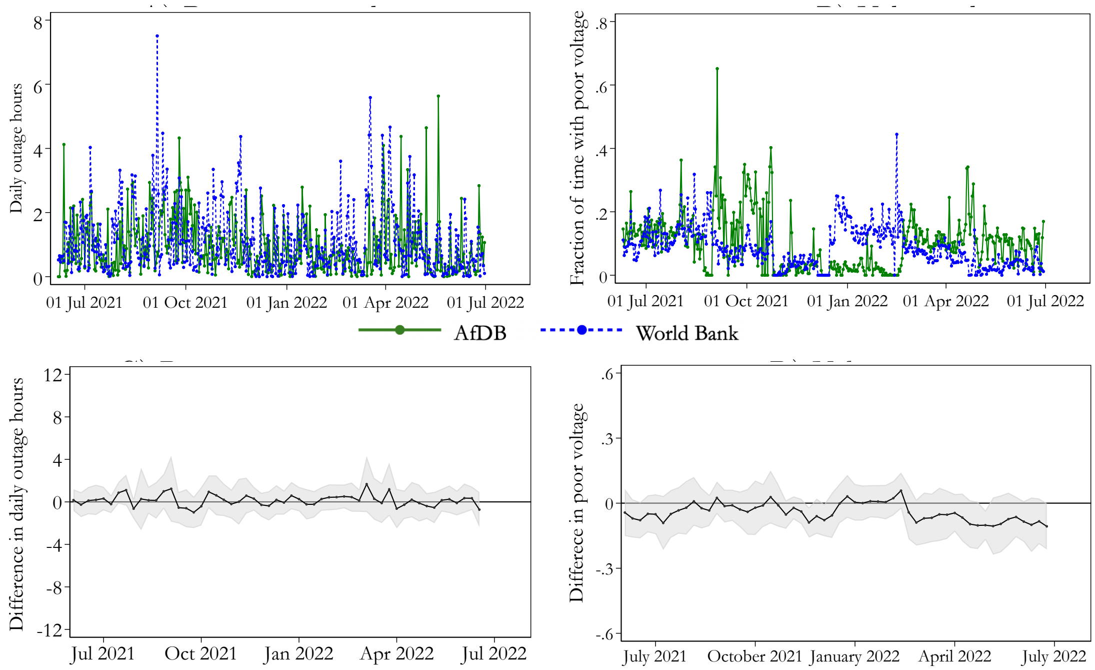
Notes: Data for 190 African Development Bank sites and 190 World Bank sites located in the five study counties collected through phone surveys with village representatives. **??** displays progress for pole installation and stringing.

Figure A9: Construction progress by audit treatment status



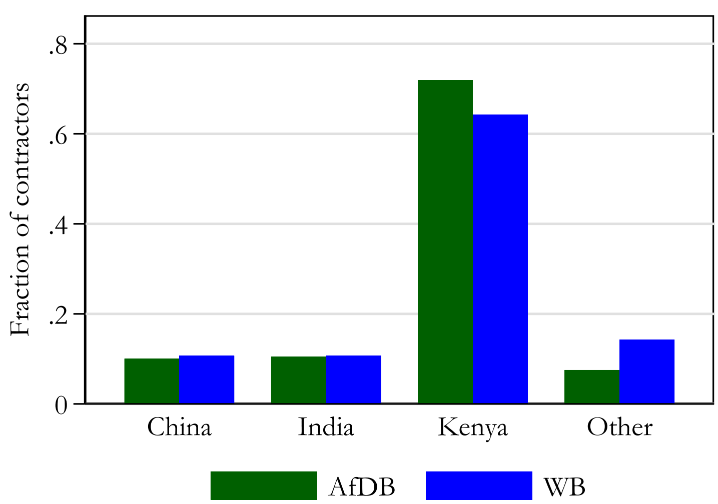
Notes: Data for 190 control sites and 190 treatment sites located in the five study counties collected through phone surveys with village representatives.

Figure A10: Reliability and voltage quality by funding source



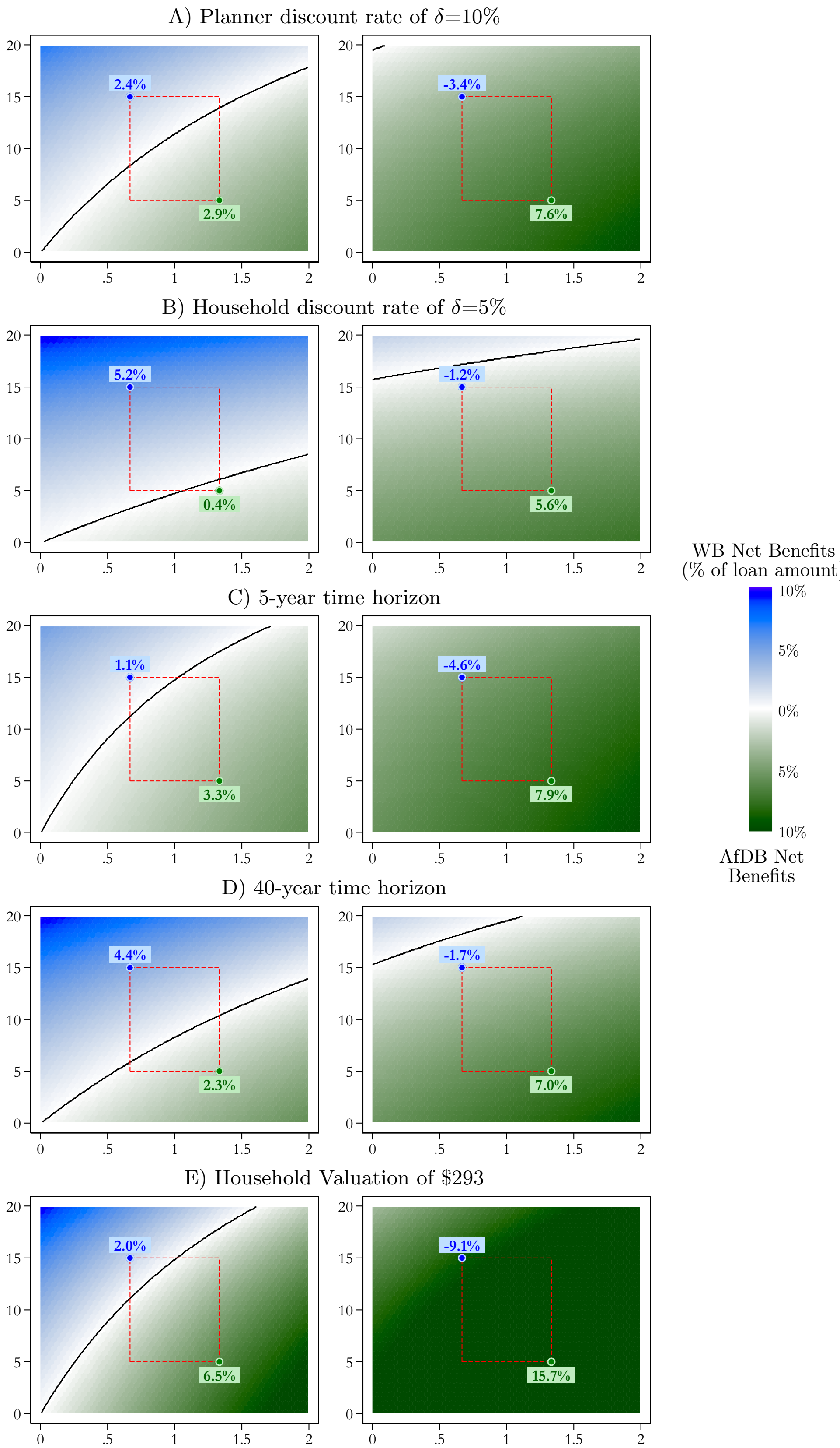
Notes: Panels A and B present the hours of power outage per day and fraction of time experiencing poor voltage quality, respectively, for World Bank and African Development Bank sites. Panels C and D estimate a separate coefficient for each week of the sample, with constituency fixed effects and standard errors clustered by site. In the voltage graphs, periods with power outages are set to missing in the voltage measurement data, but the results look similar when coding such periods as having $V = 0$.

Figure A11: World Bank contractors and African Development Bank subcontractors by country of origin



Notes: 59 companies were either awarded World Bank (WB) contracts or were approved to subcontract with one of the African Development Bank (AfDB) contractors for the procurement of poles, conductors, cables, or installation. This graph shows the distribution of countries of origin of these 59 companies. AfDB subcontractors are inverse-weighted by the number of good-specific subcontractors for which that AfDB contractor got approval, as most likely only one was used per good.

Figure A12: Costs versus benefits on various assumptions



Notes: Variations on the assumptions used for **??**, which presents results using our preferred assumptions. Each sub-title indicates the one aspect that has been changed relative to **??**.

B Appendix Tables

Table A1: Geographic balance of World Bank- and African Development Bank-funded sites

	Road Distance		VIIRS Radiance	Land Gradient
	(1)	(2)	(3)	(4)
World Bank (=1)	1.17	0.01	0.02	0.57**
	(1.67)	(1.06)	(0.06)	(0.24)
Observations	366	366	19085	347
Month FE	No	No	Yes	No
Constituency FE	Yes	Yes	Yes	Yes
AfDB Mean	57.97	72.08	.24	4.36
Outcome variable	Minutes	KM		

Notes: Columns (1) and (2) estimate distance in driving minutes and in kilometers from each study site to the nearest 'major town' (WRI 2007; HERE (2022). Column (3) estimates monthly average site-level nighttime radiance measured using VIIRS averaged across the 600 meter radius (Elvidge et al. 2017). SEs clustered by site (**??** shows the time series). Column (4) estimates average site-level land gradient recorded using the 90-meter Shuttle Radar Topography Mission Global Digital Elevation Model. This table only includes observations from study sites (**??** includes all phase 1 sites). Month and constituency FE included where indicated. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A2: Machine Learning methods to predict assignment of LMCP sites

	LPM LASSO Coefficient		Logit LASSO Coefficient		Decision Tree Importance	
Predictor	(1)	(2)	(3)	(4)	(5)	(6)
2013 Kenyatta Share	0.061	0.061	0.256	0.26	77	42
Age 14 or Under	-0.079		-0.357		63	34
Consumption	0.008		0.04		25	
Drive Distance	0.013	0	0.062		30	
Drive Time		0.001		0.003	22	
Electricity	-0.082	-0.016	-0.392	-0.082	51	
Ethnically Kalenjin-aligned	0.051	0.023	0.22	0.114	38	15
Ethnically Kikuyu-aligned	-0.002		-0.004		10	
Ethnically Luo-aligned	-0.012		-0.057		4	
High-Quality Roof	-0.034		-0.154		55	
High-Quality Wall					37	
Land Area	0.009	0.001	0.045	0.007	49	
Land Gradient	0.009	0.007	0.038	0.038	18	
Population	-0.005		-0.022		32	12
Primary Education	0.051	0.02	0.229	0.099	51	
Secondary Education	-0.008	-0.005	-0.032	-0.026	46	
Solar Home System	-0.041		-0.182	-0.004	42	10
VIIRS Radiance	0.018	0.007	0.084	0.053	33	
Voted pro-MP in 2013	-0.017	-0.011	-0.08	-0.05		
Const FEs?	No	Yes	No	Yes	No	Yes
Test RMSE	0.471	0.503	0.471	0.507	0.465	0.468
Test MAE	0.452	0.466	0.451	0.466	0.413	0.427
OoS R2	0.087	-0.043	0.088	-0.059	0.109	0.097
Class Rate	0.659	0.589	0.661	0.593	0.674	0.675

Notes: Only sites for which we have GPS coordinates and all variables (1,841 WB and 2,491 AfDB, out of a total sample of 3,308 WB and 4,184 sites). **??** includes all sites, with missing data imputed with the mean.

Table A3: Balance in 2009 census socioeconomic characteristics by number of LMCP sites per ward (nationwide sample)

	Dep. Var. Mean [SD]	Percent of LMCP Sites that are WB-funded	N
Panel A: 2009 Census			
Age 14 or Under	49.58	0.01**	1090
	[7.21]	(0.00)	
Consumption	3007.73	-1.75	1099
	[1361.76]	(1.24)	
Primary Education	57.19	0.00	1106
	[9.87]	(0.01)	
Secondary Education	20.27	-0.02**	1106
	[10.00]	(0.01)	
Solar Home System	2.00	-0.00	1106
	[2.18]	(0.00)	
Electricity	11.23	-0.02	1106
	[16.91]	(0.01)	
High-Quality Wall	16.69	0.01	1106
	[20.94]	(0.01)	
High-Quality Roof	74.80	-0.03*	1106
	[23.35]	(0.01)	
Population	23533.56	-8.22	1106
	[7774.64]	(8.45)	
Land Area (sq km)	279.73	0.15	1112
	[784.92]	(0.80)	
Panel B: Political and Ethnic Divisions			
2013 Kenyatta Share (%)	47.62	0.02	1001
	[40.55]	(0.01)	
Voted pro-MP in 2013	0.70	-0.00*	803
	[0.46]	(0.00)	
Luo-aligned	0.15	0.00	1104
	[0.36]	(0.00)	
Kikuyu-aligned	0.28	0.00	1104
	[0.45]	(0.00)	
Kalenjin-aligned	0.16	0.00	1104
	[0.37]	(0.00)	
Joint F-test		p-value = .052	

Notes: This table tests for correlations between the share of Last Mile Connectivity Project (LMCP) sites in a ward allocated to World Bank (WB) funding and baseline characteristics, at the ward level, among wards with at least 1 LMCP site. Table A5 shows a version testing balance among study sites only. Panel A tests balance on characteristics from the 2009 national census. Row 1 shows population share aged 14 years or younger. Row 2 shows monthly consumption expenditures per capita in Kenya Shillings (Ksh). Rows 3 and 4 show primary and secondary school completion rates, respectively. Rows 5–8 show percentage of households with solar, electricity, a high wall and roof quality, respectively. Rows 8–9 show the total ward population and land area, respectively. Panel B tests balance on political and ethnic data. Row 10 show the percentage of the ward that voted for Kenyatta in the 2013 presidential election. Row 11 is a dummy variable equal to one if the ward voted for the same party as their constituency MP. Rows 12-14 are dummy variables showing political alignment with major ethnic groups, equal to one if the ward voted for a member of that ethnic group in the 2013 county assembly elections. All regressions include constituency fixed effects. Data sources: Kenya National Bureau of Statistics (2006; 2009). All regressions include constituency FE. Data from KNBS (2006; 2009). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A4: Transformer facility type

Panel A) Sample field data

	N	AfDB Mean (SD)	WB (SE)
Health center	250	0.05	-0.00
		(0.22)	(0.03)
School	250	0.50	-0.13*
		(0.50)	(0.07)
Market center	250	0.17	0.09*
		(0.38)	(0.05)
Religious building	250	0.20	-0.10*
		(0.40)	(0.05)
Other	250	0.08	-0.03
		(0.28)	(0.04)
None	250	0.27	0.12*
		(0.44)	(0.06)

Panel B) Sample administrative data

	N	AfDB Mean (SD)	WB (SE)
Health center	378	0.06	-0.03
		(0.24)	(0.02)
School	378	0.09	0.18***
		(0.29)	(0.04)
Market center	378	0.13	0.03
		(0.33)	(0.04)
Religious building	378	0.05	-0.03
		(0.22)	(0.02)
Other	378	0.09	0.03
		(0.29)	(0.03)
None	378	0.08	0.29***
		(0.27)	(0.04)

Panel C) Nationwide administrative data

	N	AfDB Mean (SD)	WB (SE)
Health center	7396	0.03	-0.02***
		(0.18)	(0.00)
School	7396	0.05	-0.01**
		(0.23)	(0.01)
Market center	7396	0.16	0.01
		(0.37)	(0.01)
Religious building	7396	0.02	0.00
		(0.13)	(0.00)
Other	7396	0.38	0.22***
		(0.49)	(0.01)
None	7396	0.00	0.00
		(0.00)	(.)

Notes: Most transformers were constructed between 2005-2015 as part of a push by Kenya's Rural Electrification Authority (REA) to electrify public facilities like schools, religious buildings and markets, and there appear to be some differences in the likelihood of transformers located near specific types of facilities to be assigned to one funder or the other. We test whether transformers connected to certain types of facilities were more or less likely to be assigned to WB or AfDB funding. Total shares can exceed 1 because some transformers are located near multiple public facilities. We test this separately using field data collected during our surveys, administrative data for our entire sample, and nationwide administrative data. All regressions include constituency fixed effects.

Table A5: Balance in 2009 census socioeconomic characteristics by number of LMCP sites per ward (five counties sample)

	Dep. Var. Mean [SD]	Percent of LMCP Sites that are WB-funded	N
Panel A: 2009 Census			
Age 14 or Under	51.39	-0.01	170
	[3.76]	(0.01)	
Consumption	3063.59	1.57	170
	[1285.98]	(3.00)	
Primary Education	61.54	-0.01	170
	[4.54]	(0.01)	
Secondary Education	19.65	0.02	170
	[6.50]	(0.02)	
Solar Home System	1.10	-0.00	170
	[0.71]	(0.00)	
Electricity	6.96	0.04*	170
	[10.37]	(0.03)	
High-Quality Wall	13.06	0.01	170
	[9.24]	(0.03)	
High-Quality Roof	81.52	-0.01	170
	[12.04]	(0.03)	
Population	22801.28	5.64	170
	[6158.08]	(21.95)	
Land Area (sq km)	62.70	0.17*	170
	[44.15]	(0.10)	
Panel B: Political and Ethnic Divisions			
2013 Kenyatta Share (%)	33.84	-0.01	149
	[42.72]	(0.03)	
Voted pro-MP in 2013	0.71	-0.00	121
	[0.46]	(0.00)	
Luo-aligned	0.25	0.00	169
	[0.44]	(0.00)	
Kikuyu-aligned	0.03	0.00	169
	[0.17]	(0.00)	
Kalenjin-aligned	0.27	0.00	169
	[0.45]	(0.00)	
Joint F-test		p-value = .05	

Notes: This table tests for correlations between the share of Last Mile Connectivity Project (LMCP) sites in a ward allocated to World Bank (WB) funding and baseline characteristics, at the ward level, among wards with at least 1 study site. Table A3 shows a version testing balance among all LMCP sites nationwide. Panel A tests balance on characteristics from the 2009 national census. Row 1 shows population share aged 14 years or younger. Row 2 shows monthly consumption expenditures per capita in Kenya Shillings (Ksh). Rows 3 and 4 show primary and secondary school completion rates, respectively. Rows 5–8 show percentage of households with solar, electricity, a high wall and roof quality, respectively. Rows 8–9 show the total ward population and land area, respectively. Panel B tests balance on political and ethnic data. Row 10 show the percentage of the ward that voted for Kenyatta in the 2013 presidential election. Row 11 is a dummy variable equal to one if the ward voted for the same party as their constituency MP. Rows 12-14 are dummy variables showing political alignment with major ethnic groups, equal to one if the ward voted for a member of that ethnic group in the 2013 county assembly elections. All regressions include constituency fixed effects. Data sources: Kenya National Bureau of Statistics (2006; 2009). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A6: Summary statistics

	Mean	SD	25^{th}	50^{th}	75^{th}	N
Transformer missing fuse	0.23	0.42	0	0	0	250
Number of transformer lines	3.13	0.99	3	3	4	250
Number of poles	84.92	35.16	58	80	106	250
Number of leaning poles (<85deg)	1.69	2.57	0	1	2	250
Number of cracked poles	20.29	18.01	6	15	29	250
Number of poles without a cap	40.17	28.80	19	34	56	250
Number of stays	54.91	24.34	37	52	70	250
Households surveyed	3.78	1.63	3	4	5	250
Connected households surveyed	3.15	1.64	2	3	4	250
Year households connected	2018.89	1.13	2018	2019	2020	184

Notes: Summary statistics for surveyed sites. The question on connection year was added to the survey later, after surveying had already been completed at 66 sites.

Table A7: Impact of transformer characteristics on construction at site

	Uncompleted Mean	Completed	N
World Bank (=1)	0.55	-0.17**	378
	[0.50]	(0.06)	
Baseline nighttime radiance	0.48	-0.21**	366
	[1.03]	(0.07)	
Land gradient	5.55	-1.24***	347
	[3.47]	(0.27)	
Nearest city (KM)	32.46	1.56	347
	[17.21]	(1.59)	
Nearest city (minutes driving)	59.98	1.30	347
	[30.03]	(2.68)	
Public building...			
Health	0.08	-0.03	378
	[0.27]	(0.02)	
Secondary school	0.05	0.03	378
	[0.21]	(0.03)	
Primary school	0.16	0.09	378
	[0.36]	(0.05)	
Market center	0.13	0.01	378
	[0.34]	(0.04)	
Religious building	0.06	-0.03	378
	[0.24]	(0.02)	
None	0.20	-0.00	378
	[0.40]	(0.05)	
School	0.19	0.00	378
	[0.39]	(0.05)	
Other	0.14	-0.06	378
	[0.35]	(0.04)	
Mean	0.66	0.66	

Notes: Differences between sites that saw construction and sites that did not, among the tracked sample of 378.

Table A8: Construction quality

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 1: Construction quality index	0.00	0.64***	0.10	-0.03	250
	[1.00]	(0.21)	(0.20)	(0.18)	
∗ Transformer does not have bypassed fuse	0.40	-0.15*	-0.05	-0.08	250
	[0.49]	(0.08)	(0.08)	(0.08)	
Pole does not have a crack ≥1cm	0.74	0.05	0.00	-0.01	21022
	[0.44]	(0.03)	(0.03)	(0.03)	
Pole leaning at ≥85 degrees	0.97	0.01*	0.01*	0.00	21229
	[0.16]	(0.00)	(0.00)	(0.00)	
Line has ≥0.5m horiz clearance	0.93	-0.03***	0.01	-0.02**	19780
	[0.25]	(0.01)	(0.01)	(0.01)	
Pole has cap	0.28	0.33***	0.03	0.06	17900
	[0.45]	(0.04)	(0.04)	(0.04)	
Stay/strut properly installed	0.92	0.01	-0.01	0.00	3193
	[0.27]	(0.02)	(0.01)	(0.02)	
Stay/strut installed when required	0.79	0.16***	0.02	0.01	9811
	[0.41]	(0.03)	(0.02)	(0.04)	
Insulator properly installed	0.99	-0.02*	0.00	-0.00	3076
	[0.10]	(0.01)	(0.01)	(0.01)	
Insulator installed when required	0.98	0.01*	-0.01*	0.01	3103
	[0.13]	(0.01)	(0.01)	(0.01)	
Pole has grounding wire	0.34	0.03**	0.01	-0.02*	21229
	[0.47]	(0.01)	(0.01)	(0.01)	

Notes: The construction quality index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. Transformer bypassed fuse is measured once at each site. All other outcomes are measured for all poles measured in the engineering assessment survey (described in Section **??**). For each pole-level outcome, the sample is limited to poles for which that outcome can be assessed. Standard errors are clustered by site. An F-test of $H_0 : \beta_1 - \beta_3 = 0$ for the metering completion date has a p-val< 0.001. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A9: Network configuration

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 2: Network size and configuration index	0.00	-0.04	0.19	-0.08	244
	[1.00]	(0.16)	(0.16)	(0.18)	
Absolute Deviation in Pole Count (relative to design)	65.66	-3.87	6.44	2.46	197
	[55.90]	(11.44)	(11.26)	(12.42)	
Absolute Deviation in Drop Cables (relative to design)	62.12	15.69	-0.07	11.78	178
	[44.79]	(9.57)	(9.49)	(10.49)	
Fraction of compounds at site, within 100m of LV line, electrified	0.89	-0.02	0.04	-0.01	244
	[0.13]	(0.02)	(0.03)	(0.02)	
Fraction of poles ≤600m from transformer	0.95	0.02	0.01	0.00	244
	[0.08]	(0.01)	(0.01)	(0.01)	
Number of poles in design	134.51	-1.10	-8.89	12.52	197
	[87.55]	(15.32)	(16.60)	(15.92)	

Notes: The network size and configuration index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the site level. Compound data is collected in the household and firm survey data (described in Section **??**). Pole data is collected in the engineering assessment survey (described in Section **??**). $^* \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A10: Household installation quality

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 4: Household installation quality index	-0.00	0.05	0.02	0.23*	944
	[1.01]	(0.12)	(0.11)	(0.12)	
Outcome 4 (omitting readyboard question)	-0.01	0.15	-0.03	0.23*	944
	[1.00]	(0.12)	(0.12)	(0.12)	
Electricity has flowed to this household (=1)	0.81	0.05	0.04	0.08	944
	[0.39]	(0.06)	(0.04)	(0.05)	
Household has ≥1 meter (=1)	0.86	0.09**	0.01	0.08*	944
	[0.35]	(0.04)	(0.04)	(0.04)	
Household has meter that has worked (=1)	0.77	0.06	0.07	0.11**	943
	[0.42]	(0.06)	(0.05)	(0.05)	
Household has a readyboard (=1)	0.26	-0.14***	0.08**	0.02	944
	[0.44]	(0.04)	(0.04)	(0.05)	
(-) Number of unrequested meters (of hhs w/ meter)	0.51	-0.04	0.10*	0.09	713
	[0.50]	(0.07)	(0.06)	(0.06)	
(-) Weeks from paperwork to receiving meter (of hhs w/ meter)	13.64	4.32	1.58	-2.09	884
	[25.10]	(2.95)	(2.32)	(2.47)	
(-) Weeks from meter to receiving electricity (of hhs with elec)	2.43	-0.26	0.93*	-0.82*	761
	[4.12]	(0.44)	(0.54)	(0.46)	

Notes: The household installation quality index (shown here in rows 1 and 2) is a standardized average of sub-components shown in the remaining rows. Row 2 omits the ready board question as the absence of a ready board is not strictly an indication of poor quality. All outcomes are measured at the household level and collected in the household and firm survey data (described in Section **??**). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. $^* \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A11: Household cost, experience, and bribery

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 5: Household cost, experience, bribery index	0.02	0.13	0.06	0.11	944
	[0.99]	(0.12)	(0.11)	(0.10)	
Days given to fulfill paperwork reqs (of LMCP hh)	42.29	21.09	0.30	3.16	828
	[79.87]	(14.35)	(13.54)	(11.70)	
Did not require own wiring before connection (=1)	0.77	-0.03	-0.04	0.01	855
	[0.42]	(0.05)	(0.05)	(0.05)	
(-) KSH spent on wiring (of hh that did wiring) (w)	7774.45	-925.05	645.25	-741.25	708
	[6779.96]	(718.32)	(666.29)	(739.09)	
(-) Up-front connection payment (Ksh) (w)	6684.48	-694.60	588.85	-685.49	925
	[9104.41]	(844.78)	(776.80)	(923.51)	
Connected by KPLC/REA (=1)	0.98	0.01	0.01	0.01	837
	[0.13]	(0.02)	(0.01)	(0.01)	
Was not asked for bribe (=1)	0.91	0.02	-0.02	-0.01	944
	[0.29]	(0.03)	(0.03)	(0.03)	
Didn't do unpaid manual labor for connection (=1)	0.96	-0.02	0.04**	0.00	929
	[0.19]	(0.02)	(0.02)	(0.02)	
(-) Amount paid so far in installments (Ksh) (w)	2698.65	-24.92	-454.06	-48.46	878
	[4531.45]	(521.88)	(467.42)	(504.09)	
Satisfaction with electricity installation (1-5 scale)	4.21	-0.02	0.04	0.08	944
	[1.07]	(0.13)	(0.12)	(0.13)	
(-) Hours in past month with very low voltage	1.57	2.85	1.07	-1.80	602
	[6.61]	(1.86)	(1.73)	(1.67)	
(-) Repair costs for devices damaged b/c electricity (Ksh)	31.19	-9.37	-44.27**	-67.32**	604
	[206.11]	(32.01)	(22.40)	(33.07)	

Notes: The household cost, experience, and bribery index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section **??**). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A12: Household and firm reliability and safety

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 6: Reliability and safety index	0.01	-0.11	0.03	-0.01	944
	[0.99]	(0.13)	(0.14)	(0.11)	
Had power in past 7 days (=1) (of electrified hh)	0.88	0.06	-0.02	0.11***	787
	[0.32]	(0.04)	(0.04)	(0.03)	
No regular blackouts (=1) (of electrified hh)	0.58	-0.11**	0.03	-0.05	787
	[0.49]	(0.06)	(0.06)	(0.06)	
No blackout in past 7 days (=1) (of hh w/ power last 7 days)	0.40	0.01	0.01	0.07	703
	[0.49]	(0.07)	(0.07)	(0.07)	
(-) Hours power not working in past 7 days (of hh w/ power last 7 days)	7.12	1.74	-2.86*	0.56	700
	[15.04]	(1.91)	(1.66)	(1.86)	
No blackouts ≥30 days in past year (=1) (of electrified hh)	0.95	-0.06	0.01	-0.02	787
	[0.23]	(0.04)	(0.04)	(0.03)	
No injury fr/ electricity in past year (=1) (of electrified hh)	0.99	0.00	-0.02	-0.01	787
	[0.10]	(0.01)	(0.01)	(0.01)	
No damage fr/ electricity in past year (=1) (of electrified hh)	0.99	-0.01	0.00	-0.02**	787
	[0.09]	(0.01)	(0.01)	(0.01)	

Notes: The household reliability and safety index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section **??**). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. $^* \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A13: Knowledge

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 7: Knowledge index	0.01	0.13	-0.02	0.06	944
	[1.01]	(0.09)	(0.09)	(0.10)	
Told correct total cost of connection (=1) (of hh w/ drop cable)	0.29	0.05	0.02	0.02	930
	[0.46]	(0.06)	(0.07)	(0.06)	
Correctly told to pay monthly (=1) (of hh told of connxn cost)	0.05	-0.05***	0.02	0.00	930
	[0.22]	(0.02)	(0.01)	(0.02)	
Knows how much still owed for connection (=1)	0.43	0.16***	-0.07	0.02	944
	[0.50]	(0.06)	(0.06)	(0.06)	
Knows 20th token costs same as 1st (=1) (of hh who have topped up)	0.76	0.02	-0.02	-0.01	707
	[0.43]	(0.06)	(0.07)	(0.06)	
Knows value of 1st token	0.94	0.01	-0.00	0.02	707
	[0.23]	(0.03)	(0.02)	(0.03)	

Notes: The knowledge index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section **??**). $^* \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A14: Electricity Usage

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 8: Electricity Usage index	-0.01	0.11	0.11	0.28**	944
	[1.00]	(0.12)	(0.10)	(0.12)	
Electricity is main source of lighting (=1)	0.73	0.06	0.03	0.13**	944
	[0.44]	(0.06)	(0.05)	(0.05)	
Electricity is main source of cooking (=1)	0.00	0.00	0.00	0.00	944
	[0.00]	(.)	(.)	(.)	
Household has topped up (=1) (of hh w/ prepaid meter)	0.86	0.02	0.08**	0.11**	836
	[0.35]	(0.05)	(0.03)	(0.05)	
Electricity spending past month (Ksh) (of hh w/ meter) (w)	183.13	-9.93	-0.35	11.54	893
	[241.18]	(24.36)	(19.53)	(25.43)	
Hours of lighting used at night in past week	2.78	0.10	0.29	0.40	848
	[2.74]	(0.29)	(0.20)	(0.30)	
Hours of lighting used in morning in past week	4.66	0.63	1.50**	0.32	652
	[5.69]	(0.77)	(0.74)	(0.70)	
Number of appliances that use the grid	1.90	0.31*	0.08	0.32**	938
	[1.51]	(0.17)	(0.17)	(0.16)	
Number of households in this compound connected	1.13	0.01	0.01	0.03	944
	[0.67]	(0.04)	(0.04)	(0.06)	

Notes: The electricity usage index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section **??**). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A15: Household Socioeconomic Outcomes

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 9: Household socioeconomic outcomes index	-0.02	0.24*	-0.01	0.20	944
	[0.99]	(0.12)	(0.13)	(0.12)	
Connection allowed pursuing employment, business (1-5) (of connected hh)	2.54	0.27*	0.33**	0.16	787
	[1.19]	(0.15)	(0.14)	(0.15)	
Connection affected earnings (1-5) (of connected hh)	3.25	0.15*	0.09	0.01	787
	[0.78]	(0.09)	(0.09)	(0.09)	
Connection permitted changing hours worked (1-5) (of connected hh)	3.65	0.05	0.05	0.04	787
	[0.86]	(0.12)	(0.12)	(0.11)	
Connection affected amount of food consumed (1-5) (of connected hh)	3.10	0.14**	0.03	0.08	787
	[0.45]	(0.05)	(0.05)	(0.06)	
Connection affected health (1-5) (of connected hh)	3.59	-0.08	0.08	-0.05	787
	[0.86]	(0.11)	(0.10)	(0.11)	
Connection affected children's education (1-5) (of connected hh w/ children)	4.32	0.33***	-0.04	0.19*	691
	[0.85]	(0.09)	(0.08)	(0.10)	
Connection affected knowledge about news (1-5) (of connected hh)	4.15	0.14	0.01	0.10	787
	[0.97]	(0.10)	(0.09)	(0.10)	
Connection permited changing kerosene spending (1-5) (of connected hh)	1.51	-0.03	0.06	0.07	787
	[0.99]	(0.10)	(0.10)	(0.10)	
Connection changed phone charging freq. (1-5) (of connected hh)	3.11	0.57***	-0.13	0.36**	787
	[1.49]	(0.18)	(0.19)	(0.17)	
(-) Kerosene spending, last week (Ksh) (w)	30.02	-15.21**	15.52**	-8.91	940
	[62.30]	(6.04)	(6.32)	(5.80)	
Owns home (=1)	0.99	0.00	-0.01	0.00	944
	[0.10]	(0.01)	(0.01)	(0.01)	
Number of rooms in primary residence	3.54	-0.19	-0.05	0.08	944
	[1.66]	(0.15)	(0.13)	(0.14)	
High-quality floors (=1)	0.38	0.04	-0.12***	-0.02	944
	[0.48]	(0.05)	(0.05)	(0.05)	
High-quality roof (=1)	1.00	-0.01*	0.00	0.01	944
	[0.06]	(0.01)	(0.01)	(0.01)	
High-quality walls (=1)	0.21	0.01	-0.00	0.06	944
	[0.41]	(0.04)	(0.04)	(0.04)	
Buildings in compound (of compounds with hh)	2.94	-0.15	-0.01	-0.18	747
	[1.56]	(0.15)	(0.13)	(0.20)	
Electrified buildings in compound (of compounds with hh)	1.64	-0.04	0.01	0.14	747
	[1.31]	(0.10)	(0.08)	(0.16)	

Notes: The household socioeconomic outcomes index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section **??**). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. Due to ambiguity in the wording for one of the survey questions, a pre-specified outcome ("connection affected security") was removed from this table. The wording of the survey question allowed the respondent to interpret the question two different ways. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A16: Firm Performance

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 10: Firm Performance Index	-0.00	0.29	-0.11	0.12	373
	[1.00]	(0.19)	(0.21)	(0.17)	
Firm uses electricity (=1)	0.64	0.20**	0.02	0.11	339
	[0.48]	(0.08)	(0.08)	(0.08)	
Firm planning to buy electrical equipment in next year (=1)	0.42	0.13	-0.11	0.06	339
	[0.49]	(0.10)	(0.09)	(0.08)	
Firm uses elec beyond lighting and cell charge (=1) (of those that use elec)	0.36	-0.08	0.00	-0.19**	344
	[0.48]	(0.09)	(0.08)	(0.07)	
Number of appliances owned by Firm	1.23	0.24	-0.13	0.03	344
	[1.13]	(0.24)	(0.24)	(0.20)	
Firm household has high quality roof (=1)	0.89	0.07	-0.08	0.03	306
	[0.31]	(0.06)	(0.06)	(0.06)	
Firm household has high quality walls (=1)	0.49	-0.04	0.04	0.11	306
	[0.50]	(0.12)	(0.10)	(0.10)	

Notes: The firm performance index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the firm level and collected in the household and firm survey data (described in Section **??**). $^* \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A17: Household Political and Social Beliefs

	(1) AfDB Mean	(2) World Bank Effect Estimate (β_1)	(3) Audit Treatment Effect, WB Sites (β_2)	(4) Audit Treatment Effect, AfDB Sites (β_3)	(5) N
Outcome 11: Political and Social Beliefs index	0.00	0.03	0.01	0.03	944
	[0.99]	(0.08)	(0.08)	(0.09)	
HH electrification in top 2 most-important govt policies (=1)	0.21	0.00	-0.01	-0.01	944
	[0.41]	(0.04)	(0.04)	(0.04)	
Thinks govt doing good job providing electricity (=1)	0.98	0.00	-0.00	-0.01	944
	[0.14]	(0.01)	(0.01)	(0.01)	
Voted in August 2017 election (=1)	1.15	0.07	0.35	0.48	944
	[4.42]	(0.20)	(0.33)	(0.35)	

Notes: The household political and social beliefs index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section **??**). $^* \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A18: Impact of gradient and facility type on construction delays

Panel A) Months to stringing completion

	(1)	(2)	(3)	(4)	(5)
World Bank (=1)	6.8***	9.9***	9.5***	9.5***	8.7***
	(2.1)	(2.2)	(2.3)	(2.3)	(2.5)
Land gradient			0.6		0.4
			(0.6)		(0.7)
Health center				-0.3	1.1
				(5.4)	(5.7)
Secondary school				-0.4	-1.3
				(3.3)	(3.4)
Primary school				1.8	2.6
				(2.4)	(2.6)
Market center				1.1	1.9
				(2.7)	(2.9)
Religious building				-3.9	-4.0
				(2.9)	(3.0)
Other				2.7	4.9
				(5.8)	(6.3)
Observations	246	246	229	226	211
Constituency FE	No	Yes	Yes	Yes	Yes

Panel B) Months to metering completion

	(1)	(2)	(3)	(4)	(5)
World Bank (=1)	9.6***	12.4***	11.7***	13.2***	12.2***
	(1.8)	(1.8)	(1.9)	(1.9)	(2.0)
Land gradient			1.0*		0.8
			(0.5)		(0.6)
Health center				3.7	5.3
				(4.5)	(4.6)
Secondary school				0.9	0.4
				(2.7)	(2.7)
Primary school				1.3	1.6
				(2.0)	(2.1)
Market center				-2.0	-1.1
				(2.2)	(2.3)
Religious building				1.4	1.3
				(2.4)	(2.5)
Other				3.8	6.5
				(4.7)	(5.1)
Observations	248	248	231	227	212
Constituency FE	No	Yes	Yes	Yes	Yes

Notes: Stringing (metering) was completed at WB sites on average 6.8 (9.6) months later than at AfDB sites when pooling audit control and treatment sites. Controlling for land gradient and facility type does not affect these estimates meaningfully, and land gradient and facility type appear largely uncorrelated with time to stringing and metering completion. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A19: Heterogeneity in WB delay by facility type

	Time to stringing completion (months)				
	(1)	(2)	(3)	(4)	(5)
World Bank (=1)	18.5	5.2	8.8*	-6.0	-3.0
	(13.5)	(6.9)	(5.0)	(5.3)	(14.6)
Observations	9	64	53	17	21
Control Mean	41.5	53.16	50.52	43.1	54.36
Sample	Health centers	Schools	Market centers	Religious buildings	Others

Notes: While there are small differences between funder type in the facility type associated with each transformer (Table A4) this does not drive heterogeneity in the impact of WB conditionality on construction delays when compared with AfDB sites. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A20: Primary engineering and socioeconomic outcomes excluding Lots 3 and 5

	(1) WB Effect Estimate (β_1)	(2) Audit Treatment Effect, WB Sites (β_2)	(3) Audit Treatment Effect, AfDB Sites (β_3)	(4) N
Outcome 1: Construction quality index	0.57	0.13	0.05	161
	(0.50)	(0.49)	(0.19)	
Outcome 2: Network size and configuration index	0.66	-0.16	-0.07	156
	(0.40)	(0.37)	(0.20)	
Outcome 3: Construction timing index	-1.13***	-0.15	-0.36**	161
	(0.38)	(0.39)	(0.17)	
Outcome 4: Household installation quality index	-0.55**	0.79***	0.23*	592
	(0.26)	(0.23)	(0.13)	
Outcome 5: Household cost, experience, bribery index	0.39**	0.11	0.11	592
	(0.19)	(0.18)	(0.10)	
Outcome 6: Reliability and safety index	-0.12	-0.18	-0.08	592
	(0.16)	(0.17)	(0.10)	
Outcome 7: Knowledge index	0.31	-0.09	0.10	592
	(0.20)	(0.20)	(0.10)	
Outcome 8: Electricity Usage index	-0.24	0.53***	0.25*	592
	(0.31)	(0.19)	(0.14)	
Outcome 10: Firm Performance Index	-0.27	0.08	0.02	256
	(0.42)	(0.43)	(0.17)	
Outcome 11: Political and Social Beliefs index	0.01	-0.02	0.02	592
	(0.16)	(0.13)	(0.09)	

Notes: This table replicates **??** but excludes Lots 3 and 5 and then retains only a balanced panel of constituencies. **??** provides more detail. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A21: Connections and poles installed per site excluding nearby sites

	Entire site				Outside 600 meter boundary			
	Poles		Connections		Poles		Connections	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
β_1: World Bank (=1)	-12.8**	-5.5	-13.4**	-22.2*	-2.4***	-1.7	-1.6***	-1.4
	(6.2)	(10.7)	(6.7)	(11.5)	(0.7)	(1.2)	(0.6)	(1.0)
Treatment (=1)	9.0		6.7		0.2		0.1	
	(6.2)		(6.6)		(0.7)		(0.6)	
β_2: Treatment (WB sites)		-2.4		8.6		-0.6		-0.4
		(9.2)		(9.9)		(1.0)		(0.8)
β_3: Treatment (AfDB sites)		18.7**		4.3		0.9		0.7
		(8.8)		(9.5)		(1.0)		(0.8)
Observations	224	224	224	224	218	218	218	218
Control Mean	93.33	93.33	73.30	73.30	3.77	3.77	2.98	2.98

Notes: This table replicates **??** but excluding sites that are less than 1,200 of another site, as the areas within 600 meters of such sites would overlap (see **??** for a discussion of this problem). If anything, this version more strongly supports our results. All regressions include constituency fixed effects. Standard errors shown in parentheses. $^* \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A22: Heterogeneity by share of contractor's sites under audit

Outcome 4: Household installation quality index	
Treated	0.31***
	(0.11)
Treated x	-0.25**
ManyTreated	(0.13)
Outcome 5: Household cost, experience, bribery index	
Treated	-0.02
	(0.11)
Treated x	0.14
ManyTreated	(0.13)
Outcome 6: Reliability and safety index	
Treated	-0.12
	(0.13)
Treated x	0.13
ManyTreated	(0.16)
Outcome 7: Knowledge index	
Treated	-0.02
	(0.11)
Treated x	0.07
ManyTreated	(0.13)
Outcome 8: Electricity Usage index	
Treated	0.32***
	(0.11)
Treated x	-0.19
ManyTreated	(0.12)
Test for null hypothesis of equal treatment effects for all outcomes: p=0.252	

Notes: This table tests whether audit treatment effects differ across contractors that had a higher percentage of their sites in the treatment group. Outcome variables are indices constructed from groups of variables standardized to have mean 0 and standard deviation 1. "Treated" is a binary variable that equals 1 if the occupant is at a treated site. "ManyTreated" is a binary variable if the occupant's site is assigned to the contractor with the highest percentage of sites in the audit treatment group for its funder. All equations include constituency fixed effects, funder fixed effects, census controls, and land gradient and public facility type controls (given some baseline imbalance along these dimensions) and were jointly estimated using seemingly unrelated regression. Standard errors are clustered by site and shown in parentheses. $^* \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

C Conceptual framework

Consider a principal who has a project that they want to contract out to one or more firms, selected from a continuum of firms ($\gamma_i \in [0, \infty)$) through competitive auction. Firm i is differentiated by its firm type γ_i which incurs convex cost $c(\gamma_i)$. Firms can exert effort e_i at convex cost $d(e_i)$ with $d'(0) = 0$ and $d(0) = 0$. Each firm's output quality is the sum of its type and effort: $q_i = \gamma_i + e_i$.

The project consists of three components: design, materials, and installation. Each firm can provide at most one component. Overall project quality is the sum of the three components: $Q = q_a + q_b + q_c$. The principal can award these as one bundled contract ($t = 1$) or as three unbundled contracts ($t = 3$). The principal also imposes a minimum firm type threshold $\bar{\gamma}$ that determines firms' eligibility to submit a bid.

The principal can furthermore implement either low monitoring ($m = L$) or high monitoring ($m = H$). Setting $m = H$ allows the principal to enforce a minimum output quality threshold $\bar{q}$ for each component. If any component is produced below output quality $\bar{q}$, then the contracted firm is not paid.

The auction proceeds as follows:

(P1) The principal chooses and announces the two auction parameters (t and m).
- If the contracts are unbundled, the principal runs three sequential competitive auctions.
- If the contract is bundled, the principal runs one competitive auction for installation. The installer later selects a designer and a supplier with full discretion.

(A1) Each eligible firm decides whether to bid. If it chooses to bid, it chooses a bid amount b_i.

(P2) The principal identifies the lowest eligible bid as the winner of each auction.
- If the contracts are unbundled, the principal awards three contracts.
- If the contract is bundled, the principal awards one contract for installation. The winner then selects a designer $\gamma_a \in [0, \infty)$ and a supplier $\gamma_b \in [0, \infty)$ with full discretion. The installer can mandate their effort levels e_a and e_b.

(A2) Each firm exerts effort e_i and realizes their output quality q_i.

(P3) The principal pays the contractor(s) (or not).
- If $m = L$, all firms are paid regardless of q_i.
- If $m = H$ and $t = 1$, all firms are paid only if $q \geq \bar{q}$ for each component (and the installer pays the designer and supplier *iff* it is paid).
- If $m = H$ and $t = 3$, the designer, supplier, and installer are each paid only if their respective output quality is at least $\bar{q}$.

Finally, assuming perfect competition:

- If $t = 1$, the firm's bid is $b_c = c(\gamma_a) + d(e_a) + c(\gamma_b) + d(e_b) + c(\gamma_c) + d(e_c)$. The firm pays the design firm $c(\gamma_a) + d(e_a)$ and the supplies firm $c(\gamma_b) + d(e_b)$.
- If $t = 3$, each firm's bid is $b_i = c(\gamma_i) + d(e_i)$.

<u>Case 1 ($t = 3, m = L$):</u>

- Firms with $\gamma_i = \bar{\gamma}$ will bid $c(\bar{\gamma})$ and win all three auctions.
- There is no incentive to supply any effort, so $e_i = 0$
- Project quality will be $3\bar{\gamma}$, with cost per contract $b(3, L) = c(\bar{\gamma})$ and total cost $3c(\bar{\gamma})$

<u>Case 2 ($t = 3, m = H$):</u>

- For each component, the winning firm is the one that can produce output quality $\bar{q}$ at lowest cost, since no other firm can bid lower than them while achieving at least zero profit. The winning firms will each have type γ_i and choose e_i such that: $c'(\gamma_i) = d'(e_i)$. Let γ^* and e^* be the solution to this problem.
- Project quality will be $\bar{q}$, with cost per contract $b(3, H) = c(\gamma^*) + d(e^*)$ and total cost of $3c(\gamma^*) + 3d(e^*)$.

Case 3 ($t = 1, m = L$):

- The winning firm has $\gamma = \bar{\gamma}$ and bids $c(\bar{\gamma}) + 2c(0)$ in the auction. It is the firm of at least type $\bar{\gamma}$ that can bid the lowest. It then exerts no effort.
- For design and materials, it has no incentive to select firms with more than minimum firm type, and it will contract assuming zero effort from those firms.
- Project quality will be $\bar{\gamma}$, with total cost $b(1, L) = c(\bar{\gamma}) + 2c(0)$.

Case 4 ($t = 1, m = H$):

- With full ability to contract on firm type and effort exerted, the winning firm will wish to supply output quality $\bar{q}$ at minimum cost. The winning firm that is able to bid the lowest will have γ_c^* and choose effort level e_c^*; and will seek to contract design and materials firms with type and levels of effort $\gamma_a^*, e_a^*, \gamma_b^*, e_b^*$ such that: $c'(\gamma_a) = d'(e_a) = c'(\gamma_b) = d'(e_b) = c'(\gamma_c) = d'(e_c)$.
- Project quality will be $\bar{q}$, with total cost $b(1, H) = 3c(\gamma^*) + 3d(e^*)$..

D Additional background information and analyses

In 2014, Kenya's Ministry of Energy and Petroleum (MoE) published the Draft National Energy Policy, establishing a list of policies and strategies to *"increase rural electrification connectivity to at least 40% by 2016 and 100% by 2020"* and to *"seek funding from development partners for specific programmes especially...in rural electrification projects."* (MoE 2014). In Kenya Power's 2014-2015 annual report, they note that *"The KShs 4 Billion receivable from the GoK is part of a larger commitment by the GoK, to be financed partly through support from the World Bank and the African Development Bank to enhance universal access to electricity."* In May 2015, Kenya's President Uhuru Kenyatta announced the launch of the LMCP, with a goal of connecting *"one million new customers to electricity each year"* (Kenya Presidency 2015). In a press conference two weeks after President Kenyatta's announcement, Kenya Power's then- Managing Director Ben Chumo added that the program was designed to facilitate *"the government's objective of providing 70% households with electricity by 2017 and universal access by 2020"* (Kenya Power 2015).[1] While not quite reaching these ambitious targets, the program has been effective: nationwide household electricity access was reported to have increased from 25% in 2009 to 70% in 2019 (KNBS 2009, 2019). Many of the rural transformers selected for the LMCP had been constructed between 2005 and 2013 as part of a nationwide push by Kenya's then- Rural Electrification Authority (REA)[2] to connect all public facilities—such as markets, schools, health centers, and water points—to electricity (REA 2008, Berkouwer et al. 2018).

In November 2017 the AfDB signed 15 additional turn-key contracts to begin maximization of an additional 5,200 sites as part of its *Phase II* (which we do not examine in this study).

[1] This target date was later extended to 2022, which was also not met.

[2] Since renamed Rural Electrification and Renewable Energy Corporation (REREC).

D.1 Upfront connection costs

Beneficiaries under the LMCP are connected via 'pre-paid' meters, meaning they must buy electricity credits in advance of using electricity. Once they consume all of their prepaid electricity, they lose access to electricity, and only regain access only after they buy more credits. Households usually prevent this by purchasing additional credits before their credits run out.

To recover the \$150 connection fee, Kenya Power initially enrolled households into a payment plan consisting of 36 monthly installments of around \$4 per month. The charge was automatically added to households' accounts on a monthly basis, and any electricity payments the household made were directed towards paying off this debt prior to being directed towards electricity credits. However, this generated a significant barrier for households: as an example, if a household runs out of electricity credit in January, and then does not consume any electricity in February or March, they would have to pay at least \$16.01—4 months worth of connection fees—to be able to consume any electricity in April. The contribution was thus later capped at 50% of any topup amount (Kassem et al. 2022).

This barrier was not only a significant financial hurdle, but one that was unanticipated and poorly understood. According to Kenya Power, households should have been informed of the payment structure as part of the consent process, which was the very first step in the construction process, but it is unclear whether this consent process was regularly implemented in practice. To verify whether this process was correctly implemented, and to test whether donor conditionality and monitoring can improve adherence to these guidelines, the household survey (described in **??**) measures respondent understanding of the aggregate costs of an electricity connection under the LMCP. 58% of households do not recall ever having been told that they would have to pay Kenya Power for the connection.

An additional financial hurdle was the upfront cost of wiring, which the LMCP later tried to address by providing ready boards. In a May 2015 address, President Kenyatta described this policy as follows: *"The Ministry of Energy has also come up with designs that will enable households that do not have internal wiring in their houses to use electricity by providing a 'ready board'... [it] has switches, sockets and bulb holders and those who do not have wiring in their houses will be able to use electricity as soon as they are connected*" (Kenya Presidency 2015).

D.2 Informal and illegal connections

Illegal connections are much more common in urban areas than they are in rural areas like the villages where the LMCP was implemented. Many households in urban contexts, especially those living in informal settlement areas, are sufficiently close to the existing grid that they can be connected via a simple drop cable, which can usually be done by a local handyman at relatively low cost. Given the low population density in rural areas, connection of an additional household usually requires constructing at least one additional electricity pole, which requires more sophisticated engineering techniques. In our survey, only 2.7% of households with a working electricity connection did not have a meter. Of these, 93% said they had not been metered yet but would be metered soon, and 20% said they had not yet done the internal wiring that was required prior to connection. Nobody stated the reason they did not have a meter was because theirs was an illegal connection. Of course, these survey responses come with the usual caveats about survey questions relating to illegal behavior

D.3 Unconnected households

The LMCP's objective was to connect all unconnected households to electricity, however, in practice connectivity was not universal. At the average site at least 7% of compounds were not connected to the grid, and at the 90th percentile site at least 25% of households were not connected.[3] The most common reason (given by 31% of unconnected respondents) is that they were not present or available during the days on which construction or sign-up were administered. Second, even though the LMCP program specifications indicate there were to be no upfront connection fees, 23% of respondents still report having been unable to pay, often because they were not able to afford the internal wiring required by Kenya Power to be connected: 16% of unconnected households report this to be the reason. This suggests that despite efforts to provide free ready boards to low-income households, the cost of household wiring remained a barrier that prevented some households from getting connected.

Households could choose not to get connected, but in practice this was rare. Statistics are not available nationwide, but Lee et al. (2020) found that at most 4% of participants in a rural sample in western Kenya randomly selected to receive a free electricity connection chose not to receive one.

Some households preferred to get more than one meter in their compound, for example to leverage the lifeline tariff, or for independence between the households residing in the compound.

D.4 Experiences with bribery

Households also report numerous instances of bribery. In our household survey data, 8% of households connected under LMCP had been explicitly asked for money by the contractor, with amounts generally ranging from \$5 to \$50. Tragically, a small number of households report having paid an individual claiming to be a contractor, only to never hear from them again and to remain unconnected. 5% of unconnected households report not wanting a connection, for example because they are simply not interested in having electricity or because they think electricity is unsafe (this is similar to the rate reported in Lee et al. (2020) noted above).

D.5 Contractors

Contractors that bid on LMCP contracts are generally medium-to-large construction firms with a track record of completed projects. Contractors that won the AfDB- and WB-funded LMCP contracts were a mix of Kenyan firms and international firms, with some joint ventures comprised of two or more firms. To qualify, bidders must satisfy certain requirements related to financial capacity, prior experience including with similarly sized jobs, and any record of sanctioning and litigation.

The winners of the 12 AfDB contracts had been selected from 110 bidders. Six of the 10 turnkey contracts winners were Kenyan while four were foreign (Capital Business 2015). The set of contractors awarded WB contracts also included a mix of Kenyan and International firms, with Kenyan firms primarily awarded bids for the supply of wooden and concrete poles.

There is no blanket provision preventing firms from submitting—or being awarded—bids with both donors simultaneously. Indeed, many of the AfDB contractors named above have in the past bid on—and in many cases been awarded—WB contracts. International procurement can be thought of as a repeated game: poor contract performance can have serious ramifications on long-term outcomes. Several LMCP contractors have been debarred at least once by the WB or the AfDB (Kenya Power 2018; Spotlight East Africa 2020). For example, in October 2018 the WB Sanctions Board imposed "a sanction of debarment" on the Indian company Angelique International for "fraudulent practices as defined in Paragraph 1.16(a)(ii) of the January 2011 Procurement Guidelines." (WB 2017; WB 2011).

[3] Enumerators only counted unconnected compounds that were within connection distance of the existing electricity network, so this may be an underestimate. **??** provides more details on surveying methodology.

Many of the pole supply firms had existing relations with Kenya Power even prior to the start of the LMCP. As an example, public minutes from a pre-bid meeting for wooden pole procurement organized by Kenya Power in 2014 indicate that eight of the wooden pole suppliers that won WB contracts or AfDB sub-contracts for the LMCP in 2016-2017 were already engaging with Kenya Power as early as 2014, well before the launch of the LMCP (Kenya Power 2016), and in many cases even before that (Business Daily 2007).

D.6 Oversight

The materials inspections for both funders required detailed mechanical and chemical inspections of 10 poles out of each batch of 500 poles. These visits would usually take place at the physical factory (often located in India, China, or Kenya). However, a number of factory assessments between 2020-2022 had to be conducted via Zoom for public health reasons.

The funders' oversight structures were similar: the WB's project manager managed 22 cluster and site supervisors across six offices nationwide, while the AfDB's project manager managed 19 cluster and site supervisors across four offices nationwide. The consultants' primary activities during the construction process included conducting site-level spot checks, collecting monthly progress reports from contractors, and hosting (at least) monthly meetings with Kenya Power and each respective contractor.

D.7 Robustness tests

We begin by assessing potential endogeneity concerns related to the assignment mechanism raised in **??**. First, WB-funded sites have a 13% higher average land gradient. It is plausible that hilliness slows construction and that this difference explains the WB delays. We therefore examine whether land gradient hay have caused any of the difference in construction delays by funder assignment. Land gradient is uncorrelated with construction delays, both unconditionally and conditional on funder: the WB delays persist in a stable manner when controlling for land gradient (Table A18). Furthermore, lag between WB and AfDB is approximately constant across the entire land gradient support (**??**). The difference in land gradient is therefore unlikely to explain the results. Second, WB sites are significantly less likely to be located near a secondary school or religious building, and more likely to be located near a market center or no public facility at all (Table A4). The gap in timing between WB and AfDB sites is not significantly different across facility types (Table A19), and the gap in timing between WB and AfDB sites persists when controlling for facility type (Table A18). All results in **??** control for facility type, which do not qualitatively affect the results. Evaluated together, these analyses make it unlikely that baseline differences in facility type contribute meaningfully to the results.

The GridWatch devices recorded data between June 2021 and June 2022, even though stringing at most AfDB sites was completed between 2017 and 2019 and stringing at most WB sites was completed between 2018 and 2020. Thus, the GridWatch data measured WB sites when they were on average one year newer than the AfDB sites surveyed at the same time. If the aging of the grid negatively affects reliability and voltage quality, then this bias would favor WB in the results. Figure A13 confirms that voltage quality is constant over time, and that the lack of difference in voltage quality between the WB and the AfDB persists even among sites where the time since stringing completion was approximately equal.

For Outcome 4 measuring household installation quality (Table A10) we replicate the index omitting the question asking the respondent whether they have a ready board, since it is not obvious whether the presence of a ready board is a positive or negative component. Its presence simultaneously indicates Kenya Power provisions and a lack of household preparedness (see **??** for more detail).

Of the 250 sites that we surveyed, 26 are located less than 1,200 meters from another site. Given that AfDB sites saw construction on average earlier than WB sites, this could reduce construction at WB sites, as the subset of that site's unconnected households that lie within the 600 meter radius of the nearby site might already have been connected. This could explain why **??** indicates less construction at WB sites. To test this, we replicate this table excluding the 26 sites—12 AfDB and 14 WB—that are within 1,200 of another site. Table A21 shows the results. If anything, the gap between construction at WB and AfDB sites is even larger.

Finally, the private contractor awarded lots 3 and 5 of the WB construction contracts[4] experienced unusual financial circumstances and this may have interfered with the timeliness and quality of their construction. We therefore repeat the analysis from **??** excluding these contracts, and then only keeping a balanced panel of counties. This does not affect results: if anything, household installation quality and reliability and safety were slightly worse at the remaining WB sites, although the results are noisier (Table A20).

D.8 Cost-benefit calculations

The cost-benefit calculations in **??** make several simplifying assumptions. They value quality differences according to discounted future costs to replace poles at the end of their useful life. The calculations assume that other maintenance costs are similar, despite differences in construction quality. Each pole is assumed to have a constant probability of failure in any given year. The total number of new connections nationwide is assumed to be as reported in citepKenyaPower20171108. Meanwhile, consistent with survey data from the five counties study area, the total number of poles is assumed to be 1.51 times the total number of new connections. We assume a uniform replacement cost of $100 per pole (for materials alone), consistent with contract amounts and discussion in (Muthike and Ali 2021). While the procurement cost per pole was different for AfDB and WB contracts during the LMCP, Kenya Power, not the multilateral donor, is responsible for long-term maintenance and repair and would thus procure these items independently. We assume that about half of total replacement costs is for materials alone, which is roughly consistent with contract amounts in the WB Phase I construction.

D.9 Resilience

Construction might affect resilience through two key engineering channels. First, voltage quality tends to worsen with distance from the central transformer.[5] We find that this is primarily due to the increasing number of customers connected more closely to the transformer rather than the distance traveled along the LV electricity wire per se. Table A23 shows no difference between funders in distance resilience.

Panel A of Figure A13 explores the correlation between 10th percentage of voltage quality and distance to the transformer along the LV network.[6] There does not appear to be a significant or discontinuous decline after 600 meters, the eligibility cutoff for a subsidized LMCP household connection, suggesting greater returns to scale might have been achieved under a higher distance eligibility cutoff.

[4] A single consortium won both of these contracts.

[5] Jacome et al. (2019) find a similar result in Zanzibar, Tanzania.

[6] The results look similar when using mean voltage. Using the 10th percentage of voltage quality is in line with engineering expectations around how resilience might affect voltage quality.

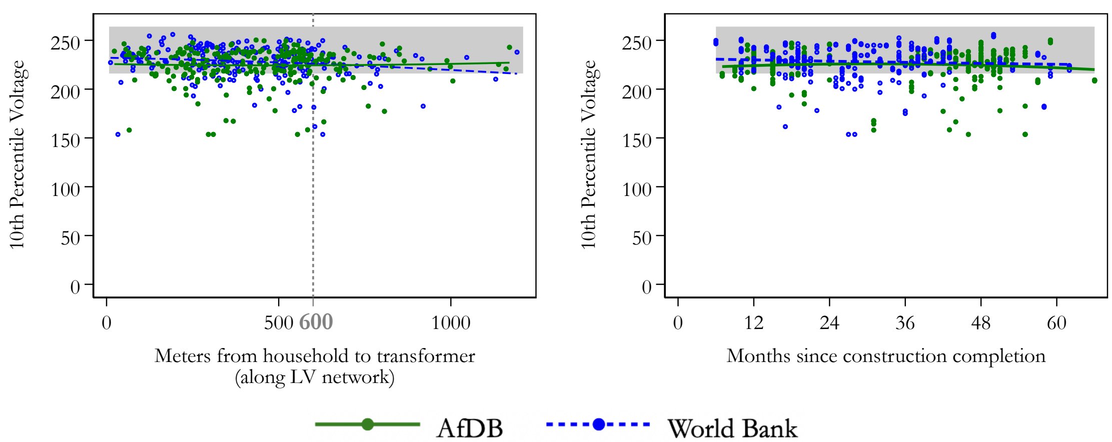
Table A23: Resilience of voltage to distance from transformer

	(1)	(2)	(3)
Distance Along Wire	-0.000	-0.000	-0.000
	(0.003)	(0.003)	(0.003)
Customer Connections	-0.490***	-0.490***	-0.615***
	(0.160)	(0.163)	(0.230)
World Bank		0.043	-0.788
		(1.305)	(2.741)
World Bank=1 × Distance Along Wire			-0.002
			(0.008)
World Bank=1 × Customer Connections			0.261
			(0.347)
Constant	237.937***	237.918***	238.452***
	(1.345)	(1.459)	(1.507)
Observations	377314	377314	377314
Control Mean	235.69	235.69	235.69

Notes: Standard errors are clustered by respondent and shown in parentheses. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Figure A13: Voltage quality resilience to distance and infrastructure aging

A) Distance along LV network B) Time since construction



Notes: 10th percentile of hourly voltage readings with quadratic fit line. The gray area indicates Kenya's nominal voltage, 240 V, ±10% as per international utility guidelines. Panel A explores how a household's distance to the central transformer (as measured along the LV network) affects voltage quality. Panel B explores how the passage of time since the initial completion of construction affects voltage quality. Neither appear to strongly affect voltage quality. WB and AfDB exhibit similar trends.

Second, voltage quality could worsen with the passage of time, as infrastructure ages. Higher quality construction might make infrastructure more resilient and slow any associated decay. The time since construction varies across our sample since stringing was completed between June 2017 and January 2021, while GridWatch devices recorded data between June 2021 and June 2022. Panel B of Figure A13 examines the correlation between voltage quality and time since construction. At both AfDB and WB sites, the grid appears resilient to aging for the first five years after the completion of stringing.

E List of individuals engaged in qualitative interviews

Qualitative research included detailed in-person (or on Zoom, where required due to Covid-19) conversations with key leadership personnel at Kenya Power, World Bank, African Development Bank, and the Consultant charged with supervising construction. An asterisk (*) indicates that a single position was held by different individuals at different points in time.

- World Bank employees:
  - Practice manager, Global energy and extractives practice, Africa region
  - Senior energy specialist, Kenya country team
  - Energy finance specialist, Kenya country team
- African Development Bank employees:
  - Principal power engineer*
  - Principal power engineer*
- Kenya Power employees:
  - General manager of connectivity
  - General manager of infrastructure development
  - LMCP Contract Project Manager (AfDB Phase I)
  - LMCP Project Leader (AfDB Phase I)
  - LMCP Contract Project Manager (WB)
  - LMCP Project Leader (WB)
  - LMCP Project Leader for (AfDB Phase II)
- Project Management Consultant employees:
  - Senior Manager