Donor contracting conditions and public procurement: Causal evidence from Kenyan electrification

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Abstract

Public infrastructure procurement regulations often aim to improve value-for-money, expediency, and quality, but causal evidence is limited due to the endogeneity and homogeneity of regulations across infrastructure projects. Multilateral donors impose similar conditions when financing public infrastructure construction, but again, their impacts are fiercely debated. This paper uses policy and experimental variation to generate causal evidence on how contracting conditions—in particular, bundled or unbundled procurement contracts—affect economic development project outcomes. We leverage an unusual feature of Kenya's nationwide electrification program: the quasi-random allocation of multilateral funding sources across nearby villages. African Development Bank villages used bundled contracts while World Bank villages used unbundled contracts and strengthened inspections. We collect on-the-ground engineering assessments of the electricity network, minute-by-minute outage and voltage data, household survey data on connection quality and usage, procurement contracts, and inspection reports. The analysis shows that WB procedures delayed construction by 9.6 months on average relative to AfDB sites but improved construction quality by 0.6 standard deviations. To disentangle procurement and audits—two distinct oversight mechanisms—we implement a randomized audits scheme. Audits improve network size, voltage, and household connectivity at AfDB sites, but have no impact at WB sites, in line with the WB's already strong inspections. Net benefits depend on time preferences and infrastructure longevity: modest assumptions indicate anywhere from a USD 5.6mn net benefit of AfDB processes to a USD 2.8mn net benefit of WB processes. In this context, streamlining contracting procedures while strengthening ex post audits could improve outcomes while avoiding delays.

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1 Introduction

Government agencies often rely on private firms to supply goods and services: public procurement spending amounts to about 12% of global GDP (Bosio et al. 2022). Regulations concerning procurement and implementation can improve project outcomes, but also introduce bureaucratic inefficiencies or inhibit useful regulatory discretion (Williamson 1999; Hart et al. 1997; Bosio et al. 2022). One important procurement choice concerns the (un-)bundling of project components across contracts, but "empirically we know relatively little about how procurement choices affect contract outcomes in (infrastructure) procurement" (Glaeser and Poterba 2021). Multilateral agencies face a similar procurement problem: between 2009 and 2019, multilateral agencies provided an average of USD 33 billion per year in loans to low- and middle-income country (LMIC) governments, much of it to contract private firms for public infrastructure construction.[1] Donor conditions around such funding often regulate procurement activities. While much existing research on donor conditions focuses on the policy conditionality of the 1980s, procedural conditionality around procurement is designed to strengthen contracting procedures and enforce institutional processes. The impacts of procurement regulations, by governments and by donors, continue to be widely debated (Makovšek and Bridge 2021; Archibong et al. 2021; Andersen et al. 2022; Easterly 2002). Causal evidence is limited, hampered by the infrequent, endogenous, often politicized, and often bundled procurement processes for large infrastructure projects.

This paper exploits natural policy variation and experimental variation to generate some of the first causally identified evidence on the benefits and costs of contracting conditions for public procurement and their mechanisms. We do so in the context of the Last Mile Connectivity Project (LMCP): at a cost of USD 600 million, one of Kenya's largest public infrastructure projects. Launched in 2015, the LMCP aimed to connect all Kenyan households to electricity by 2020. The Government of Kenya and Kenya Power (Kenya's electric utility) jointly selected villages for the LMCP, where all unconnected households would be connected to the grid. The World Bank (WB) and the African Development Bank (AfDB) funded the first wave of construction, which was outsourced to dozens of private contractors selected through international competitive bidding. Importantly, distinct processes and regulations applied to the 4,200 sites funded by the WB and the 5,320 sites funded by the AfDB. The AfDB used 'turn-key' contracting, with 10 contracts that bundled network designs, materials, and installation. In contrast, the WB used a segregated contracting approach, awarding 29 specialized contracts.[2] The WB also required additional inspections of procured poles and completed sites before being handed over to Kenya Power.

The identification strategy leverages a useful program feature: LMCP sites were assigned to be funded either by the WB or the AfDB without obvious regard to factors that would impact the project outcomes this paper studies. Other key program features—eligibility, pricing, and network specifications—were identical across all LMCP villages, as was Kenya Power's eventual ownership

[1] Total loans minus principal and interest payments. Agencies include the World Bank, regional banks, and other multilateral and intergovernmental agencies.

[2] These numbers exclude metering and consulting contracts, which we discuss in more detail below.

and operation of electricity networks. Here we have a case where two multilateral organizations are funding sites within the same government program—often with different funders supporting literally neighboring villages—but with each funder imposing its own distinct set of procedural conditions.

We use natural and experimental variation to identify the causal impacts of conditionality. First, we leverage the ad-hoc assignment of sites to funders, which the evidence indicates was largely arbitrary and we argue below can reasonably be thought of as quasi-random. Sites are spatially interspersed: 95% of WB sites in our sample are within 10km (6mi) of an AfDB site. The econometric analyses include constituency fixed effects to account for fixed local geographic or socioeconomic differences. We conduct a battery of baseline balance tests using geographic, satellite, and census data to quantify the extent of imbalance between WB and AfDB sites across a range of covariates: they appear balanced along many attributes, and any selection appears uncorrelated with the outcomes of interest. Second, to disentangle the role of two major components of conditionality—contract bundling and audits—we implement a randomized auditing intervention (with the support of partners at the WB, the AfDB, and Kenya Power) designed to mimic the WB's additional inspections. A random subset of sites was randomized into the audit intervention: through in-person meetings, contractors were informed that key aspects of the completed construction at these sites would be measured and reported to the WB and AfDB.

A key contribution of the paper is the collection of detailed construction and power quality data, building on a small but growing literature emphasizing the importance of detailed infrastructure measurement (Olken (2007) is an early influential example of this approach). We track construction progress for 380 designated LMCP villages through in-person visits and phone calls to village leaders, and then collect three types of on-the-ground data. First, we measure construction quality for key infrastructure such as transformers, poles, and wires, following Kenya Power engineering standards. Second, we deploy state-of-the-art sensors to measure minute-by-minute power outages and voltage quality. Third, we conduct socioeconomic surveys to understand household connection experiences and energy usage. We complement these directly measured data with Kenya Power procurement contracts and inspection reports. Finally, over the course of six years we conduct dozens of in-depth conversations with management at Kenya Power, the WB, and the AfDB to understand each funder's contracting, construction, and audit procedures.[3]

The analysis generates two key findings. First, construction at WB-funded sites was delayed and reduced. Metering at WB sites was completed on average 9.6 months later than at AfDB-funded sites, though after four year the share of completed sites is nearly identical across the two funders, and there were 12% fewer poles (and 14% fewer customer connections) per site at surveyed WB sites. Second, in terms of potential benefits, the WB requirements improved on-the-ground construction quality by 0.6 standard deviations: 74% of WB sites had higher quality construction than the median AfDB site. These improvements in construction quality manifested across several dimensions: poles at WB sites 27% were more likely to have a pole cap, no crack,

[3]These included conversations with senior personnel at Kenya Power, the AfDB, the WB, and the consultant charged with supervising construction. Appendix D provides an anonymized list of those interviewed.

and a correctly installed strut and stay when required. This could have meaningful implications for pole longevity and long-term maintenance costs. The impacts of WB procedures on other outcomes such as household installation quality, cost, and energy usage are positive but modest in size and not generally statistically significant, and there are no differences in the electricity reliability and voltage quality experienced by households.

To disentangle the contracting and inspection elements of WB procedures, we examine the results of the randomized audit experiment. The audits have no impact at WB sites, in line with the fact that WB sites already experienced an additional layer of inspections, and that the selection of designers, suppliers of materials, and contractors for installation at WB sites faced additional constraints under the unbundled contracting approach. On the other hand, the audits cause significant improvements in construction quality at AfDB sites. Contractors installed 20% more poles (and 11% more customer connections, though this is not significant). Households at these site experience higher quality voltage, measured using GridWatch power quality monitoring devices: the audit treatment cuts the gap between average experienced and nominal voltage in half. Households furthermore report higher household connectivity and energy usage. Importantly, the audits came at relatively low cost and caused less delay.

Finally, we compare the various approaches' costs and benefits. The average cost per new household connection was USD 402 at AfDB sites and USD 489 at WB sites, driven in part by a larger number of new connections at AfDB sites. The net impact of improved longevity but delayed construction will depend on the foregone household benefit, and on the funder's discount rate and time horizon. The net benefit will also depend on the impact of improved construction quality on long term maintenance and replacement costs: engineering sources suggest these gains could be substantial, on the order of multiple years. Under even a modest range of assumptions, the net benefit could range anywhere from a USD 5.6mn net benefit at AfDB sites to a USD 2.8mn net benefit at WB sites.

These results point to a trade-off between short-term expediency and long-term resilience. For policymakers or individuals with a higher discount rate or a shorter time horizon, or for projects with compounding benefits, expediency might increase net benefits. In situations where maintenance costs are expected to rise more quickly with poor quality, a delayed start might be worth the improved long-term outcomes. This framework can also explain a preference for donors with higher expediency by political agents facing electoral or other short-term domestic pressures. That said, this trade-off might be avoidable, at least in contexts with relatively strong domestic institutions such as Kenya (relative to many of its East African neighbors): streamlining ex ante contracting procedures while enhancing ex post audits could reduce delays while achieving similar improvements in quality, and might therefore be preferred to both approaches.

That said, any relatively short- to medium-run analysis focusing on project outcomes, like ours, has empirical limitations. Procedural stringency may generate additional positive benefits in ways we cannot measure, such as strengthened institutional capacity in Kenya's public sector. We are unable to measure leakage, and this may have been an important concern (Andersen et al. 2022), although to the extent that leakage would have reduced construction quality or quantity, we find limited evidence of this. Independent audits have furthermore been shown to improve state performance in LMICs (Olken 2007; Ferraz and Finan 2008; Finan et al. 2017; Duflo et al. 2018).

The debate about donor conditionality dates back to the 'Washington Consensus' era in the 1980s (Williamson 2009; Rodrik 2006; Easterly 2002; Mosley 1986). Archibong et al. (2021) acknowledge that market-oriented reforms may have led to short-term frictions but boosted long-term economic growth by strengthening policies and institutions. However, since the 1980s, donor conditions increasingly emphasize procurement procedures. Research suggests procedural conditionality can cause politically-motivated delays and incur costs that exceed the benefits (Kersting and Kilby 2016; Kilby 2013). And, concerns around political interference remain relevant: Andersen et al. (2022) find that up to 10% of WB financing are transferred to offshore financial havens in the months after a transfer. In empirically evaluating on-the-ground construction of WB projects we relate to Moscona (2020) and Marx (2018).

The growth of more rapidly dispersed Chinese state lending to LMICs after roughly 2000 has been subject to recent debates (Mihalyi et al. 2022; The Africa Report, 2022). The Chinese government states its approach is one of non-interference in local policy-making and politics (State Council 2011). Its expediency can be preferred by politicians operating under shorter time horizons, but the limited oversight generates concerns about the quality and resilience of construction (Dreher et al. 2021; The Economist, 2017). There is recent evidence that Chinese aid projects increase reports of local corruption substantially in African settings (Isaksson and Kotsadam 2018; Ping et al. 2022; Malik et al. 2021).

Finally, studying rural electrification per se is important because mass government electrification programs are widespread and ongoing in LMICs, especially in Sub-Saharan Africa. Poor construction quality can harm power quality, and Blimpo and Cosgrove-Davies (2019) find that in some countries in Sub-Saharan Africa, most connected households "reported receiving electricity less than 50% of the time in 2014," undermining the economic growth that household connections were designed to generate. Lee et al. (2020) find that transformer outages in rural Kenya frequently last for more than four months, which may contribute to the low uptake and limited impacts of household electricity that they find, similar to Kassem et al. (2022). In India, Burlig and Preonas (2021) find that improved electricity reliability increases the impacts of rural electrification in larger villages. To the extent that low quality infrastructure exacerbates poor power quality and slows economic growth, identifying opportunities to improve construction quality—including through donor contracting conditions—may lead to meaningful improvements in economic outcomes.

2 Stylized framework for contract bundling

An extensive literature in contract theory studies the public procurement of goods and services (Bosio et al. 2022; Tadelis 2012; Levin and Tadelis 2010; Williamson 1999; Hart et al. 1997). However, in the context of infrastructure construction, relatively few papers have empirically studied the impacts of different procurement structures. In particular, there is scant empirical evidence on the bundling of sequential tasks (often 'design-and-build') despite this being a common design feature in procurement auctions for major public infrastructure projects. In Glaeser and Poterba (2021), Makovšek and Bridge (2021) state that "empirically we know relatively little about how procurement choices affect contract outcomes in (infrastructure) procurement" and that "it is still not fully clear whether contracts that bundle the design-and-build phase outperform the traditional design-bid-build contract, where the two phases are procured separately." Even fewer papers leverage experimental variation to causally estimate the impact of bundling contracts: the experiment in Hoppe et al. (2013) is conducted among 400 German university students.

We contribute to this literature by empirically studying the bundling of the design, materials, and build phases of a major infrastructure project in a high-stakes public procurement context using natural and experimental variation and granular, independently-collected construction quality data.

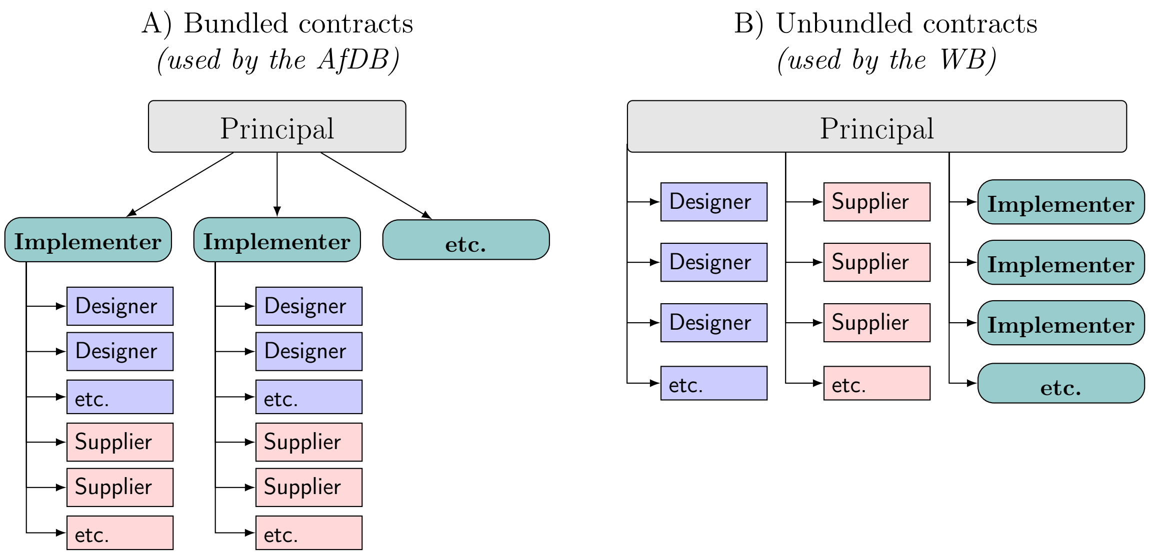
Figure 1 presents a stylized framework of bundled and unbundled contracting structures. A principal (such as a government agency) identifies a set of project components (such as designs, materials, and installation) to contract out. In the bundled method, the principal awards contracts to implementers, who procure project components from subcontractors. In the unbundled method, the principal themself contracts out all project components directly. Contract bundling affects the principal's outcomes in five distinct ways.

Mechanism 1: Oversight Bundling creates a layer of opacity between the principal and the project component providers. Implementers may obscure its activities, quality control mechanisms, or even the allocation of funding across components. Averting this opacity would require the principal to implement additional costly oversight. Without this additional oversight, the principal risks worse project outcomes (in terms of cost, expediency, or quality). Opacity may generate benefits if the implementer has private information (for example about subcontractors, quality, or funding requirements) that is not contractable and thus would benefit from implementer discretion.

Mechanism 2: Principal workload By decreasing the number and the heterogeneity of contracts signed by the principal, bundling decreases the principal's direct workload. The number of contracts matters because each contract requires effort (bid elicitation, review, donor approval, and award). Contract heterogeneity also matters because preparing each contract type incurs a fixed cost of writing and structuring.

Mechanism 3: Coordination costs Bundling shifts coordination costs away from the principal and may even change them. Coordination activities can be informational (as when designs inform materials requirements) or physical (as when materials must be physically transferred to implementers). These coordination costs can be large, especially when contract types are interdependent. If the principal lacks in-house expertise (or conversely, has significant expertise), coordi-

Figure 1: Bundled and unbundled contracting structures



In the bundled contracting method (Panel A), the principal awards contracts to implementing firms who then subcontract out components. In the unbundled contracting method (Panel B), the principal contracts directly with designers, suppliers, and implementers. In the case of the LMCP, the principal Kenya Power used a bundled structure at AfDB sites (awarding 10 turn-key contracts to implementing firms, who procure designs and materials from subcontractors) and an unbundled structure at WB sites (awarding 35 contracts to directly procure designs, materials, and installation).

nation costs may be higher (or lower) than when incurred by an implementer. In settings where contracts are interdependent, imperfect coordination could also cause temporal or physical frictions that increase project costs.

Mechanism 4: Procurement cost Bundling may increase prices by taking away the principal's monopsony market power generated by direct procurement. By bundling components the principal may be able to lower aggregate costs. Other common institutional rules may also affect aggregate costs under bundling and unbundling. For example, an unbundled approach may lead to lower costs if less stringent bidder requirements for experience and financial capacity leads to greater competition (Li et al 2015).

Mechanism 5: Discretion in provider selection Bundling may affect which component providers are selected. To the extent that the principal and the implementer would use different selection procedures, this can lead to differences in the quality of the providers that are selected and therefore differences in project quality and timeliness. For large procurement items, the principal is frequently subject to regulations that limit its discretion. For example, the principal may be required to run a competitive auction, with bidders subject to certain eligibility criteria. In contrast, subcontractors are rarely subject to such stringent regulations and so under the bundled approach, implementers may have substantially more discretion over which providers to select. Adherence to procurement rules may result in higher quality providers being selected by removing the option to cut costs by choosing lower quality providers. On the other hand, discretion may carry benefits if the implementer has information about provider characteristics that are difficult to contract on.

For example, discretion may allow an implementer to select a higher quality provider, even if at somewhat higher cost (Carril et al 2022; Fazio 2022; Li et al 2015).

This paper primarily focuses on the aggregate differences between bundled and unbundled contracts. To disentangle mechanisms, we focus quantitatively on the first channel: the degree of oversight that the principal can exert. We focus on on-the-ground inspections, a key form of oversight commonly used in practice by public actors: Subsection 4.2 presents the experimental design to evaluate the impact of inspections in this context. We explore the way that the remaining four channels were at play in our study setting qualitatively throughout the paper.

3 Kenya's Last Mile Connectivity Project

In May 2015, Kenya's President Uhuru Kenyatta announced the launch of the LMCP, which aimed to connect 70% of households to electricity by 2017 and universal access by 2020. 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). The LMCP's cost, totalling over USD 600 million, was financed through loans and guarantees from the AfDB, the WB, the European Investment Bank, and the Agence Française de Développement, a grant from the European Union, and funding from the Government of Kenya (Kenya Power 2016a). This paper focuses on transformer sites funded by the WB and by Phase I of the AfDB, which we refer to jointly as Phase I of the LMCP. Appendix C provides additional qualitative information about the LMCP.

While the LMCP was financed through various channels, it was a single nationwide project implemented by Kenya Power under a uniform set of specifications. As of 2019, there were around 60,000 electrical transformers across Kenya, which convert high- and medium voltage power lines (33kV or 11kV respectively) down to low voltage (LV) lines (usually 0.415kV) that can be connected to households. The LMCP's objective was to connect all unconnected households located within 600 meters of one of the transformers selected for the program, by extending the local LV network. This process of connecting between 20 and 100 households at a site at the same time—referred to as 'maximization'—generated cost efficiencies by leveraging economies of scale. Eligible households benefited from a reduced electricity connection price, from USD 350 to USD 150, and from the ability to pay it off in monthly installments rather than upfront. The program was also touted as reducing the red tape frequently associated with new electricity connections: the long and laborious process of applying for electricity, which can take months and often requires significant paperwork, would be replaced by a system where Kenya Power contractors proactively visit households to initiate the connection process, with minimal effort for households.

The process of determining exactly how many and which transformers in each constituency would be maximized involved extensive communication between Kenya Power and each constituency's Member of Parliament (MP), factoring in cost and human development considerations to target an equitable distribution of LMCP sites across Kenya. Phase I of the LMCP eventually targeted 8,520 transformers across the country. AfDB Phase I financed the maximization of 5,320 of these transformers and the WB financed the maximization of an additional 3,200 (Kenya Power 2017, 2016a).[4] LMCP transformers were assigned to be funded by either the WB or the AfDB in a seemingly arbitrary and ad hoc manner, as discussed in detail in Section 4.

3.1 Corruption concerns

There was widespread concern that political interference and corruption within Kenya Power could jeopardize the quality, cost-efficiency, timeliness, and equity of the LMCP (The Star 2018; Kenya Power 2018b, 2020; ESI Africa 2020; Wolfram et al. 2022; Lee et al. 2020).[5] These concerns are not unique to Kenya of course, nor to the electricity sector. Extensive WB regulations designed to curtail these abuses—detailing the procurement, financial management, and disbursal of funds—apply widely:

> "Borrowers using the Regulations spend billions each year procuring works, services, or goods from third-party suppliers, contractors and consultants... in over 170 countries across the globe [and] range from highly complex infrastructure, cutting edge consultancy, major pieces of plant/equipment, and high tech information technology."
>
> World Bank Procurement Regulations for Borrowers (2020)

WB policies have sometimes been described as more prescriptive compared to other development banks, with some concerns that this inflexibility may delay projects without necessarily limiting fraud or improving outcomes (AfDB 2014, WB 2014). That said, leakage is notoriously hard to measure. We are unable to identify specific instances of stolen or diverted funds in this paper, but it is an important concern that may have motivated the donors' different contracting decisions. Section 7 compares aggregate costs with construction quantity and quality to evaluate spending efficacy.

Over the past 20 years international donors have increased their efforts to moderate the cost of complying with these regulations by streamlining and harmonizing procurement policies for donor-financed projects. WB and AfDB regulations now have significant overlap, lowering the costs of complying with both simultaneously (WB 2014).

3.2 Contracting procedures

LMCP construction was segregated into contracts that domestic and international private sector contractors could bid on. The WB financed USD 135 million in contracts and the AfDB financed USD 154 million in contracts. Both funders financed contracts with external consultants to oversee

[4] The WB provided additional funding to install new transformers at 1,000 of these sites. For comparability those projects are excluded from this paper's analyses.

[5] For example, in July 2018, Kenya Power's CEO Ken Tarus and his predecessor Ben Chumo were arrested and—alongside several other senior Kenya Power officials—faced various charges relating to corrupt procurement practices that resulted in significant losses of public funds (Reuters 2018; The Nation 2022). Tarus faced additional charges relating to "failure to comply with the law relating to management of public funds" (Business Daily 2018). In 2019, bidding collusion led to "the supply of substandard wooden poles for [USD 8 million]" (The Nation 2021).

construction and manage relationships with contractors. They also coordinated nationwide contracts for the procurement of meters to facilitate integration with Kenya Power's operational systems.

Still, differences in procurement procedures were meaningful. The AfDB imposed a bundled contracting approach often referred to in this context as 'turn-key', which "provides for full design, supply, erection and commissioning of the works by a single contractor at a fixed lump sum price" (AfDB 2018). Each AfDB turn-key contract comprised the entire construction process of all LMCP transformers in one of ten geographical clusters of counties. This process included identifying unconnected households at each site and designing an efficient extension of the LV network to reach those households, procuring the materials required to complete those designs, and installation of materials according to the designs: contractors usually procured designs and materials from subcontractors. Together with a metering contract and a consulting contract, Kenya Power awarded 12 LMCP contracts under the AfDB component.

The WB on the other hand opted for an unbundled approach for the LMCP. Eight contracts were first issued for designs detailing the proposed LV network extension at each site. Once the designs had been completed, 15 contracts were issued to procure the required materials: six contracts for wooden poles, three for concrete poles, three for conductors, and three for cables. Kenya Power then issued six contracts for the installation of the materials following the designs in six geographic clusters of sites. The WB component also included two metering contracts[6] and four consulting contracts for a total of 35 contracts.[7]

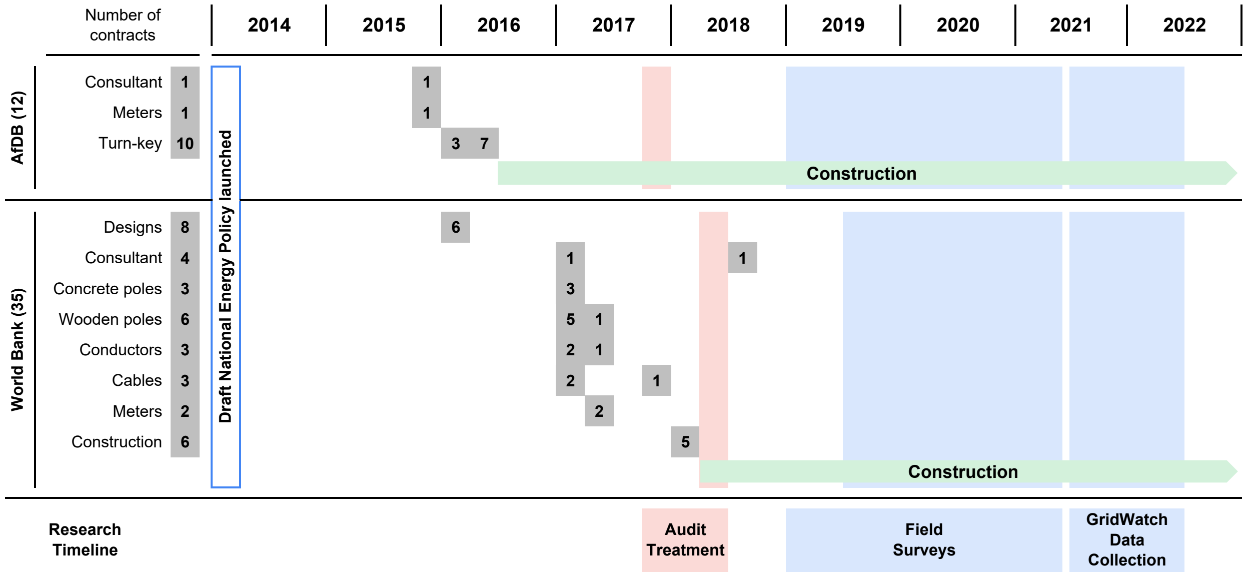
These structures are not fixed by donor: the AfDB and WB decisions to use bundled and unbundled contracting for the LMCP were made independently, ex ante, informed by discussions with Kenya Power and the donors' previous experiences with infrastructure projects in Kenya. In other sectors and countries the WB often awards bundled contracts, and vice versa. The WB Procurement Regulations for Borrowers (2020) states that the "selection of contract types and arrangements takes into account the nature, risk, and complexity of the procurement, and [Value for Money] considerations". The AfDB Operations Procurement Manual (2018) similarly states that, "In complex cases, a 'turnkey' or 'design-and-build' approach may be more appropriate." Neither funder specifies a strict rule on how this decision is to be taken, but in this case (fortunately for the analysis in this study) they reached different conclusions about the appropriateness of particular contracting approaches.

Figure 2 shows that initial funding approvals from the AfDB and WB were finalized at a similar time (November 2014 and March 2015, respectively). Project appraisal reports for both funders (released in October 2014 and March 2015 respectively) indicate that initial contract signing was planned for early 2016 (AfDB 2014; WB 2015). In December 2015, Kenya Power signed all 12 AfDB contracts (Kenya Power 2015a). The WB initially followed a similar timeline, with design contracts signed by March 2016, however contracting proceeded more slowly after this. Materials

[6] One for the meters and one for metering accessories (e.g. boxes, circuit breakers), both with the same company.

[7] A 36th contract was signed for the procurement of new transformers for a subset of villages, but we exclude these from our analysis since the 'maximization' of existing transformers was the component that was most consistent across WB and AfDB and applied at most WB locations.

Figure 2: Dates of contract signing, construction, and research activities by multilateral



Timeline of the experimental components and the contracting process for the WB's 35 contracts and the AfDB's 12 contracts. Four WB consultant contracts included one for inspections, one for procurement, and two for supervision. Discussions with both parties started after the release of the Draft National Energy Policy in 2014. AfDB sites that had been completed prior to the implementation of the audit treatment in late 2017 were excluded from the RCT sample. Surveys were conducted after construction completion.

contracts were signed starting in February 2017 and installation contracts in November 2017, a substantial delay relative to the project timeline at the time of approval (Kenya Power 2017). The AfDB turnkey contracts specified that construction would start June 2016 and commissioning would take place by June 2017. The WB installation contracts specified that installation would commence between January and August of 2018 and site commissioning would take place by June 2019.

3.3 Contractor and subcontractor selection

For both AfDB and WB, contractors were chosen via a competitive bidding process. The 12 AfDB contracts were awarded to 10 unique contractors, with two contractors winning two turn-key contracts each. The 35 WB contracts were awarded to 31 unique contractors with four contractors winning two contracts each.[8] Other than a harmonized metering contractor,[9] there was no overlap between AfDB and WB contractors. There was, however, overlap between WB contractors and AfDB subcontractors.

One policy lever at the disposal of the WB and AfDB is the debarment of contractors with egregiously poor performance. This generally applies globally: under-performance can lead to disqualification from contracts in other countries by other donors in different sectors. Independent

[8] One contractor was awarded both meters contracts, one was awarded two cables contracts, one was awarded two wooden poles contracts, and one was awarded two installation contracts.

[9] All three contracts for meters and metering accessories were awarded to Shenzhen Clou Electronics Co. (China) for the purposes of harmonization with Kenya Power's management and billing systems.

audits can therefore be a meaningful economic threat for contractors, which we exploit in our randomized audits treatment, discussed in Subsection 4.2. The WB appears to have stricter standards, leading to more frequent debarment. This mechanism is beyond the scope of the current paper as our intervention started after the contractors were selected. Nonetheless, we do not see this as a potential concern for bias, but rather we view this as an additional mechanism through which donor conditionality may operate.

As is common under bundled contracting, AfDB contractors procured much of the design, materials, and installation from subcontractors. There was significant overlap between the WB pole contractors and the subcontractors from which AfDB turnkey contractors procured poles. All three WB contractors awarded concrete pole contracts were also approved by Kenya Power to act as subcontractors to AfDB turnkey contractors.[10] Similarly, one of the WB contractors awarded a wooden pole contract was approved by Kenya Power to act as a subcontractor for at least one AfDB turnkey contractor. This degree of overlap suggests that the concrete and wooden poles for AfDB- and WB-funded sites had often been manufactured at the same facilities.

This overlap could have affected the timing or quality of poles supplied if firms supplied high-quality poles to initial AfDB contracts, leaving lower quality poles for WB sites. However, if anything WB sites had higher quality poles, and conversations with Kenya Power suggest that the timing of pole delivery was not a source of project delay. In fact, pole storage became an issue for some WB sites, as materials arrived before contractors for installation were able to begin work.

3.4 Quality assurance and oversight

The tender documentation for both the WB and the AfDB also contained detailed specifications for the procurement and installation of poles, wires, conductors, fuses, and meters. These specifications were frequently harmonized, lowering the cost compliance by Kenya Power staff. However, there remain meaningful differences, as we discuss below. WB oversight procedures are generally more onerous than AfDB procedures: this may reflect a WB preference for strengthened oversight, as the WB's unbundled procurement structure also provides them with closer oversight over subcontractor behavior. Quality assurance and oversight procedures can be broadly split into four mechanisms.

First, when implementing the above-described contracting process, each donor had to provide a "no objection" approval at critical stages. These recurring reviews are designed to ensure that Kenya Power was in compliance with the donors' technical guidelines. That said, our interviews with staff suggest that the WB's "no objection" process was on average more involved, consisting of more steps, than that of the AfDB.

Second, each donor required similar materials inspections. A team representing Kenya Power (including members from Kenya Power's LMCP management team, supply chain department, and operations & management department) would visit the contractors' factories to inspect the mate-

[10] As donors provide relatively little oversight into subcontracting (AfDB 2014) we cannot confirm how many poles were actually procured from these contractors. The fact that they were named in AfDB turnkey contracts suggests there is likely to have been significant overlap.

rials.The WB furthermore required that each pole be physically marked such that these could be easily verified upon arrival at Kenya Power storage facilities.

Third, each donor required the contracting of a 'consultant', led by a project manager responsible for project coordination, monitoring, and supervision for all contractors. Once construction at a particular site was complete, the consultant, the contractor, and Kenya Power would do a joint inspection and sign a "Joint Measurement Certificate" (JMC) to certify that a contractor completed construction at a site and that the site can be handed over to Kenya Power for activation.

The inspection procedures set by AfDB and WB consultants contained one notable difference. Prior to the joint inspection that would produce the JMC, the WB consultant often did an on-site inspection together with the contractor (but without a Kenya Power representative) to produce an "Inspection Report" (IR). The IR would list any construction errors or oversights identified in the materials or installation.[11] One of the goals of the IR was to provide the contractor with an opportunity to fix the error before the JMC inspection visit. IRs were usually conducted in advance of the JMC, but in some cases the JMC and the IR were conducted concurrently to reduce travel costs. Since the IR was not required at AfDB sites, it was common for a JMC to be issued even when no new household meters had been installed yet—before the local community was actually receiving power.

Fourth, each funder engaged in direct monitoring. Kenya Power would combine and summarize the contractors' monthly summary progress reports and share these with funders. At least twice per year, each funder conducted a week-long 'supervision mission' consisting of meetings with senior Kenya Power and Ministry of Energy officials in Nairobi as well as 1-2 days of site visits in nearby regions. The information collected in each mission was recorded in a Supervision Mission Report, which was generally similar between the two donors.

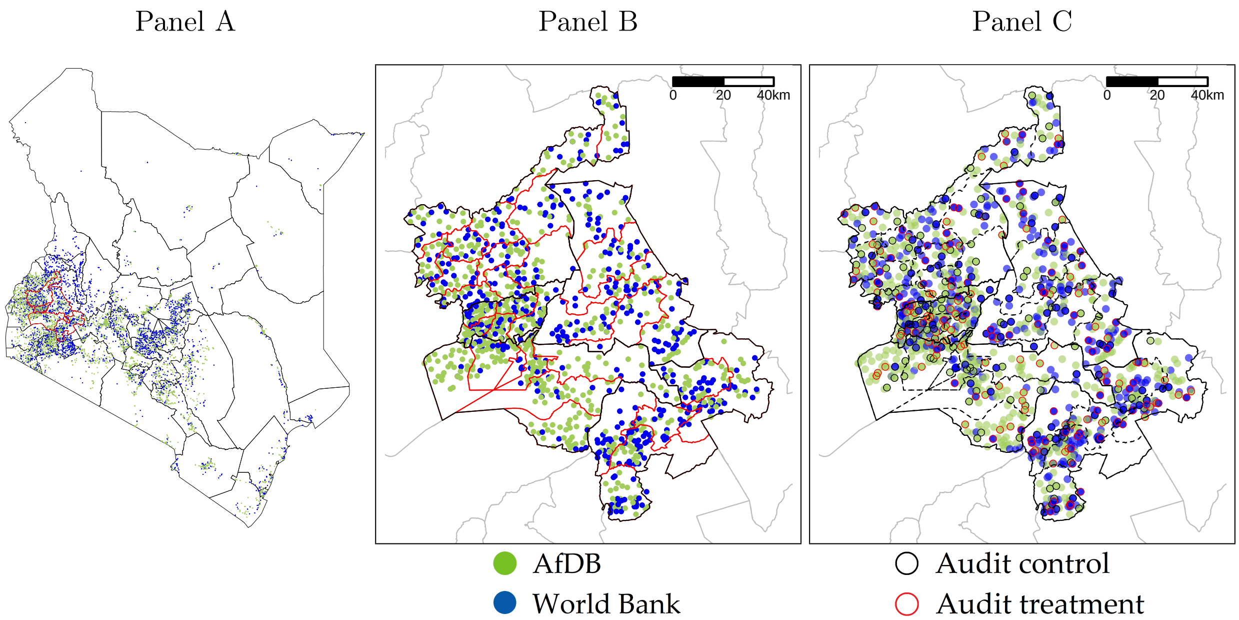
3.5 Household involvement

A correctly installed electricity connection with a functioning meter is of little benefit to a household without power sockets or light switches. The final household connection and wiring is thus crucial. During the original LMCP rollout, households were responsible for installing—or hiring a local handyman to install—internal wiring, defined as anything between the meter and the appliances a household consumes. Our household surveys indicate that households who were connected prior to the LMCP spent on average USD 125 on internal wiring.

For most households, the internal wiring posed a significant financial and logistical barrier, on top of Kenya Power's connection fees. To address this issue, Kenya Power decided to provide low-income households who could not afford internal wiring with a 'ready board': an electrical panel that would satisfy the wiring requirements of a connection.

[11] Comments from the IRs include, for example, "pole caps are poorly installed" and "the strut pole bolt is not secured with nut and washers," often accompanied by a photograph.

Figure 3: Sites by funding source and audit treatment status



Panel A displays locations of the nationwide LMCP Phase I sites colored by funding source. Highlighted in red are the five counties where we conduct engineering and socioeconomic surveys (Kakamega, Kericho, Kisumu, Nandi, and Vihiga). Panel B focuses on this area and emphasizes constituency boundaries within the 5 counties, highlighting that there does not appear to be spatial clustering by donor in the study area. Panel C shows audit treatment and control sites circled in red and black respectively (without black or red circles are not in the RCT sample; see Subsection 4.2 for detail).

4 Research Design

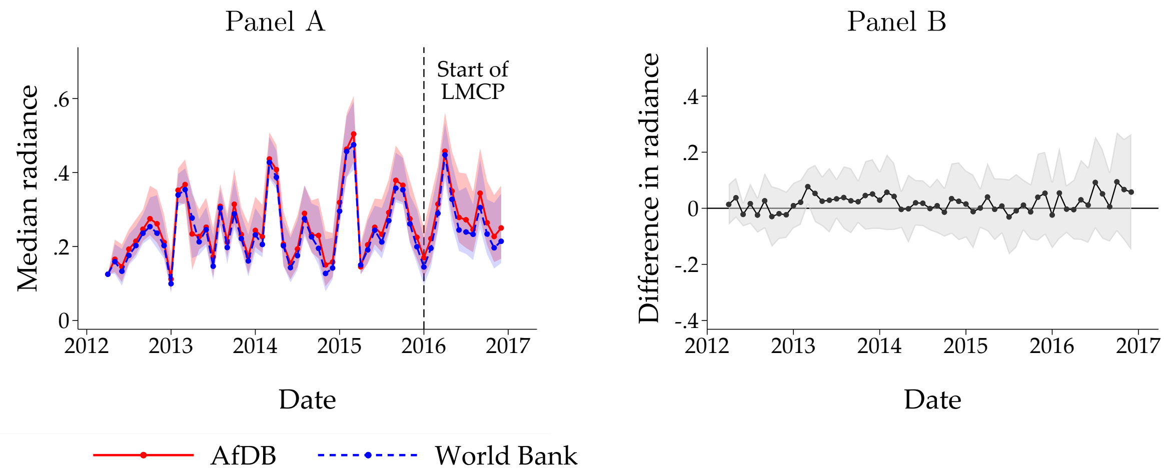
To estimate the causal impact of donor procurement structure on construction outcomes we exploit the quasi-random assignment of sites to two different international donors that implemented different contracting and oversight structures. To examine how ex-post audits alone affect project outcomes, we then implement a randomized audits scheme. This section describes both sources of variation in more detail in turn.

4.1 Quasi-random assignment of sites to international financing

A threat to our identification strategy would be if Kenya Power employees prioritized certain sites to WB or AfDB, for example to influence expediency or quality. While we have no evidence of this, possible reasons could include political influence, economic growth expectations, or personal favor. We conduct qualitative analyses and quantitative balance checks to examine whether there are any underlying differences between WB and AfDB sites.

The transformers selected to be maximized under the LMCP were assigned to be financed by either the WB or the AfDB. From June 2016 through July 2022 members of the research team held extensive private meetings with key Kenya Power personnel responsible for the LMCP. This included meetings with the General Manager for Connectivity (who was responsible for all of Kenya

Figure 4: Site-level nighttime radiance by funding source



Panel A presents median monthly nighttime radiance from the Visible Infrared Imaging Radiometer Suite (VIIRS) between 2012-2017 per site-month, with bands showing the 25th to 75th percentile. Panel B confirms that radiance is statistically indistinguishable across World Bank and African Development Bank-funded sites (estimates include constituency FE). Table A1 confirms baseline balance using a pooled regression of these data.

Power's activities connecting new households to power) and the two Project Managers who oversaw the nationwide construction of the LMCP. We read dozens of letters of correspondence between Kenya Power and individual Members of Parliament discussing and deciding which transformers would be included in each phase of the LMCP. Overall, the pattern that we consistently observed was that assignment was ad hoc and did not follow any particular allocation rule. Given that the mandates were identical—to connect all households within 600 meters of a transformer—Kenya Power and the GoK did not appear to see any strategic benefit in having a transformer be funded by one donor or the other.

The causal identification strategy leverages this quasi-random allocation of each LMCP Phase I transformer site to a funder. Among Kenya's 290 constituencies, 265 contain at least one LMCP Phase I site and 210 contain at least one AfDB and one WB site.[12] 1,139 of the 8,520 nationwide LMCP Phase I sites are located in the five study counties where we collected detail on the ground assessments: Kakamega, Kericho, Kisumu, Nandi, and Vihiga (shown with red borders in Panel A of Figure 3). The five study counties comprise 36 constituencies (shown with red borders in Panel B of Figure 3), of which 35 have at least one WB site and at least one AfDB site. In line with explanations provided by the electric utility, there does not appear to be spatial clustering by donor. 95% of WB sites among this sample are located within 10km of an AfDB site (and vice versa). Still, we restrict site selection to the 35 overlapping constituencies and include constituency-level fixed effects in the primary outcomes regressions laid out below. Panel C presents the overlay of funding source and randomized audit treatment, discussed in Subsection 4.2.

We also formally test for balance across AfDB and WB sites using several independent datasets. Figure 4 compares trends in monthly nighttime radiance (Elvidge et al. 2017). WB and AfDB sites

[12] A constituency is a relatively small geographic unit: the average population is approx. 185,000.

Table 1: Balance in 2009 census socioeconomic characteristics by number of LMCP sites per ward

	Share of LMCP Sites that are WB-funded	N	Dep. Var. Mean (SD)
Age 14 or Under	-1.34	170	51.39
	(0.89)		(3.76)
Consumption	157.02	170	3063.59
	(300.38)		(1285.98)
Primary Education	-1.19	170	61.54
	(1.18)		(4.54)
Secondary Education	2.06	170	19.65
	(1.68)		(6.50)
Solar Home System	-0.19	170	1.10
	(0.16)		(0.71)
Electricity	4.49*	170	6.96
	(2.52)		(10.37)
High-Quality Wall	0.84	170	13.06
	(2.61)		(9.24)
High-Quality Roof	-0.68	170	81.52
	(2.72)		(12.04)
Joint F-test	p-value = .16		

This table tests for correlations between the share of LMCP sites in a ward allocated to each funder and baseline characteristics, among wards with at least 1 LMCP site. Specifically, we regress the ward-level variable listed in the first column on the share of LMCP sites in that ward that are WB-funded. Row 1 shows these correlations for the percentage of individuals who are 14 years or younger. Row 2 shows monthly consumption expenditures per capita in Ksh. Rows 3 through 8 shows percentage of, in order: individuals who completed primary school education; individuals who completed secondary school education; households with solar; households with electricity; households with a high quality wall; and, households with a high quality roof. All regressions include constituency fixed effects. Data source: 2006 Household Budget Survey and 2009 Census data. $^* \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

have indistinguishable nighttime brightness levels and trends prior to the LMCP. Columns (1) and (2) of Table A1 present a pooled balance test of pre-LMCP radiance levels confirming these were statistically indistinguishable.

Table 1 conducts balance checks at the ward level for the number of WB-funded LMCP sites by baseline socioeconomic characteristics (measured during the 2006 Household Budget Survey and 2009 Census data, well before the launch of the LMCP), controlling for the number of LMCP sites in each ward. The number of WB-funded sites in a ward is not correlated with the fraction of households with a high quality roof or electricity, the fraction of individuals with primary or secondary education, the fraction of residents who are 14 years or younger, and average consumption. There is a slight difference in the fraction of households with an electricity connection and the fraction of households with a solar panel, but these magnitudes are small (about 1 p.p. or less). To minimize the possibility that these baseline differences may cause bias, the main results therefore control for the fraction of households in the ward that have an electricity connection and the fraction with a solar panel.

Despite these similarities, there are modest differences between WB and AfDB sites. Most transformers had been connected as part of a push by REA between 2005 and 2013 to connect all public facilities nationwide to electricity. 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. For example, 30 out of the 132 AfDB transformers we surveyed (23%) were located near a secondary school, whereas only 10 out of the 118 WB sites were (8%). We do not have a clear explanation for this; nonetheless all regressions therefore control for these baseline characteristics. Table A2 quantifies these differences using field surveys and administrative data. The difference is largest for secondary schools. WB transformers are also slightly less likely to have a religious building nearby and slightly more likely to have a market center nearby, or no public facility at all. There are also small differences in site geography across funding sources. WB sites have a 13% higher average land gradient, indicating they were more likely to be located in hillier villages (Table A1). Extensive robustness checks confirm that delays and construction quality are uncorrelated with land gradient and facility type, and that the results are constant across the entire support of land gradient and facility type. To minimize any remaining source of biases, all regressions control for land gradient and facility type. Subsection 6.5 shows that the above imbalances do not affect, nor can they explain, the results.

Donor practices may also affect contractor selection. Firms with certain characteristics may be more likely to bid on WB or AfDB contracts, and this may cause differences in outcomes. Speculatively, firms with more streamlined operations may be more likely to submit for projects with more stringent requirements. However, this would be a mechanism through which donor conditionality may operate to affect outcomes rather than a threat to identification.

4.2 Randomized audits

To disentangle two key components of donor conditionality—ex ante procurement procedures and ex post inspections—we implement a randomized audits scheme designed to mimic the latter. In particular, we design an audit treatment that closely mirrors the WB's Inspection Reports (discussed in Subsection 3.4). Field officers hired by the research team visited each site to inspect crucial details of the electricity networks—such as line sag, LV wiring, and the presence of pole caps—at the conclusion of construction. The research team identified these dimensions in collaboration with retired Kenyan electrical engineers (see Subsection 5.1 for more detail).

Of the 1,139 LMCP Phase I sites in the region, we select 380 sites for the randomized audits experiment.[13] We randomly assign 190 to the treatment group and 190 to the control group, stratifying by constituency and funder. Panel C of Figure 3 maps treatment and funder assignments.

The randomized audits are implemented (in collaboration with the WB and the AfDB) as follows. During in-person meetings set up for this purpose, senior Kenyan field staff notify contractors that an independent, international team of engineers will audit a specific list of selected sites once construction is complete. During the meeting they provide formal, written notification that is signed by senior management at Kenya Power, the WB, and the AfDB (Figure A1). This notification also includes the specific set of sites within their contract region that were selected to be audited.

[13] This follows the Pre-Analysis Plan submitted to the AEA RCT Registry (#2389, available here.)

In communications with WB officials (in both Washington D.C. and Nairobi), the WB indicated they would take contractor-level evidence of leakage (on both WB and AfDB funded projects) into account in future contracting. This setup can therefore be thought of as a repeated game environment where there are real consequences to contractor performance in the audited sites. Contractors depend on their repeated relationship with international organizations such as the WB and the AfDB for future projects in many sectors—many also work in sectors outside electricity. This provides an incentive for contractors to implement high-quality infrastructure projects, or at least to be perceived as doing so, in order to win future contracts. To remind contractors of this incentive the notification states the issue of future contracts explicitly.

Unbeknownst to the contractor, the list of sites that they are told will be audited is in fact a randomly selected subset of the full set of sites that are surveyed by our research team. Given the random selection, any difference in construction outcomes between the sites about which contractors are notified and the control sites can be attributed to contractors' response to the audits.

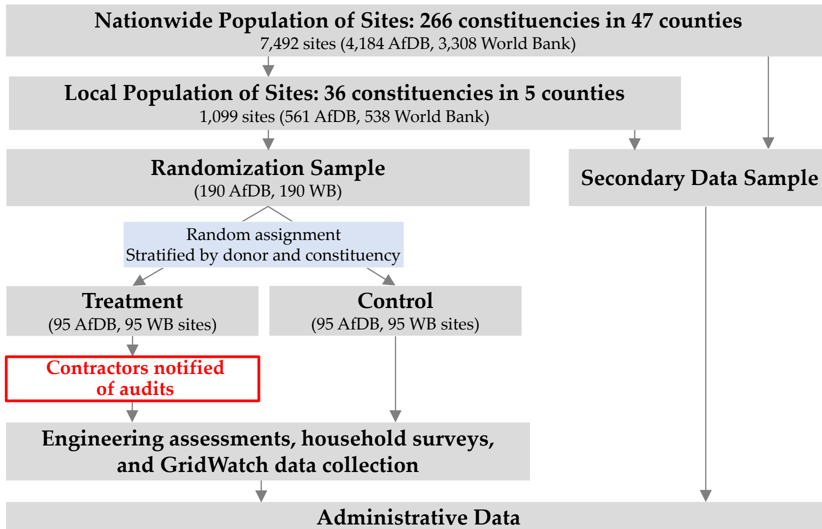
Audit treatment effects could be underestimated if audit treatment caused contractors to believe (correctly) that other sites were also more likely to be audited. While the research team took efforts to conceal its activities, it is possible that contractors learned that audits took place at sites not in the audit list. Similarly, if treatment impacted a contractor's general operations across treatment and control sites, this would cause us to underestimate the impacts of the audit treatment. On the other hand, audit effects may be overestimated if contractors shifted effort from control sites to treatment sites. We think spillovers to control sites are likely small. Only a fraction (on average 7.6%) of a contractors' sites were selected for audits.[14] Still, to the extent that contractor resources or effort were diverted from control site, a scaled-up auditing scheme could have smaller impacts than seen in this study.

5 Data

We use nationwide administrative data on construction progress at thousands of construction sites provided by the electric utility to conduct sample selection. Of the 1,139 LMCP Phase I sites in the region, we randomly select 380 for detailed on-the-ground data collection, stratifying by constituency and funder. Field managers employed by the research team conduct frequent, short, repeated assessments with village representatives—over the phone or in person—at all 380 sites to track construction progress at each site over time. This yields a panel dataset of construction progress at the site level. To verify the accuracy of these reports, we plot event study graphs of nighttime radiance around key construction stages (Figure A2). Reassuringly, the start of construction and stringing are not correlated with nighttime radiance, while nighttime radiance does increase noticeably in the 12 months after the completion of household metering, when electricity begins flowing to LMCP households).

[14] Effects of the audit treatment do not vary by whether a below or above the median percentage of a contractor's sites were audited.

Figure 5: Project design



Sample selection and randomization. Contractors were notified in 2017-2018 and assessments and surveys were done 2018-2021. Engineering assessments and household surveys were completed at the 250 sites where considerable construction had been carried out by the end of surveying activities in 2021. Additional tracking of construction progress at the remaining sites continued through 2022.

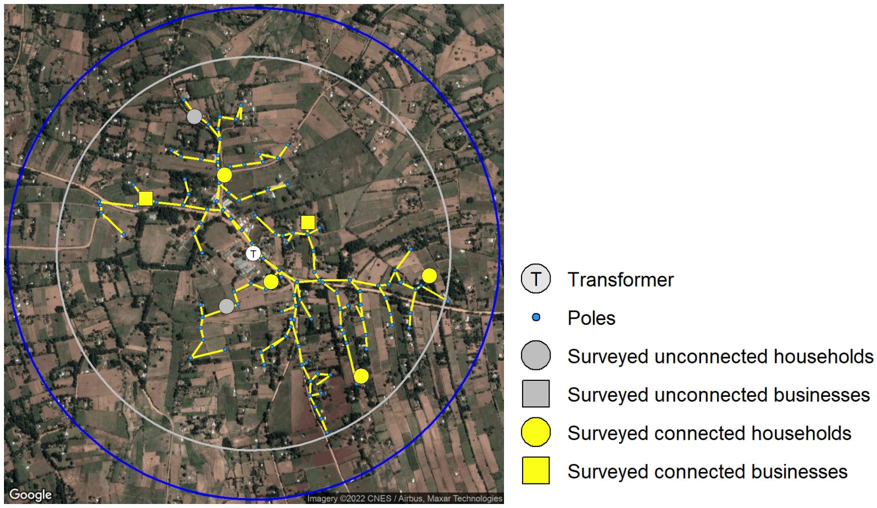
We conduct on-the-ground engineering assessments and socioeconomic surveys at all 250 sites where construction had made significant progress by the end of the main field activities in May 2021. Construction had still not been completed—and usually not even begun—in the remaining sites, limiting surveying activities there to short assessments of any initial planning activities. Field surveys are conducted between six and twelve months after construction is reported to have begun at a site.[15] Roughly half of the surveying sites are WB sites and half are AfDB sites. Figure 5 provides an overview of these study design elements.

5.1 Engineering assessments

The engineering measurements that our survey team conducted were developed in coordination with recently retired REA engineers with expertise on the technical specifications of Kenya's electricity grid, and consist of two parts. In the initial infrastructure census, field officers record the locations of all poles in the low-voltage network, as well as their connectivity, up to 700 meters from the existing transformer. Kenya Power's LMCP regulations specified that only households within 600 meters of the transformers were eligible for a free connection: the 700 meter radius thus allows us to test whether construction was completed beyond the eligible region, for example in order to earn informal side payments. They also document the number of poles in the low-voltage network that are further than 700 meters from the transformer and are within sight. Figure 6 displays network data recorded in this first part of the engineering assessment at an example site. The field officers also record the number of drop-down cables connected to each pole (the connection between a home

[15] Due to logistical constraints, surveys were conducted several months earlier or later in some cases.

Figure 6: Infrastructure data collected (example site)



This map displays the construction data collected at an example site. Figure A3 presents additional examples of sites. The grey line denotes 600 meters and the blue line denotes 700 meters from the transformer ('T') at the center. The engineering surveys record the locations of poles, lines connecting poles, and infrastructure quality. At each site, between 4-9 connected and unconnected residential compounds and firms were randomly selected to participate in the socioeconomic survey (Subsection 5.2) and to receive GridWatch devices to measure power quality (Subsection 5.3): these are marked with yellow and gray circles and squares (random spatial noise has been added to their locations to preserve anonymity).

or business and the electricity pole), whether the drop-down cable connected a residential compound or a firm, as well as any unconnected compounds located near the pole. This provides a measure of the number of connected and unconnected firms and households across the entire site.

In cases where the local network was too large to comprehensively map in a single day, field officers selected a random subset of branches to assess, and then recorded all poles connected to every selected branch. At these sites, scaling the surveyed connections proportionally to the fraction of the grid that was surveyed yields an unbiased estimate of the total number of household connections at that site.[16]

In the second part of the engineering assessment, field officers record characteristics of every pole and the conductors (wiring) that connect them. These measurements focus on outcomes that are most likely to affect the quality and longevity of the electricity grid. They include quality measurements of the pole itself, such as angle relative to the ground, whether it is wood or concrete, whether it is firmly placed in the ground, whether it has a pole cap, whether it has any visible cracks, and whether it has the appropriate grounding wires, stay wires, and struts. For a subset of poles, field officers also collect even more detailed pole measurements, such as pole height, circumference

[16]This can be seen for example in the bottom right site shown in Figure A3, where we only surveyed the Southern half of the site. At sites that appeared too large to survey, we first recorded the number of distinct branches in the LV that started at the transformers, and then randomly pre-selected the branches that the field team is able to complete in the time that was allocated for the site. To obtain site-wide estimates, we scale the on-the-ground measurements according to the fraction of the grid that was surveyed.

at various points, and characteristics of each strut or stay that provides support for that pole.[17] Measurements taken of the conductors that connect the poles include whether it has appropriate ground clearance and clearance from other objects (such as trees, brush, or structures), and whether any electric lines cross. Measurements of the drop-down cables from the pole to the customer include the distance between the pole and the customer's structure, and whether the cable ends at a meter. Field officers also note down whether it appears to be an illegal connection, although this is quite rare in this rural setting, in contrast to some urban and peri-urban settings in Kenya and elsewhere. Finally, measurements of the central transformer at each site include whether the poles on which the transformer is mounted are leaning excessively, the number of missing or bypassed fuses, and whether the transformer has any other obvious defects.

Table A3 presents summary statistics on transformers, poles, and households surveyed at the 250 transformer sites. At around one quarter of transformers at least one fuse was missing or had been bypassed. We surveyed on average 87 poles per site, of which about a quarter had a large crack, and 40% of poles were missing a pole cap. 95% of surveyed households were connected in 2016 later, and the median year in which households were connected was 2019.

5.2 Household and firm survey data

After the infrastructure census had been completed, a random subset of connected and unconnected compounds and firms were invited to complete a socioeconomic survey. The goal of the household and firm surveys was to understand household and community experiences with the construction process and electricity connections. For example, anecdotally, households are occasionally asked to contribute manual labor to construction for example by digging their own holes for distribution poles, even though this is strictly against Kenya Power policy. Higher construction quality could also potentially reduce local power outages and increase power reliability, which could have tangible benefits for household well-being and firm productivity and profits, especially in the medium- to long-run. Finally, anecdotal evidence suggests that Kenya Power occasionally installs multiple meters within a single home compound, overstating the total number of households that are connected nationwide in order to exaggerate public perceptions of program progress. To disentangle this from compound residents' genuine preference for multiple meters, the survey asks not just how many meters are at the compound, but also how many they had requested.

5.3 Power quality: outages and voltage

To measure reliability and voltage we deploy the GridWatch technology (Klugman et al. 2021; Klugman et al. 2019) with a subset of households and firms that had completed the socioeconomic survey. GridWatch measures minute-by-minute power state and voltage and can be installed by

[17] The rate at which poles were sampled for more detailed measurements varied by the size of each site. At smaller sites, field officers would conduct detailed measurements of every third or fourth pole, while at larger sites of 120 poles or more field officers would conduct detailed measurements of every sixth pole. The survey had been pre-programmed to automatically perform a calculation and provide instructions to the field officers.

plugging a PowerWatch device (Figure A4) into a power outlet. 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 aggregates data to detect patterns in power outages and reduce noisy signals. We aggregate these high-frequency measurements to the daily level, coding outages as hours of outage per site per day. Voltage quality is measured as the fraction of time voltage is within 10% of Kenya's nominal voltage of 230V (IEEE 2019).

We collect power outage and voltage quality across 150 sites for two months each, staggered between June 2021 and June 2022, deploying four PowerWatch devices per site at a time.[18] Since the staggered deployment rounds overlap, all regressions include day-of-sample and constituency fixed effects to control for power quality confounds such as weather and demand.

6 Results

Subsection 6.1 first presents extensive margin results: how many sites saw construction, and among these sites, how much construction was completed? The next two subsections examine intensive margin results, defined as construction quality conditional on having a physical connection: Subsection 6.2 examines power outages and voltage quality, while Subsection 6.3 presents results from the on-the-ground household and engineering assessments, both using the following estimating equation:

$$y_i = \beta_0 + \beta_1 \mathrm{WB}_i + \beta_2 \mathrm{Treat}_i \cdot \mathrm{WB}_i + \beta_3 \mathrm{Treat}_i \cdot \mathrm{AfDB}_i + \gamma + \epsilon_i, \quad (1)$$

where WB_i and AfDB_i indicate whether site i is WB-funded or AfDB-funded. Treat_i indicates whether the site is an audit treatment site. β_1 measures outcomes at WB sites relative to AfDB sites. β_2 and β_3 examine the treatment effect of randomized audits at WB sites and at AfDB sites, respectively. γ_c are fixed effects which vary across specifications. Standard errors are clustered by site in all regressions except those run at the site level.

Subsection 6.5 performs robustness tests on land gradient, facility type, and time since construction. While some correlations exist, these cannot explain our results. Finally, Subsection C.7 examines how these results affect grid resilience.

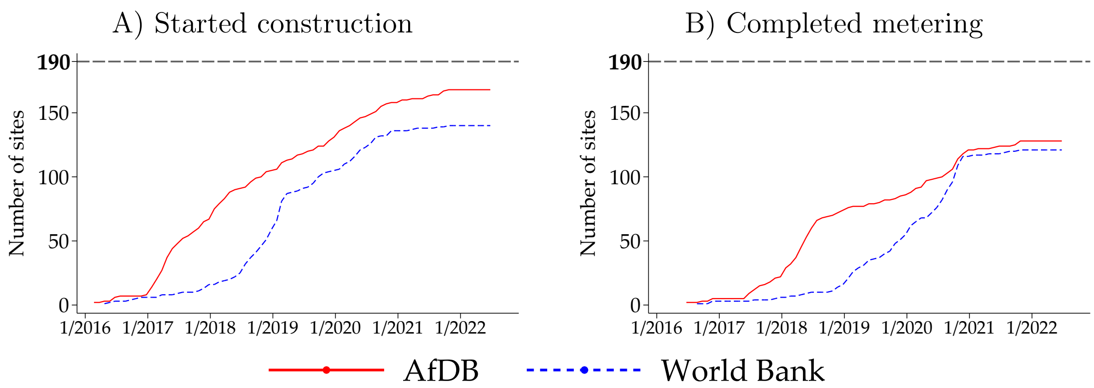
6.1 Extensive margin results

Figure 7 demonstrates that construction progress at WB sites lagged significantly behind AfDB sites. Panel A demonstrates that this lag is driven by the initial delay in starting construction, which resulted from the ex ante contracting procedures shown in Figure 2. Construction at WB sites started on average 7.6 months later than at AfDB sites. In mid-2018, as construction at WB sites was just beginning, AfDB sites reached 50% metering completion.[19]

[18] Due to delays and cost increases associated with Covid-19, our sample size for the power measurements had to be constrained to 150 of the 250 sites.

[19] This timeline is in line with Kenya Power's own nationwide progress metrics, which reported that 49% of the AfDB Phase I household connections targeted had been achieved by mid-2018 (Kenya Power 2018a).

Figure 7: Construction progress by funding source



Data for 190 AfDB sites and 190 WB sites located in the five study counties collected through phone surveys with village representatives. Figure A6 displays progress for the completion of two intermediate construction milestones: pole installation and stringing.

However, once construction had started in 2019, it proceeded more quickly at WB sites than at AfDB sites. By late 2020, four years after the start of contracting, the difference was minimal: household metering had been completed at 67% of AfDB sites and at 64% of WB sites. Still, AfDB and WB sites all lagged significantly behind the timelines originally agreed to in the contracts, which planned commissioning for June 2017 and June 2019, respectively.

Among sites where construction had been completed, WB sites saw fewer poles and customer connections (Table 2). The average number of poles is 134 at AfDB sites and 121 at WB sites (p-val $= 0.062$). The average number of customer connections at completed sites is 95 at AfDB sites and 83 at WB sites (p-val $= 0.11$; Table A4). Among both WB and AfDB sites, 22% of households who did not get connected reported the key barrier to be up-front costs, consisting of either the internal wiring required (16%) or fees required by Kenya Power or the contractor (among connected households, 9% report having been asked to pay a bribe). This is noteworthy because according to LMCP information campaigns, there was not supposed to be any up-front cost (Kenya Power 2016a): ready boards were supposed to have been made available for households who were unable to pay the upfront wiring costs. A further 30% noted that they were absent on the day on which Kenya Power enrolled households or when construction happened and thus they were unable to get connected.

In line with the fact that the WB already had additional inspections, Columns (2) and (4) of Table 2 indicate that the audit treatment increased the number of poles constructed at AfDB sites but not at WB sites. In addition, AfDB contractors were able to change site designs and thus increase construction at audit treatment sites, whereas WB construction contractors were constrained by the site designs that had already been finalized by a separate contractor.

Columns (5) and (6) point to a slight increase in construction 600-700 meters from the transformer at AfDB sites. This is in line with Kassem et al. (2022), who find that almost 30% of LMCP households are located beyond 600m of the transformer. The fact that this occurs less at WB sites

Table 2: Poles constructed per site

	(1)	(2)	(3)	(4)	(5)	(6)
World Bank (=1)	-15.0*	0.9	-12.3	2.4	-2.7***	-1.5
	(8.0)	(11.2)	(7.7)	(10.7)	(0.9)	(1.2)
Treatment (=1)	9.4		9.5		-0.1	
	(7.7)		(7.4)		(0.8)	
Treatment (WB sites)		-6.6		-5.3		-1.3
		(11.1)		(10.6)		(1.2)
Treatment (AfDB sites)		24.5**		23.4**		1.1
		(10.8)		(10.3)		(1.2)
Observations	242	242	242	242	242	242
600 M Boundary	All	All	Inside	Inside	Outside	Outside
Control Mean	124.20	124.20	119.30	119.30	4.90	4.90

Counts account for the fact that the grid was often too large to be fully covered by field officers, and instead only a randomly selected subset was surveyed: at 93% of sites we surveyed at least 50% of the network. The mean and median portion surveyed were both two-thirds. Table A4 presents the equivalent for the number of customer connections at a site. All regressions include constituency FE. Standard errors shown in parentheses. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

may indicate more stringent adherence to official LMCP rules: this could be viewed as a positive attribute, but does result in fewer connections per site. The household survey data indicate similar rates of requests for informal side payments—approximately 8%—inside and outside the 600 meter boundary. Among both WB and AfDB sites, approximately 4% of households report having had to contribute unpaid labor to the LMCP construction process. While voltage does decrease with distance from the transformer, this decrease is not correlated with funder (Subsection C.7). We also find no correlation between power quality and time between grid construction and voltage measurement.

The delays and reduced construction at LMCP sites speak to the costs of the segregated contracting and additional audits employed by the WB. These are important to enumerate but inconclusive on their own from a policy perspective: the delays might be worth it if they generate significant benefits. To examine this, the following sections examine power quality, construction quality, and household experiences.

6.2 Power quality

Control sites experience on average 0.9 hours (54 minutes) of power outage per day. They also experience poor voltage quality: Kenya's nominal voltage is 240V, but voltage in the control group is on average only 233V. This could affect day-to-day appliance usage and damage appliances in the long run. Were the delays at WB sites associated with an improvement in power quality? To answer this question, Table 3 presents results from Equation 1 using hourly GridWatch data.

First, the estimates show no significant difference in power outages or in voltage quality between AfDB and WB sites. WB procedures did not appear to have caused statistically or economically meaningful reductions in outages or improvements in voltage quality over the time period we study.

The results are similar when estimating daily or monthly coefficients (Figure A7).

Table 3: Donor and audit impacts on outages and voltage

	Outage			Voltage		
	(1)	(2)	(3)	(4)	(5)	(6)
World Bank (=1)	0.19	0.25	0.31	1.73	1.64	2.86
	(0.21)	(0.21)	(0.22)	(2.34)	(2.40)	(2.72)
Treatment for WB Sites	0.00	-0.01	-0.33*	3.45	3.49	1.39
	(0.24)	(0.23)	(0.17)	(2.22)	(2.18)	(1.77)
Treatment for AfDB Sites	0.15	0.18	-0.10	4.35**	3.81*	4.94*
	(0.18)	(0.17)	(0.18)	(2.01)	(1.96)	(2.59)
Observations	9,906	9,906	9,906	654,541	654,541	645,648
Week of Sample FE	No	Yes	Yes	No	No	No
Day of Sample FE	No	No	No	No	Yes	Yes
Hour of Day FE	No	No	No	No	Yes	Yes
Constituency FE	No	No	Yes	No	No	Yes
All FE Interacted	No	No	Yes	No	No	Yes
Control Mean	0.90	0.90	0.90	232.63	232.63	232.63

Columns (1)-(3) display daily hours of outage per site. Columns (4)-(6) display hourly voltage per respondent. Nominal voltage in Kenya is 240V. Power quality is measured using GridWatch devices. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Second, the audit treatment has no statistically significant impacts on power quality at WB sites. However, we see a statistically and economically meaningful effect of the audit treatment on voltage quality at AfDB sites. Our preferred specification is Column (6) as it includes interacted constituency, hour-of-day, and day-of-week fixed effects. Treatment sites experience average voltage of 237V, significantly closer to nominal voltage of 240V than the control mean of 233V. These results align with the differences in WB and AfDB audit procedures described in Subsection 3.4. The AfDB required fewer ex-post audits, such that additional audits would generate an important benefit at those sites, whereas the audit treatment had limited effects at WB sites as these already required an additional layer of inspections.

6.3 Engineering assessment and survey results

WB sites did not experience improved electricity quality of household electricity connections relative to AfDB sites in the short term. However, WB procedures could still have generated construction quality improvements with potentially long run benefits. Table 4 presents results for Equation 1 using primary outcome indices of the engineering measurements and socioeconomic outcome surveys, described in Section 5.[20] All indices are standardized to have a mean of zero and a standard deviation of one. Outcomes 1–3, measuring construction quality, network configuration, and construction timing, use site level observations. Outcomes 4–11 use respondent level observations.

Construction quality (Outcome 1) is on average 0.6 standard deviations higher at WB sites.

[20]These indices were pre-specified in the pre-analysis plan (Berkouwer et al. 2019).

Table 4: Primary engineering and socioeconomic outcomes

	(1) WB Effect Estimate	(2) Audit Treatment Effect, WB Sites	(3) Audit Treatment Effect, AfDB Sites	(4) N
Outcome 1: Construction quality index	0.60***	0.11	-0.06	250
	(0.21)	(0.21)	(0.18)	
Outcome 2: Network size and configuration index	0.01	0.27	0.04	241
	(0.19)	(0.17)	(0.18)	
Outcome 3: Construction timing index	-0.90***	-0.07	-0.29*	250
	(0.17)	(0.16)	(0.17)	
Outcome 4: Household installation quality index	0.05	0.02	0.23*	944
	(0.12)	(0.11)	(0.12)	
Outcome 5: Household cost, experience, bribery index	0.13	0.05	0.11	944
	(0.12)	(0.11)	(0.10)	
Outcome 6: Reliability and safety index	-0.11	0.03	-0.01	944
	(0.13)	(0.14)	(0.11)	
Outcome 7: Knowledge index	0.14	-0.00	0.07	944
	(0.10)	(0.09)	(0.10)	
Outcome 8: Electricity Usage index	0.12	0.11	0.28**	944
	(0.13)	(0.10)	(0.13)	
Outcome 9: Household socioeconomic outcomes index	0.24*	-0.00	0.20	944
	(0.12)	(0.13)	(0.13)	
Outcome 10: Firm Performance Index	0.29	-0.11	0.12	373
	(0.19)	(0.21)	(0.17)	
Outcome 11: Political and Social Beliefs index	0.03	0.01	0.03	944
	(0.08)	(0.07)	(0.09)	

Outcome variables are indices constructed from groups of variables standardized to have mean 0 and standard deviation 1. Column (1) displays the impact of WB funding relative to AfDB funding. Columns (2) and (3) display the treatment randomized audit treatment among WB sites and among AfDB sites, respectively. In rows 1–3, observations are transformer sites; standard errors are shown in parentheses. For rows 4 through 8, observations are occupants of connected compounds. All regressions control for site land gradient and public facility type. Standard errors are clustered by transformer site and shown in parentheses. We interpret the difference between columns (2) and (3) with caution since the interaction between WB status and audit treatment directly is not statistically significant (Table A7). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$. The sub-components for each index are presented in Table A8, Table A9, Table A10, Table A11, Table A12, Table A13, Table A14, Table A15, Table A16, Table A17, and Table A18.

This is primarily driven by increased presence of pole caps, struts, and stays on poles at WB sites (Table A8). These features may be important for network longevity: engineering research suggests that capped poles generally experience inner-pole moisture levels between 8–20% whereas uncapped poles experience levels between 30–80%, well above the threshold of 28–30% "considered necessary for fungal attack," over the 10 years after construction (UPRC 2018). While these features may have limited impacts on power quality over the five years we observe, they can reasonably be expected to increase the lifetime of the poles over the long-term.

Columns (2) and (3) of Table 4 estimate the effect of audits among WB and AfDB sites, respectively. As expected, additional audits do not affect outcomes at WB sites, which already experienced an additional round of inspections. However, the randomized audit treatment increased household installation quality (Outcome 4) and among AfDB sites, which can explain the positive impact on voltage quality identified in Table 3. It may also be why wee see increased household electricity usage (Outcome 8).

These results are driven primarily by more expedient meter activation, higher likelihood of having a working meter, and increased use of lighting, appliances, and purchases of electricity tokens at treatment sites (Table A11, Table A15). The audits benefits came at the cost of a small delay (Outcome 3), however this delay is smaller in magnitude than the delay caused by WB contracting, and these delays do not persist (Table A10, Figure A5).

In line with the results presented in Subsection 6.1, according to household reports of when they were connected, the WB ex ante contracting requirements caused a delay of 0.9 standard deviations. This delay is driven by delays to the start of construction, as well as delays between when stringing was completed and when meters were eventually activated (Table A10).

6.4 Contract bundling mechanisms

The five potential bundling mechanisms discussed in Section 2 all affected project outcomes for the principal in this context—Kenya Power. The experimental audit treatment shed light on the first mechanism, principal oversight. We now explore the role of the remaining four channels using qualitative data gathered during informational interviews with Kenya Power, the WB, and the AfDB. An anonymized list of individuals that our research team interviewed for the purposes of this research is included in Appendix D. While the examples are context-specific, the mechanisms are sufficiently general to be likely to be at play in any procurement structuring decision.

Mechanism 1: Oversight TBD

Mechanism 2: Principal workload Kenya Power's workload under the WB scheme was significant higher than under the AfDB scheme. The large absolute number of contracts, and the substantial heterogeneity in legal text across contracts, required more dedicated time by Kenya Power staff—to write, issue, review, and award bids—as did the more involved 'no objection' process for WB procurement. In the absence of additional staffing, these requirements may have contributed to the delays. In addition, contracting between the principal and the designers and suppliers was significantly more involved (requiring official tender and bid review processes) than the subcontracting between the implementer and the components for those same goods and services, as the implementer leveraged discretionary knowledge about subcontractor quality. Importantly, these requirements were not compensated for with additional labor. Despite these substantial differences in labor requirements, Kenya Power employed one staff member to manage the WB contracting procedures and one staff member to manage the AfDB contracting procedures: we confirmed in our interviews that total Kenya Power staff time availability was equal across the WB and AfDB components. The employees who held these positions were all certified electrical engineers with similar skill and education levels—at least a bachelor's degree in electrical engineering. As a result, workload requirements may have exacerbated bureaucratic delays.

Mechanism 3: Coordination costs Contract unbundling generated substantial coordination costs. The lack of coordination between the design and installation contracts meant that the designs were often out of date by the time construction began, requiring costly adjustments to the as-built designs or a change in the required materials. Similarly, a lack of coordination between materials and installation contracts means that materials were often physically transported into Kenya Power custody well before installation contractors were ready to begin work, causing Kenya Power to have to furnish expensive temporary storage facilities.

Mechanism 4: Procurement cost One of the WB's reasons for electing to award unbundled contracts was its belief that having coordinated nationwide contracts for major materials would enable them to obtain lower prices through auction. This turns out to have been true on paper: the cost per wooden and per concrete pole was 61% and 21% higher, respectively, in the AfDB subcontracts when compared with the WB contracts. However, anecdotal evidence suggests that these reported costs may have been intentionally distorted by the implementers, perhaps facilitated by the fact that the principal has less insight into true the component costs of bundled contracts. In reality, the aggregate costs per site are similar somewhat lower for the AfDB's bundled contract structure. Subsection 7.1 discusses this further.

Mechanism 5: Selection TBD

6.5 Robustness

Subsection 4.1 discussed the mechanism through which villages were assigned to a multilateral development bank for funding. While assignment is largely uncorrelated with observable characteristics, two notable differences stand out. This section explores the extent to which such selection may drive the results above.

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 examines the correlation between land gradient, funder assignment, and construction delays as measured by time to stringing completion.[21] 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 A6). Furthermore, lag between WB and AfDB is approximately constant across the entire land gradient support (Figure A8). 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 A2). The gap in timing between WB and AfDB sites is not significantly different across facility types (Table A5), and the gap in timing between WB and AfDB sites persists when controlling for facility type (Table A6). All results in Table 4 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.

[21] This is our preferred outcome because it captures significant construction process, but has a higher sample size than the subset of sites where metering was completed.

We examine robustness in our results to one additional potential source of bias. 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 A1 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.

We conduct two additional robustness checks. First, for Outcome 4 measuring household installation quality (Table A11) we replicate the index omitting the question asking the respondent whether they have a readyboard, since it is not obvious whether the presence of a readyboard is a positive or negative component. Its presence simultaneously indicates Kenya Power provisions and a lack of household preparedness (see Subsection 3.5 for more detail). Outcomes 5, 6, and 7 show little difference in household experiences. As an example, 41% of AfDB respondents and 43% of WB respondents reported having been told that they would have to pay Kenya Power for their electricity connection prior to construction, though this difference is not statistically significant. More detail is provided in Table A12, Table A13, and Table A14.

Second, the private contractor awarded lots 3 and 5 of the WB construction contracts[22] experienced unusual financial circumstances and this may have interfered with the timeliness and quality of their construction. We therefore repeat the analysis from Table 4 excluding these contracts, and then only keeping a balanced panel of counties. This does not affect results, although the results are slightly noisier.

7 Cost effectiveness

The WB's more onerous contracting and inspection requirements improved construction quality, but at the cost of significant delays. Subsection 7.1 first investigates each donor's program costs, in aggregate and by component. Subsection 7.2 then investigates the trade-off between short-term construction expediency and long-term infrastructure resilience, and examines whether this trade-off is necessary: could improvements in long-term construction quality be achieved without any associated delays?

7.1 Cost analysis

The WB and AfDB contracting guidelines are nearly identical on paper, specifying that turn-key or staggered contracting are both acceptable. Given this, why did the WB opt to use disaggregated contracting? One argument is that pooling nationwide materials procurement generates cost savings. The AfDB and World Bank's contracting methodology prevents a site-by-site analysis:

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

Table 5: Site, connection, and materials costs by donor

	World Bank	African Development Bank	Percent Difference
Sites	4,200	5,320	+27%
New household connections per site	62	72	+16%
Contract amount per site	30,331	28,938	–5%
Contract amount per household connection	489	402	–18%
Wooden poles contracted	199,119	159,604	–20%
Concrete poles contracted	44,701	159,198	+256%
Cost per wooden pole	99	159	+61%
Cost per concrete pole	199	240	+21%

Aggregate connection and pole procurement quantities and costs, per the contracts signed between Kenya Power and contractors under WB and AfDB funding tranches.

contract amounts aggregate costs for design, procurement, and construction across hundreds of sites, usually spanning several counties, such that even Kenya Power lacks the detailed information about contractor activities that would enable them to disaggregate costs. We therefore investigate aggregate contract amounts instead. These suggest that the average cost per household connection at AfDB sites is USD 402 while at WB sites it is USD 489: 22% higher. This excludes any additional labor contributed by Kenya Power towards administrative tasks associated with the WB's more onerous contracting and inspection procedures.

The cost per pole enumerated in Table 5 would suggest that WB contracts have a cheaper cost per pole.[23] However, in practice the contracted amounts listed in bundled contracts may not reflect true procurement on the ground: anecdotally, contractors have a preference for shifting costs onto materials as these invoices are paid sooner, providing them with much needed liquidity. In unbundled contracts, on the other hand, the principal has perfect insight into the cost of each procurement component. This is an example of how bundling contracts can create opacity.

To circumvent the fact that the cost of components listed in bundled contracts may not reflect true costs, we examine the aggregate contracted amounts. Kenya Power awarded USD 154mn in consulting, metering, and turn-key contracts for construction at the 5,320 AfDB sites, and USD 133mn in consulting, design, materials, and installation contracts for the 4,200 WB sites.[24] Average costs are thus USD 28,938 per AfDB site and USD 30,331 per WB site.[25]

In the 250 surveyed sites, our survey team identified on average 72 new LMCP household connections at AfDB sites and 62 at WB sites. This implies that the average cost per connection would

[23] Poles are generally homogeneous and therefore allow straightforward comparisons across contracts.

[24] Approximately 20.7% of WB sites included the construction of a new transformer. These sites are excluded from our surveying sample, and we exclude the USD 2.0mn contract awarded for the procurement of 1,000 new transformers from cost calculations. However, since these 1,000 sites received similar shares of the remaining contracts, we include them in the aggregate cost calculations.

[25] The cost-per-site numbers account for the fact that the 1,000 WB sites with new transformers were designed to have approximately 20.9% more new household connections.

have been USD 402 at AfDB sites and USD 489 at WB sites.[26] These cost estimates are significantly lower than the USD 739 average total cost per connection that Lee et al. (2020) estimate under a 100% electrification scenario in a similar area in rural Kenya using data collected in 2014. The difference can be reasonably attributed to implementation efficiencies derived from the nationwide coordination of design, supply, and installation activities, as well as general learning that occurred between 2014–2018.

Finally, there appear to be disparities between the contract amounts and the actual built amounts. For example, according to the procurement contracts, 18% of WB poles and 50% of contracted AfDB poles were concrete—however, according to our on-the-ground surveys, only 3% of poles at WB sites and 25% of poles at AfDB sites were concrete. However, we cannot distinguish pre-existing poles from poles that were newly constructed during LMCP, so if pre-existing poles were disproportionately wood poles then this could explain this discrepancy. For these reasons, we refrain from over-interpreting this result.

7.2 Cost-benefit analysis

To evaluate the potential costs and benefits of different contracting methodologies, we focus on potential gains and losses in construction speed and construction quality. The data show that on average AfDB sites reached construction milestones six to ten months faster than WB sites. Depending on the discount rate, allowing benefits to be realized earlier will increase their net present value. However, as shown in Table A8, WB sites score higher in the construction quality index, with differences driven largely by aspects of pole and pole installation quality, which could reduce long-term repair and replacement costs for Kenya Power.

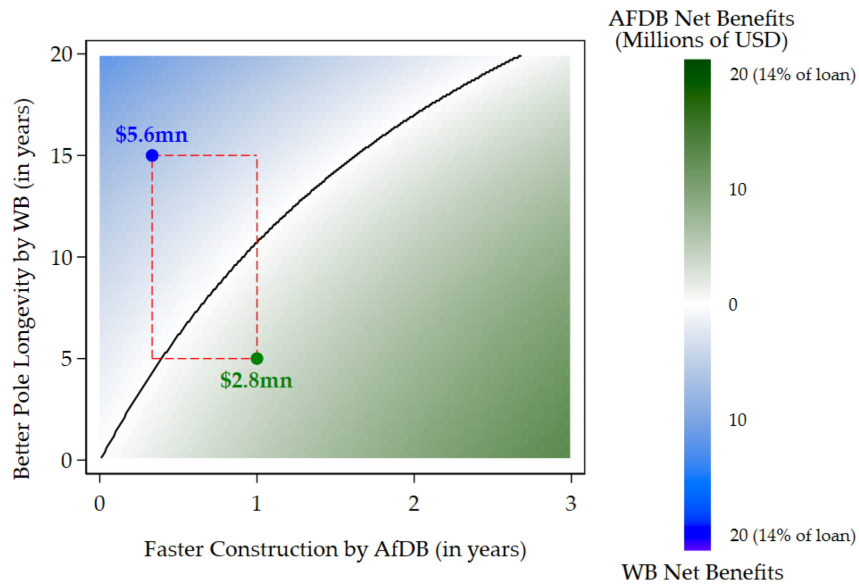
Household valuation of rural electrification is assumed to be $147, following revealed willingness-to-pay estimates from Lee et al. (2020). We assume that households discount delayed provision of electricity services, and planners discount future maintenance costs, both at a 10% annual discount rate. The range of the vertical axis corresponds to roughly a 20 to 40 year average service life for a pole, depending on pole quality (Muthike and Ali 2021). Table A20 and Figure A9 explore alternative assumptions.

Figure 8 estimates the net benefits of different contracting approaches under different assumptions. The red box illustrates a region between 4 to 12 months faster construction and between 5 to 15 years improved service life for poles that appear to be consistent with the data and with Muthike and Ali (2021). Using plausible estimates of the gains in construction speed and in quality of poles, we find that the overall net benefits of either set of policies are ambiguous.

While the assumptions that are made in this exercise are particular to mass electrification in Kenya, the calculations in Table A20 are intended to illustrate the trade-offs that may influence

[26] The national targets announced by Kenya Power would have required an average of 59 new household connections at each AfDB site and 74 new household connections at each WB site (Kenya Power 2016a). Using these numbers, the average cost per connection would have been USD 520 at AfDB sites and USD 410 at WB sites. Assuming a uniform 80 households per site would yield a construction cost of approximately USD 362 per household connection at AfDB sites and USD 396 at WB sites.

Figure 8: Costs versus benefits of different contracting approaches



The horizontal axis represents the gains from more expedient contracting procedures, allowing households to experience benefits sooner. Households are assumed to value a connection at $147 (Lee et al. 2020), with an annual discount rate of 10%. The vertical exist represents potential gains in grid longevity due to grid quality, assumed to accrue to the expected service life of poles with a constant annual probability of pole failure. The utility is assumed to have a time horizon of 40 years and an annual discount rate of 10%. The red box marks 4–12 months faster construction (consistent with the results above) and 5–15 years improved service life for poles (following Muthike and Ali 2021).

the contracting approaches best suited to large-scale development projects more generally. If the planner discounts future costs and benefits more severely, if household benefits are larger, or if a more stringent contracting approach is likely to produce greater delays, then a more expedient approach may be more worthwhile. Conversely, if a more expedient approach is expected to be associated with a greater decline in quality–perhaps because quality is more difficult to monitor and enforce through other mechanisms in a particular context– then a more stringent approach may be better suited.

Given the detail of the Inspection Reports (IRs) (discussed in more detail in Subsection 3.4), in particular with regards to the correct installation of visible materials such as pole caps, struts, and stays it appears likely that these played a big role in improving construction quality and therefore pole longevity. We do not have cost estimates of the IRs per se, however these costs could pay for themselves in reduced long-term repair and maintenance expenditures. For comparison, the research team budgeted approximately $125,000 for data collection at 380 sites, or about $329 per site (approximately 1% of the average per-site LMCP expenditures), however these data include household and firm surveys and their level of detail far exceeded the intensity of the IRs.

These results come with important caveats. These back-of-the-envelope calculations do not consider any additional staff time incurred by the World Bank, Kenya Power, and other government agencies due to increased paperwork and processing necessary to implement the World Bank's contracting procedures. We also do not consider any potential spillover benefits such as increased knowledge of oversight mechanisms within Kenyan government agencies. We also do not consider possible degradation of electricity service quality over time due to lower quality construction. Perhaps most importantly, we do not observe leakage. It is possible that WB contracting requirements meaningfully reduce leakage of funds that were recently observed, for example, by Andersen et al. (2022). We cannot observe or rule out differences in funds leakage, but to the extent that this would have reduced the availability of funds for intended construction, this does not appear to have affected construction outcomes in the short to medium run.

8 Conclusion

This research evaluates the impact of different procurement regulations on the costs, timeliness, and quality of a government infrastructure project. We study this topic in the context of the Last Mile Connectivity Project (LMCP)–one of Kenya's largest public infrastructure construction projects–where different donor conditions cause differences in regulations even within the same government program. The roughly USD 600 million cost of the LMCP is financed in large part by international donors, including in particular the WB and the AfDB. We exploit quasi-random variation in the assignment of specific communities designated for inclusion in the LMCP to be funded by either the WB or the AfDB. Contractors who win bids issued by the WB are required to comply with the WB's relatively more stringent conditions that placed restrictions on how firms must be selected to produce designs, supply materials, and compete installation at different sites. Our measurements include high-frequency household-level outage and voltage data, on-the-ground engineering measurements of the local electricity network, and household and firm socioeconomic surveys inquiring about the connection experience, knowledge, and electricity usage. In addition to primary data collection, we analyze LMCP procurement contracts, inspection reports, and infrastructure data, and we conduct informational interviews with dozens of senior personnel at Kenya Power, the AfDB, and the WB.

We find that the WB's requirements cause significant delays in implementation, with households at WB sites receiving their electricity connections on average 9.6 months later than households in sites that are funded by the AfDB. We can rule out that the conditions causing these delays generated statistically or economically meaningful improvements in power outages or voltage quality in the short term. However, we find a 0.6 standard deviation improvement in construction quality at WB site, driven by increased presence of pole caps, stays, and struts, which were key components examined during the WB's additional inspection round. The estimates on several other key outcomes—such as household installation quality, cost, and electricity usage—are positive but generally modest in size and not statistically significant, although improvements may emerge in the longer run.

To investigate the difference between two key components of donor conditionality—contracting requirements and audits—we implement a randomized audit treatment where contractors are informed of a subset of sites that are selected for monitoring. The randomized audit treatment generates a 0.2 standard deviation improvement in household installation quality and a 0.3 standard deviation improvement in electricity usage, while causing significantly fewer delays than the WB approach. This suggests some benefits can be captured from this much less burdensome component of donor conditionality.

These analyses generate several tangible policy recommendations. First, and holding constant the two funders' contracting procedures, we identify a trade-off between short-term expediency and long-term grid resilience. Weighing the short-term benefits of earlier access to electricity with the long-term benefit of lower maintenance and upgrading expenditures implies that the social planner's time preferences will affect the relative net benefits. Under even a modest range of assumptions, our estimates can rationalize anywhere from a USD 5.6mn net benefit at AfDB sites to a USD 2.8mn net benefit at WB sites, both non-trivial shares of the total project budget. Second, more streamlined upfront contracting with more rigorous auditing could prevent significant delays without necessarily compromising construction quality. This is likely especially the case when target contractors participate in a repeated game where poor construction performance could threaten a contractor's future contracting opportunities.

Several important limitations are worth noting. First, WB conditionality could generate substantial benefits that are unobservable to our research team, such as improved institutional capacity or accounting practices in Kenya public sector organizations. Second, the latest we inspect a site is five years after construction. While we see no correlation between construction quality and time since construction over this period, it is possible that construction quality worsens over time, and that the stringent WB contracting procedures will improve grid resilience against such depreciation over a longer time horizon. Finally, Kenya is a relatively high-capacity state in East Africa, and its internal regulatory system may be sufficiently rigorous so as not to benefit meaningfully from additional WB requirements. It is possible that our results would not hold in a lower-capacity state. Additional research is needed to understand these dimensions and potential impacts of donor conditionality over time and in other settings.

References

"A Thousand Golden Stars: China Goes to Africa." 2017. https://www.economist.com/middle-east-and-africa/2017/07/20/china-goes-to-africa.

Andersen, Jørgen Juel, Niels Johannesen, and Bob Rijkers. 2022. "Elite Capture of Foreign Aid: Evidence from Offshore Bank Accounts". *Journal of Political Economy* 130 (2): 388–425.

Archibong, Belinda, Brahima Coulibaly, and Ngozi Okonjo-Iweala. 2021. "Washington Consensus Reforms and Lessons for Economic Performance in Sub-Saharan Africa". *Journal of Economic Perspectives* 35, no. 3 (): 133–56.

Berkouwer, Susanna, Eric Hsu, Edward Miguel, and Catherine Wolfram. 2019. "Pre-Analysis Plan for The Political Economy and Governance of Rural Electrification".

Berkouwer, Susanna, Kenneth Lee, and Michael Walker. 2018. "Secondary School Electrification in Western Kenya". AidData Working Paper 57.

Blimpo, Moussa P., and Malcolm Cosgrove-Davies. 2019. "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact". *Africa Development Forum;. Washington, DC: World Bank.*

Bosio, Erica, Simeon Djankov, Edward Glaeser, and Andrei Shleifer. 2022. "Public Procurement in Law and Practice". *American Economic Review* 112, no. 4 (): 1091–1117.

Burlig, Fiona, and Louis Preonas. 2021. "Out of the darkness and into the light? Development effects of rural electrification". Working Paper.

Business Daily. 2018. "DCI raid led to arrests at Kenya Power, says official". Visited on 08/04/2022. https://www.businessdailyafrica.com/bd/news/dci-raid-led-to-arrests-at-kenya-power-says-official-2221694.

— . 2007. "Kenya: KPLC Allows Tree Farmers to Supply Untreated Poles". Visited on 08/24/2022. https://allafrica.com/stories/200712121237.html.

Cappellazzi, Jed, and Matt Konkler. 2018. *38th Annual Report 2018*. Tech. rep.

Dinkelman, Taryn. 2011. "The Effects of Rural Electrification on Employment: New Evidence from South Africa". *American Economic Review* 101, no. 7 (): 3078–3108.

Dreher, Axel, Andreas Fuchs, Bradley Parks, Austin Strange, and Michael J. Tierney. 2021. "Aid, China, and Growth: Evidence from a New Global Development Finance Dataset". *American Economic Journal: Economic Policy* 13, no. 2 (): 135–74.

Duflo, Esther, Michael Greenstone, Rohini Pande, and Nicholas Ryan. 2018. "The Value of Regulatory Discretion: Estimates From Environmental Inspections in India". *Econometrica* 86 (6): 2123–2160.

Easterly, William. 2002. *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*. Vol. 1. MIT Press Books 0262550423. The MIT Press.

Elvidge, Christopher D., Kimberly Baugh, Mikhail Zhizhin, Feng Chi Hsu, and Tilottama Ghosh. 2017. "VIIRS night-time lights." *International Journal of Remote Sensing* 38 (21): 5860–5879.

ESI Africa. 2020. "Kenya Power contests High Court ruling over its tender cancellation". News Article. Visited on 01/29/2021. https://www.esi-africa.com/industry-sectors/finance-and-policy/kenya-power-contests-high-court-ruling-over-its-tender-cancellation/.

Ferraz, Claudio, and Frederico Finan. 2008. “Exposing corrupt politicians: the effects of Brazil’s publicly released audits on electoral outcomes”. *The Quarterly journal of economics* 123 (2): 703–745.

Finan, Frederico, Benjamin A Olken, and Rohini Pande. 2017. “The personnel economics of the developing state”. In *Handbook of Economic Field Experiments*, 2:467–514. Elsevier.

Glaeser, Edward L., and James M. Poterba. 2021. *Economic Analysis and Infrastructure Investment*. University of Chicago Press.

Hart, Oliver, Andrei Shleifer, and Robert W. Vishny. 1997. “The Proper Scope of Government: Theory and an Application to Prisons*”. *The Quarterly Journal of Economics* 112, no. 4 (): 1127–1161. eprint: https://academic.oup.com/qje/article-pdf/112/4/1127/5393947/112-4-1127.pdf.

Hoppe, Eva I., David J. Kusterer, and Patrick W. Schmitz. 2013. “Public–private partnerships versus traditional procurement: An experimental investigation”. *Journal of Economic Behavior & Organization* 89:145–166.

“IEEE Recommended Practice for Monitoring Electric Power Quality”. 2019. *IEEE Std 1159-2019 (Revision of IEEE Std 1159-2009)*: 1–98.

Isaksson, Ann-Sofie, and Andreas Kotsadam. 2018. “Chinese aid and local corruption”. *Journal of Public Economics* 159:146–159.

Jacome, Veronica, Noah Klugman, Catherine Wolfram, Belinda Grunfeld, Duncan Callaway, and Isha Ray. 2019. “Power quality and modern energy for all”. *Proceedings of the National Academy of Sciences* 116 (33): 16308–16313.

Kangethe, Kennedy. 2015. “AfDB To Finance Sh15bn Electrification Project”. CAPITAL BUSINESS. Visited on 02/08/2022. https://www.capitalfm.co.ke/business/2015/12/afdb-to-finance-sh15bn-electrification-project/.

Kassem, Dana, Giulia Zane, and Eustace Uzor. 2022. “Revisiting the Last Mile: The Development Effects of a Mass Electrification Program in Kenya”. Working paper.

Kenya National Bureau of Statistics. 2009. “Kenya Population and Housing Census”.

— . 2019. “Kenya Population and Housing Census”.

Kenya Power. 2018a. “ANNUAL REPORT AND FINANCIAL STATEMENTS FOR THE YEAR ENDED 30TH JUNE 2018”.

— . 2017. “Kenya Power signs contracts for implementation of the Last Mile Connectivity Project”. Press Release. Visited on 01/29/2021. https://www.kplc.co.ke/content/item/2272/kenya-power-signs-contracts-for-implementation-of-the-last-mile-connectivity-project.

— . 2020. “Kenya Power staff and several other suspects arrested over various crimes undermining quality power supply”. Press Release. Visited on 03/10/2021. https://www.kplc.co.ke/content/item/3484/kenya-power-staff-and-several-other-suspects-arrested-over-various-crimes-undermining-quality-power-supply.

— . 2018b. “Kenya Power to blacklist contractors for shoddy work”. Press Release. Visited on 01/29/2021. https://www.kplc.co.ke/content/item/2513/kenya-power-to-blacklist-contractors-for-shoddy-work.

— . 2015a. “KPLC awards contracts for implementation of the Last Mile Project”. Press Release. Visited on 01/29/2021. https://www.kplc.co.ke/content/item/1226/kplc-awards-contracts-for-implementation-of-the-last-mile-project.

— . 2016a. “Last Mile Connectivity Program Q & A”. https://www.kplc.co.ke/content/item/1694/last-mile-connectivity-program-q---a.

— . 2016b. “Minutes of pre-bid meeting for tender NO KP1/9AA-2/PT/20/14-15 - supply of treated powr distribution wooden poles held on 16/10/2014 at the Stima Plaza basement floor”. %7Bhttps://kplc.co.ke/img/full/2Gwl66r7xFCG_MINUTES%5C%20OF%5C%20PRE_BID%5C%20MEETING%5C%20FOR%5C%20%5C%20SUPPLY%5C%20OF%5C%20TREATED%5C%20POWER%5C%20DISTRIBUTION%5C%20WOODEN%5C%20POLES(LOCAL%5C%20MANUFACTURERS%5C%20ONLY).pdf%7D.

— . 2015b. “Notes by Dr. Ben Chumo, Kenya Power Managing Director and Chief Executive Officer, During the Press Conference on Implementation of the Last Mile Project”. Press Conference. Visited on 01/29/2021. https://kplc.co.ke/img/full/2nPEsH9Dge4K_Notes%20-%20MD%20-%20Press%20Conference.pdf.

Kenya Presidency. 2015. “Cost Of Installing Electricity Drops To Ksh15,000 With Option Of Instalments”. https://www.president.go.ke/2015/05/27/cost-of-installing-electricity-drops-to-ksh15000-with-option-of-instalments/.

Kersting, Erasmus, and Christopher Kilby. 2016. “With a little help from my friends: Global electioneering and World Bank lending”. *Journal of Development Economics* 121 ().

Kilby, Christopher. 2013. “The Political Economy of Project Preparation: An Empirical Analysis of World Bank Projects”. *Journal of Development Economics* 105 (): 211–225.

Klugman, Noah, Joshua Adkins, Emily Paszkiewicz, Matthew Podolsky, Jay Taneja, and Prabal Dutta. 2021. “Watching the Grid: Utility-Independent Measurements of Electricity Reliability in Accra, Ghana”. IPSN Conference Presentation, to appear.

Klugman, Noah, Catherine Wolfram, Jay Taneja, Prabal Dutta, Joshua Adkins, Susanna Berkouwer, Kwame Abrokwah, Ivan Bobashev, Pat Pannuto, Matthew Podolsky, Aldo Suseno, and Revati Thatte. 2019. “Hardware, apps, and surveys at scale: insights from measuring grid reliability in Accra, Ghana”. In *Proceedings of the Conference on Computing & Sustainable Societies - COMPASS ’19*, 134–144. Accra, Ghana: ACM Press.

Lee, Kenneth, Edward Miguel, and Catherine Wolfram. 2020. “Experimental Evidence on the Economics of Rural Electrification”. *Journal of Political Economy* 128 (4).

Levin, Jonathan, and Steven Tadelis. 2010. “CONTRACTING FOR GOVERNMENT SERVICES: THEORY AND EVIDENCE FROM U.S. CITIES”. *The Journal of Industrial Economics* 58 (3): 507–541.

Makovšek, Dejan, and Adrian Bridge. 2021. “Procurement Choices and Infrastructure Costs”. In Glaeser and Poterba 2021, 277–327.

Malik, Ammar A., Bradley Parks, Brooke Russell, Joyce Jiahui Lin, Katherine Walsh, Kyra Solomon, Sheng Zhang, Thai-Binh Elston, and Seth Goodman. 2021. *Banking on the Belt and Road: Insights from a new global dataset of 13,427 Chinese development projects.* Tech. rep. Williamsburg, VA: AidData at William & Mary.

Marx, Benjamin. 2018. “Elections as Incentives: Project Completion and Visibility in African Politics”. Working paper.

Mihalyi, David, Jyhjong Hwang, Diego Rivetti, and James Cust. 2022. “Resource-Backed Loans in Sub-Saharan Africa”. Policy Research Working Paper 9923, *World Bank Group.*

Ministry of Energy and Petroleum, Republic of Kenya. 2014. *Draft National Energy Policy.* Tech. rep.

Moscona, Jacob. 2020. “The Management of Aid and Conflict in Africa”. *Working Paper*.

Mosley, Philip. 1986. “Book Reviews”. *Theory, Culture & Society* 3 (3): 192–194.

Muthike, George, and Godfrey Ali. 2021. “Concrete vs Wooden Poles: Effects of the Shift to Concrete Poles on Tree Growers”.

Olken, Benjamin A. 2007. “Monitoring Corruption: Evidence from a Field Experiment in Indonesia”. *Journal of Political Economy* 115 (2): 200–249.

Ping, Szu-Ning, Yi-Ting Wang, and Wen-Yang Chang. 2022. “The Effects of China’s Development Projects on Political Accountability”. *British Journal of Political Science* 52 (1): 65–84.

Reuters. 2018. “Kenya Power’s CEO charged in court over economic crime”. Visited on 03/10/2021. https://www.reuters.com/article/us-kenya-corruption/kenya-powers-ceo-charged-in-court-over-economic-crime-idUSKBN1K60WG.

Rodrik, Dani. 2006. “Goodbye Washington Consensus, Hello Washington Confusion? A Review of the World Bank’s Economic Growth in the 1990s: Learning from a Decade of Reform”. *Journal of Economic Literature* 44, no. 4 (): 973–987.

Rural Electrification Authority. 2008. *Strategic Plan 2008-2012*.

Silva, Cláudio. 2022. “Angola (Re)Model: How Angola’s honeymoon with China came to an end”.

Spotlight East Africa. 2020. “AfDB blacklists another Chinese Kenya Power contractor over fraud”. Visited on 03/10/2021. https://www.spotlighteastafrica.com/post/afdb-blacklists-another-chinese-kenya-power-contractor-over-fraud.

State Council. 2011. *White Paper on China’s Foreign Aid*. Tech. rep. Xinhua/Information Office of the State Council, People’s Republic of China.

Tadelis, Steven. 2012. “Public procurement design: Lessons from the private sector”. Selected Papers, European Association for Research in Industrial Economics 38th Annual Conference, Stockholm, Sweden, September 1-3, 2011, *International Journal of Industrial Organization* 30 (3): 297–302.

The African Development Bank. 2014a. “Comprehensive Review of the AFDB’s Procurement Policies and Procedures – Summary of Literature on Harmonization in Public Procurement”.

— . 2014b. “LAST MILE CONNECTIVITY PROJECT, PROJECT APPRAISAL REPORT”.

— . 2018. “Operations Procurement Manual”.

The Nation. 2022. “Kenya Power graft scam: State barred from introducing new charges”. Visited on 08/04/2022. https://nation.africa/kenya/business/kenya-power-graft-scam-state-barred-from-introducing-new-charges-3901214.

— . 2021. “Rural electricity firm bought substandard poles for Sh800m”. Visited on 01/17/2022. https://nation.africa/kenya/business/rural-electricity-firm-bought-substandard-poles-for-sh800m-3646434.

The Star. 2018. “State lost Sh201m in Kenya Power scandal”. Visited on 03/10/2021. https://www.the-star.co.ke/news/2018-12-18-state-lost-sh201m-in-kenya-power-scandal/.

The World Bank. 2017. *Issuance of Sanctions Board Decision No. 102*.

The World Bank Group. 2015. "INTERNATIONAL DEVELOPMENT ASSOCIATION PROJECT APPRAISAL DOCUMENT ON A PROPOSED CREDIT IN THE AMOUNT OF SDR 172.6 MILLION (US$250 MILLION EQUIVALENT) PROPOSED STRATEGIC CLIMATE FUND-SCALING-UP RENEWABLE ENERGY PROGRAM GRANT IN THE AMOUNT OF US$7.5 MILLION AND A PROPOSED GUARANTEE IN AN AMOUNT EQUIVALENT TO US$200 MILLION TO THE REPUBLIC OF Kenya FOR AN ELECTRICITY MODERNIZATION PROJECT".

— . 2011. "Procurement of goods, works, and non-consulting services under IBRD loans and IDA credits & grants by World Bank borrowers".

— . 2020. "Procurement Regulations for IPF Borrowers". Fourth Edition.

— . 2014. "The World Bank and Public Procurement—An Independent Evaluation".

Williamson, John. 2009. "A Short History of the Washington Consensus Preface". *Law and Business Review of the Americas* 15:7.

Williamson, Oliver. 1999. "Public and private bureaucracies: a transaction cost economics perspectives". *The Journal of Law, Economics, and Organization* 15, no. 1 (): 306–342.

Wolfram, Catherine D., Eric Hsu, Susanna B. Berkouwer, Oliver W. Kim, Felipe Vial, and Edward Miguel. 2022. "Decomposing Political Favoritism in Kenyan Mass Electrification". Working Paper.

A Appendix Figures

Figure A1: Monitoring Intervention

THE WORLD BANK
IBRD • IDA

Kenya Power

Contractor XYZ
ADDRESS
P.O. Box YYY-ZZZ
Nairobi, Kenya

June 2017

TO: CONTRACTOR NAME
RE: ENHANCED MONITORING PROGRAM ("EMP") FOR LMCP MAXIMIZATION SITES

Dear Sir/Madame:

Kenya Power aims to provide the highest quality of electricity to all Kenyans. To achieve this goal, an international team of engineers will closely audit the quality of construction at a number of Last Mile Connectivity Project ("LMCP") maximization sites. These independent audits will be performed as part of the Enhanced Monitoring Program ("EMP"), and will target both African Development Bank and World Bank project sites. The results of the EMP audits will be shared with project supervisors, financiers, and international agencies, all of which may impose consequences on future contracting opportunities, as they see fit.

Upon project completion, EMP technicians will extensively measure the quality of various aspects of construction, including:

- Distance between poles
- Line sag
- Quality of connection between transformer and LV wiring
- Blackouts and electricity reliability post-connection

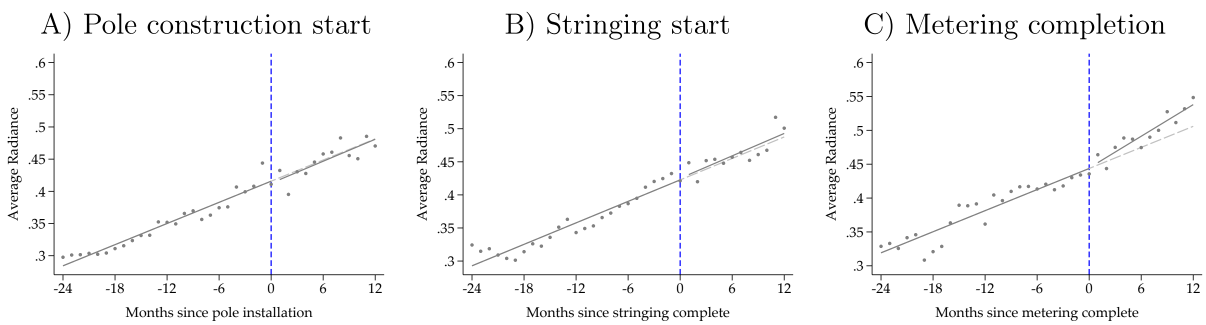
We wish to inform you of the sites that have been awarded to you that have been selected for the EMP. Please find attached a list of these sites.

Sincerely yours,

L	S	J
Senior Energy Specialist	Principal Power Engineer	Electrification Project Manager
The World Bank	The African Development Bank	Kenya Power & Lighting Company

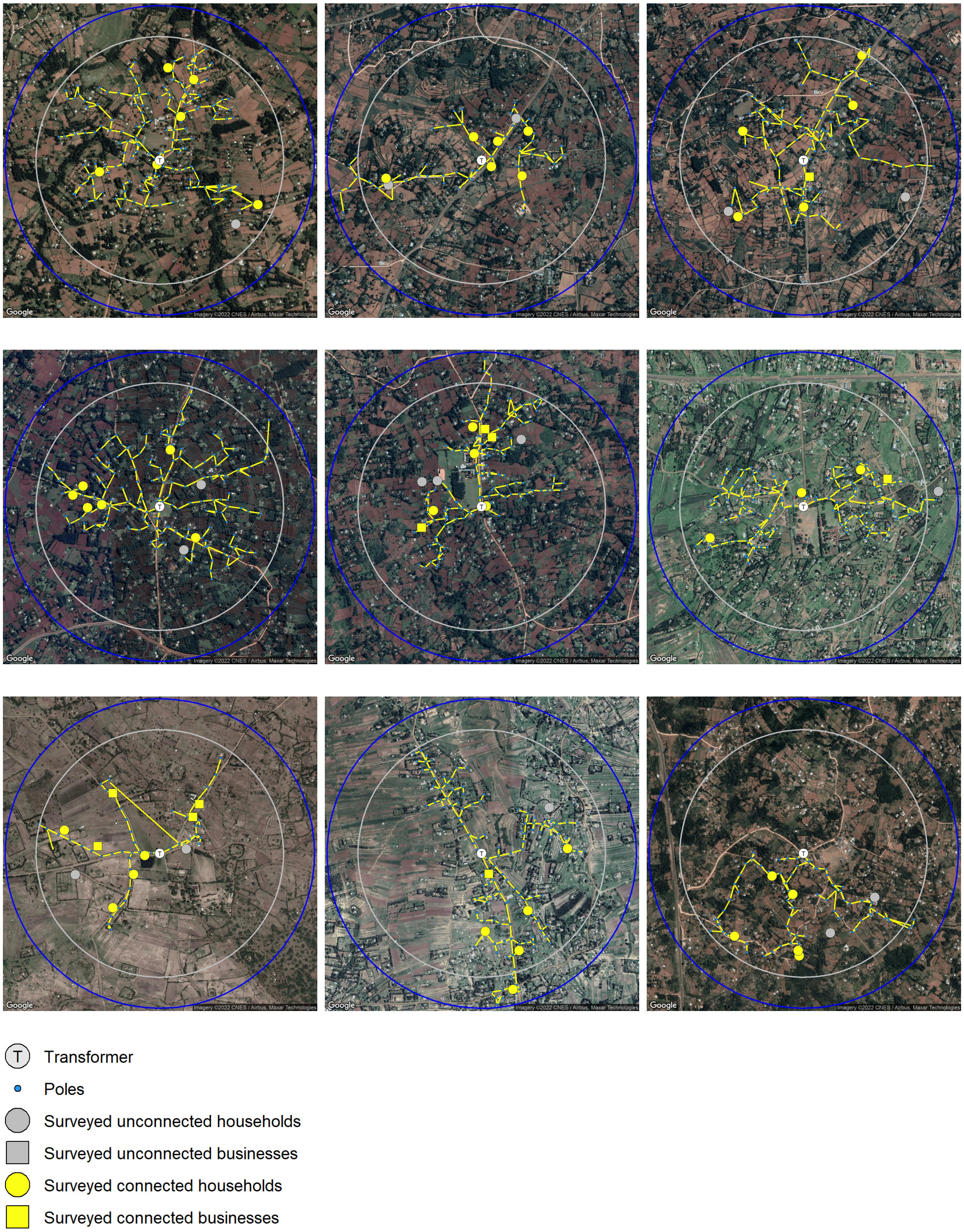
This figure displays the monitoring intervention sent to contractors. Each contractor's name, contact information, and site details were entered individually. The names and positions of the relevant representatives from Kenya Power, the World Bank, and the AfDB were entered, and the letter was signed by these parties. The letters were then hand-delivered to management at the relevant contractors by members of our research team to ensure receipt, together with the list of treatment sites referenced in the letter.

Figure A2: Event study: nightlights after construction progress



Data on construction progress for the 135 AfDB sites and 121 WB sites located in the five study counties collected through phone surveys with local village representatives. As expected, nighttime radiance data (VIIRS) increases after metering completion (when the electricity connection is activated) but not earlier.

Figure A3: Engineering data collected (additional example sites)

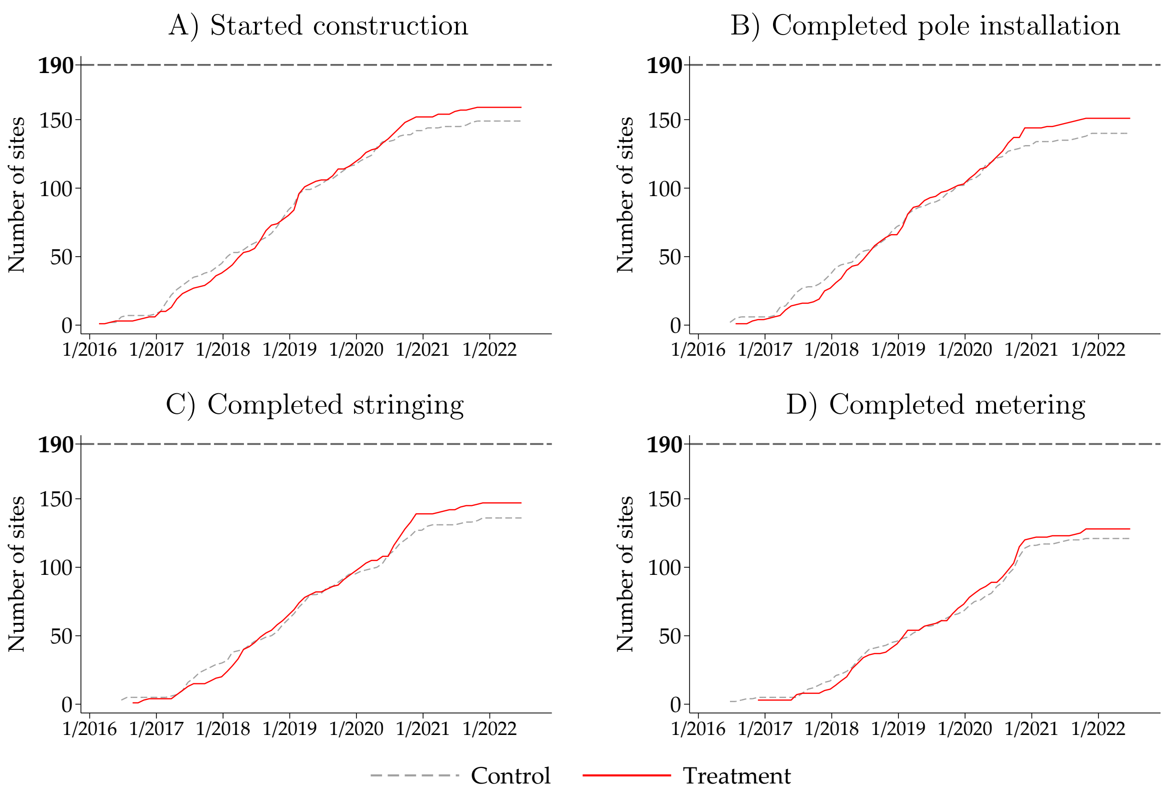


These maps displays the construction data collected at example sites. The grey line denotes 600 meters and the blue line denotes 700 meters from the transformer ('T') at the center. Subsection 5.1 provides additional information on data collection. To preserve anonymity random spatial noise has been added to household and business locations.

Figure A4: A PowerWatch device

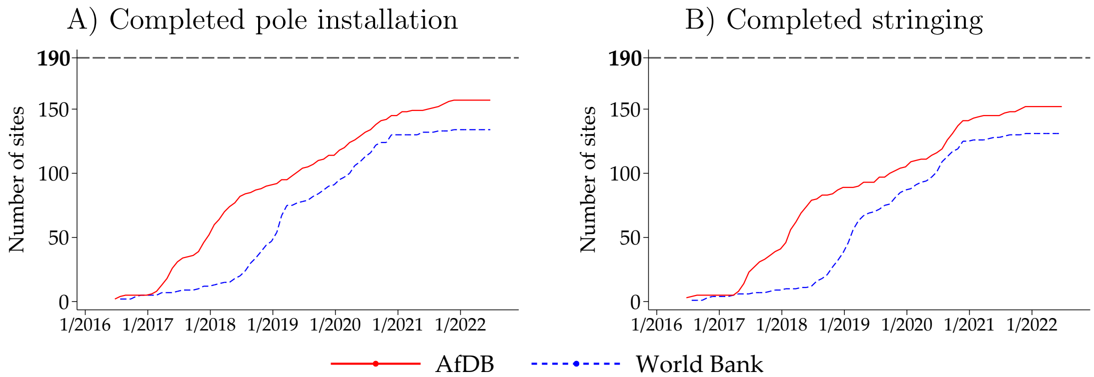
A PowerWatch device, part of nLine's GridWatch technologies used to measure household-level power outages and voltage.

Figure A5: Construction progress by audit treatment status



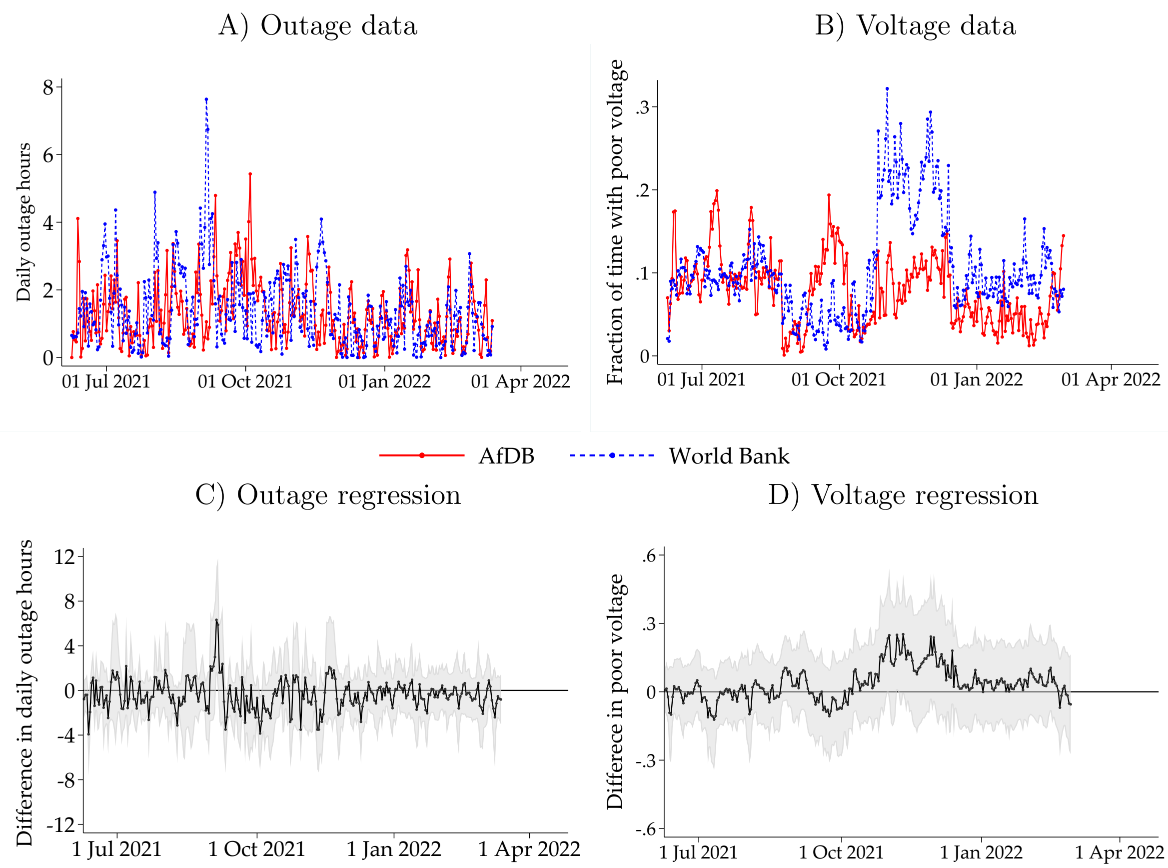
Data for 190 control sites and 190 treatment sites located in the five study counties collected through phone surveys with village representatives.

Figure A6: Construction progress by funding source



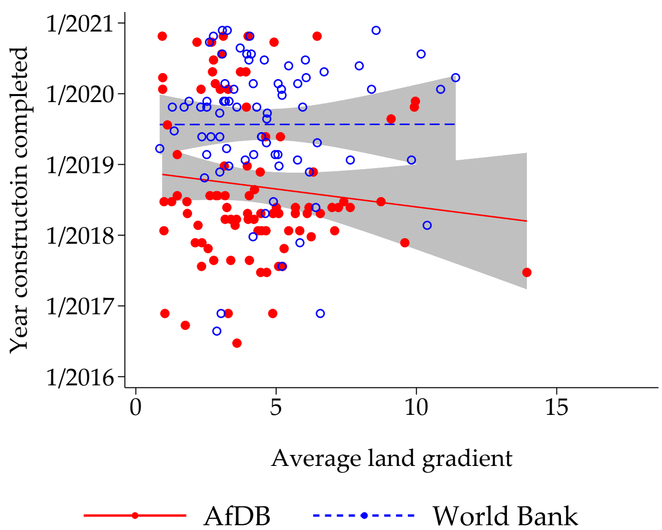
Data for 190 AfDB sites and 190 WB sites located in the five study counties collected through phone surveys with village representatives.

Figure A7: Reliability and voltage quality by funding source



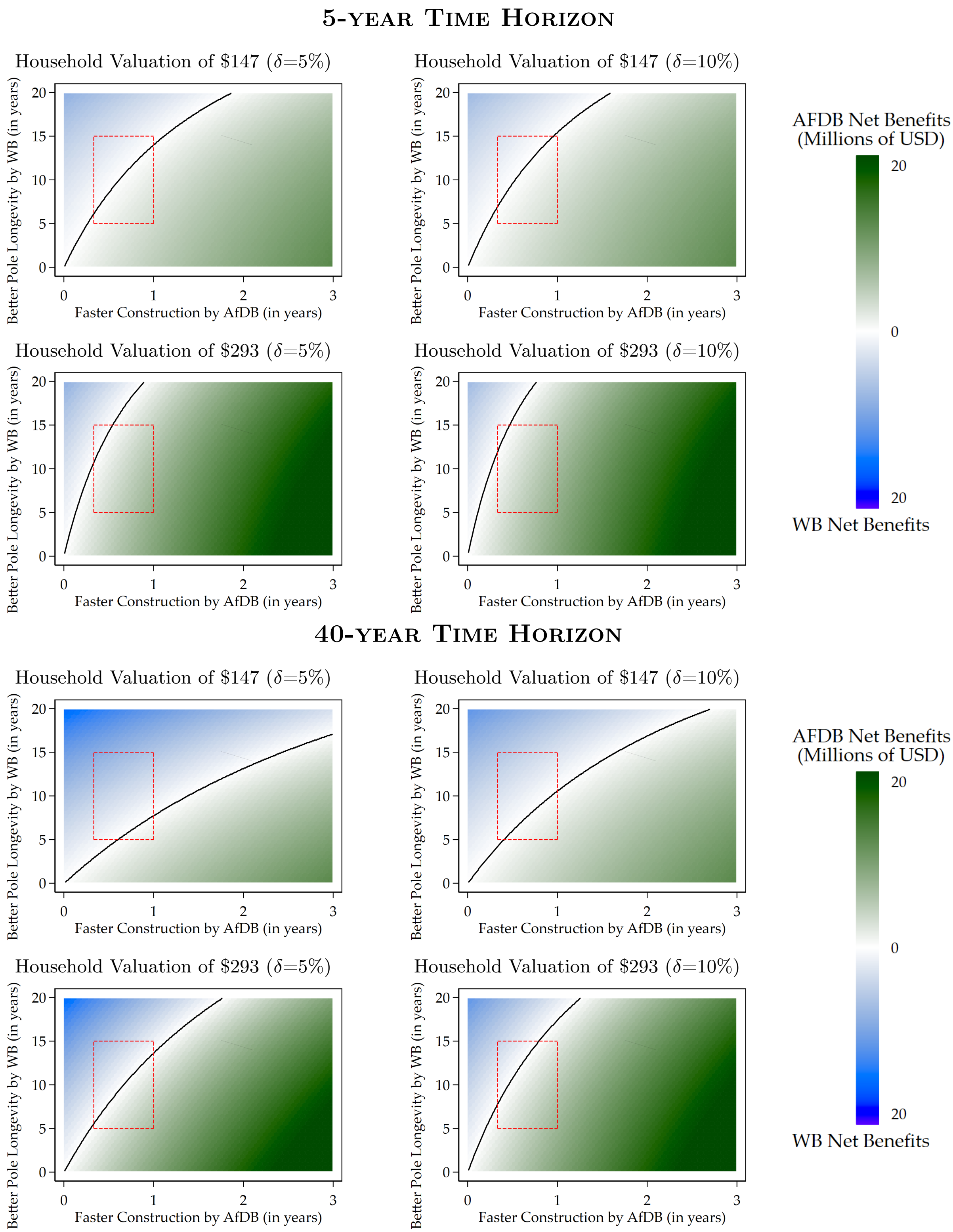
Panels A and B present the hours of outage per day and fraction of time experiencing poor voltage quality, respectively, for WB and AfDB sites. Panels C and D estimates a separate coefficient for each day of the sample. In panels A and C, outages are defined as hours of outage per day, averaged across sites. In panels B and D, poor voltage is defined as the fraction of time voltage is outside 230±10% per day, averaged across sites. 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 A8: Construction delays and land gradient



Average land gradient is calculated for each site over the 600 meter radius around its transformer. Land gradient is uncorrelated with construction delays, both unconditionally and conditional on funder. The lag between WB and AfDB is approximately constant across the entire land gradient support. Data source: Shuttle Radar Topography Mission (SRTM) Global Digital Elevation Model. Gradient is measured in degrees from 0 (perfectly flat) to 90 degrees (perfectly vertical) (Dinkelman 2011).

Figure A9: Costs versus benefits on various assumptions



Expected net benefits from adopting either AfDB procedures or WB procedures. The black line indicates similar expected net benefits for AfDB and WB procedures. δ=10, 5% refers to the planner's annual discount rate. Households are assumed to have an annual discount rate of 10%. Figure 8 presents results for our preferred specification. Lee et al. (2020) find a household valuation of $147 when using revealed preference and $293 when using stated preference.

B Appendix Tables

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

	VIIRS Radiance		Land Gradient	
	(1)	(2)	(3)	(4)
World Bank (=1)	-0.006	-0.027	0.989***	0.573**
	(0.065)	(0.065)	(0.309)	(0.239)
Observations	51446	51446	347	347
Month FE	No	Yes	No	No
Constituency FE	No	Yes	No	Yes
Control Mean	.41	.41	4.36	4.36

Columns (1) and (2) estimate monthly average site-level nighttime radiance measured using VIIRS averaged across the 600 meter radius. Standard errors are clustered by site. Columns (3) and (4) estimate average site-level land gradient recorded using 90-meter Shuttle Radar Topography Mission (SRTM) Global Digital Elevation Model, a measure of site mountainousness.$^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

In column 1, we assume that higher quality construction translates to an average pole lifespan that is 40 years as compared to 20 years for lower quality construction.

Table A2: 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)	(.)

Most transformers were constructed between 2005-2015 through a nationwide program by Kenya's Rural Electrification Authority to connect public facilities to electricity. 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 FE.

Table A3: 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	84.64	35.78	57	80	106	242
Number of leaning poles (<85deg)	1.72	2.60	0	1	3	242
Number of cracked poles	20.76	17.98	7	15	29	242
Number of poles without a cap	40.39	29.05	19	34	57	242
Number of stays	54.63	24.71	36	52	70	242
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

Summary statistics for surveying sites.

Table A4: Customer connections per site

	(1)	(2)	(3)	(4)	(5)	(6)
World Bank (=1)	-13.0	-8.5	-12.0	-7.8	-1.7**	-0.9
	(8.0)	(11.3)	(7.9)	(11.1)	(0.7)	(1.0)
Treatment (=1)	5.7		5.1		-0.1	
	(7.7)		(7.6)		(0.7)	
Treatment (WB sites)		1.3		0.8		-0.9
		(11.2)		(11.0)		(1.0)
Treatment (AfDB sites)		9.9		9.2		0.7
		(10.9)		(10.7)		(1.0)
Observations	242	242	242	242	242	242
600 M Boundary	All	All	Inside	Inside	Outside	Outside
Control Mean	92.11	92.11	88.26	88.26	3.85	3.85

Counts account for the fact that the grid was often too large to be fully covered by field officers, and instead only a randomly selected subset was surveyed. The mean and median portion surveyed were both two-thirds. Table 2 presents the equivalent for the number of poles at a site. All regressions include constituency FE. Standard errors shown in parentheses. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A5: 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

While there are small differences between funder type in the facility type associated with each transformer (Table A2) this does not drive heterogeneity in the impact of WB conditionality on construction delays when compared with AfDB sites.

Table A6: Impact of gradient and facility type on 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

Stringing was completed at WB sites on average 6.8 months later than at AfDB 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 completion. Table A19 displays the same for months to metering completion. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A7: Primary engineering and socioeconomic outcomes with funder–audit interaction

	WB Effect Estimate	Audit Treatment Estimate	Interaction Estimate	N
Outcome 1: Construction quality index	0.60***	-0.06	0.17	250
	(0.21)	(0.18)	(0.29)	
Outcome 2: Network size and configuration index	0.01	0.04	0.24	241
	(0.19)	(0.18)	(0.26)	
Outcome 3: Construction timing index	-0.90***	-0.29*	0.22	250
	(0.17)	(0.17)	(0.24)	
Outcome 4: Household installation quality index	0.05	0.23*	-0.21	944
	(0.12)	(0.12)	(0.17)	
Outcome 5: Household cost, experience, bribery index	0.13	0.11	-0.06	944
	(0.12)	(0.10)	(0.16)	
Outcome 6: Reliability and safety index	-0.11	-0.01	0.04	944
	(0.13)	(0.11)	(0.18)	
Outcome 7: Knowledge index	0.14	0.07	-0.07	944
	(0.10)	(0.10)	(0.14)	
Outcome 8: Electricity Usage index	0.12	0.28**	-0.17	944
	(0.13)	(0.13)	(0.17)	
Outcome 9: Household socioeconomic outcomes index	0.24*	0.20	-0.21	944
	(0.12)	(0.13)	(0.18)	
Outcome 10: Firm Performance Index	0.29	0.12	-0.23	373
	(0.19)	(0.17)	(0.28)	
Outcome 11: Political and Social Beliefs index	0.03	0.03	-0.02	944
	(0.08)	(0.09)	(0.12)	

Outcome variables are indices constructed from groups of variables standardized to have mean 0 and standard deviation 1. Each column presents results when the treatment variable is either: (1) WB funding source, or (2) the randomized audit treatment. In rows 1–3, observations are transformer sites; standard errors are shown in parentheses. For rows 4 through 8, observations are occupants of connected compounds. All regressions control for site land gradient and public facility type. Standard errors are clustered by transformer site and shown in parentheses. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A8: Construction quality

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 1: Construction quality index	0.00	0.60***	0.11	-0.06	250
	[1.00]	(0.21)	(0.21)	(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	0.73	0.06*	-0.00	-0.00	20282
	[0.44]	(0.03)	(0.03)	(0.03)	
Pole leaning at ≥85 degrees	0.97	0.01**	0.01*	0.00	20483
	[0.16]	(0.00)	(0.00)	(0.00)	
Line has ≥0.5m horiz clearance	0.93	-0.03***	0.01	-0.02*	19068
	[0.25]	(0.01)	(0.01)	(0.01)	
Pole has cap	0.28	0.33***	0.04	0.06	17377
	[0.45]	(0.04)	(0.05)	(0.04)	
Stay/strut properly installed	0.92	0.01	-0.01	0.01	3083
	[0.28]	(0.02)	(0.01)	(0.02)	
Stay/strut installed when required	0.78	0.17***	0.01	0.01	9482
	[0.41]	(0.04)	(0.02)	(0.04)	
Insulator properly installed	0.99	-0.03**	0.01	-0.01	2971
	[0.10]	(0.01)	(0.01)	(0.01)	
Insulator installed when required	0.98	0.01*	-0.01**	0.01	2996
	[0.13]	(0.01)	(0.01)	(0.01)	
Pole has grounding wire	0.34	0.03**	0.00	-0.03*	20483
	[0.47]	(0.01)	(0.01)	(0.01)	

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 5.1). For each pole-level outcome, the sample is limited to poles for which that outcome can be assessed. Standard errors are clustered by site. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A9: Network size and configuration

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 2: Network size and configuration index	-0.00	0.01	0.27	0.04	241
	[1.00]	(0.19)	(0.17)	(0.18)	
Deviation in Pole Count (relative to design)	69.90	1.59	7.06	3.02	194
	[63.48]	(12.55)	(12.10)	(12.71)	
Deviation in Drop Cables (relative to design)	38.98	3.25	-2.54	-3.44	176
	[25.93]	(6.88)	(7.91)	(5.35)	
Fraction of compounds at site, within 100m of LV line, electrified	0.89	-0.02	0.04	-0.01	241
	[0.13]	(0.02)	(0.03)	(0.02)	
Fraction of poles ≤600m from transformer	0.94	0.02	0.01	0.00	241
	[0.08]	(0.01)	(0.01)	(0.01)	

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 5.2). Pole data is collected in the engineering assessment survey (described in Section 5.1). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A10: Construction timing

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 3: Construction timing index	0.00	-0.90***	-0.07	-0.29*	250
	[1.00]	(0.17)	(0.16)	(0.17)	
LMCP construction start date (months since Jan 2015)	37.22	10.18***	1.66	4.00**	250
	[11.38]	(1.90)	(1.72)	(1.93)	
Pole erection completion date (months since Jan 2015)	45.20	9.90***	1.85	3.52	249
	[15.17]	(2.67)	(2.49)	(2.59)	
Stringing completion date (months since Jan 2015)	46.91	9.47***	1.33	2.70	247
	[15.48]	(2.76)	(2.52)	(2.56)	
Metering completion date (months since Jan 2015)	47.73	15.67***	-1.23	4.71*	226
	[14.56]	(2.48)	(2.17)	(2.65)	
months between construction start and pole erection complete	7.83	-0.06	0.18	-0.32	249
	[10.19]	(1.81)	(1.63)	(1.52)	
months between pole erection complete and stringing complete	1.90	-0.73	-0.48	-0.53	246
	[4.41]	(0.80)	(0.64)	(0.68)	
months between stringing complete and metering complete	0.95	6.25***	-2.01*	0.37	224
	[8.04]	(1.53)	(1.20)	(1.47)	

The construction timing 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 and collected via surveys with village representatives (described in section 5).$^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A11: Household installation quality

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(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 $\geq$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)	

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 readyboard question as it is the presence or absence of a readyboard is not strictly an indication of quality. All outcomes are measured at the household level and collected in the household and firm survey data (described in Section 5.2). 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 cost, experience, and bribery

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(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)	

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 5.2). 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: Household and firm reliability and safety

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(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 $\geq$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)	

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 5.2). 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 A14: Knowledge

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 7: Knowledge index	0.01	0.15	-0.03	0.08	930
	[0.99]	(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)	

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 5.2). $^{*} \leq 0.10$, $^{**} \leq .05$, $^{***} \leq .01$.

Table A15: Electricity Usage

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(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/	0.86	0.02	0.08**	0.11**	836
prepaid meter)	[0.35]	(0.05)	(0.03)	(0.05)	
Electricity spending past month (Ksh) (of hh	183.13	-9.93	-0.35	11.54	893
w/ meter) (w)	[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	4.66	0.63	1.50**	0.32	652
week	[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	1.13	0.01	0.01	0.03	944
connected	[0.67]	(0.04)	(0.04)	(0.06)	

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 5.2). $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A16: Household Socioeconomic Outcomes

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 9: Household socioeconomic outcomes	-0.02	0.24*	-0.01	0.20	944
index	[0.99]	(0.12)	(0.13)	(0.12)	
Connection allowed pursuing employment,	2.54	0.27*	0.33**	0.16	787
business (1-5) (of connected hh)	[1.19]	(0.15)	(0.14)	(0.15)	
Connection affected earnings (1-5) (of	3.25	0.15*	0.09	0.01	787
connected hh)	[0.78]	(0.09)	(0.09)	(0.09)	
Connection permitted changing hours worked	3.65	0.05	0.05	0.04	787
(1-5) (of connected hh)	[0.86]	(0.12)	(0.12)	(0.11)	
Connection affected amount of food consumed	3.10	0.14**	0.03	0.08	787
(1-5) (of connected hh)	[0.45]	(0.05)	(0.05)	(0.06)	
Connection affected health (1-5) (of	3.59	-0.08	0.08	-0.05	787
connected hh)	[0.86]	(0.11)	(0.10)	(0.11)	
Connection affected children's education	4.32	0.33***	-0.04	0.19*	691
(1-5) (of connected hh w/ children)	[0.85]	(0.09)	(0.08)	(0.10)	
Connection affected knowledge about news	4.15	0.14	0.01	0.10	787
(1-5) (of connected hh)	[0.97]	(0.10)	(0.09)	(0.10)	
Connection permited changing kerosene	1.51	-0.03	0.06	0.07	787
spending (1-5) (of connected hh)	[0.99]	(0.10)	(0.10)	(0.10)	
Connection changed phone charging freq. (1-5)	3.11	0.57***	-0.13	0.36**	787
(of connected hh)	[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	1.64	-0.04	0.01	0.14	747
compounds with hh)	[1.31]	(0.10)	(0.08)	(0.16)	

The household socioeconomic outcomes index (shown here in row 1) is a standardized average of subcomponents 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 5.2). 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 A17: Firm Performance

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(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)	

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 5.2). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A18: Household Political and Social Beliefs

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(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)	

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 5.2). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A19: Impact of gradient and facility type on 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

Metering was completed at WB sites on average 9.6 months later than at AfDB 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 completion. Table A6 displays the same for months to stringing completion. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A20: Costs vs benefits of different contracting approaches

	(1)	(2)	(3)	(4)	(5)
Annual discount rate	0.05	0.05	0.05	0.15	0.15
Quality difference	Larger	Larger	Smaller	Smaller	Smaller
Delay	8 months	18 months	18 months	18 months	18 months
Planner's time horizon	40 years	40 years	40 years	40 years	5 years
Timeliness benefits	1.6	3.4	3.4	10	10
Quality costs	15.7	15.7	6.2	3.2	2.1
AfDB procedures net benefit	-14.1	-12.3	-2.8	6.8	7.8

Smaller quality difference is assumed to be a 40-year vs 30-year difference in average lifespan of a pole. Larger quality difference is assumed to be a 40-year vs 20-year difference in average lifespan of a pole. The probability of pole failure is assumed to be constant in any given year, and expected future maintenance costs are discounted according to the annualized discount rate specified in row 1. Net benefit of AfDB is the estimated net benefit of AfDB procedures as compared to WB procedures.

C 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 2015b).[27] 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)[28] 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).

C.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 USD 150 connection fee, Kenya Power initially enrolled households into a payment plan consisting of 36 monthly installments of around USD 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 USD 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 Subsection 5.2) measures respondent understanding of the aggregate costs of an electricity connection under the LMCP. 58%

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

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

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 readyboards. 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).

C.2 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.[29] 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 readyboards 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.

C.3 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 USD 5 to USD 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).

C.4 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. In addition selection on the basis of bid amounts, bidders must satisfy certain requirements related to financial capacity, prior experience including with similarly sized jobs, and any record of sanctioning and litigation.

[29] Enumerators only counted unconnected compounds that were within connection distance of the existing electricity network, so this may be an underestimate. Subsection 5.1 provides more details on surveying methodology.

The winners of the 12 AfDB contracts had been selected from 110 bidders. Six of the 10 turn-key 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 2018b; 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).

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 2016b), and in many cases even before that (Business Daily 2007).

C.5 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.

C.6 Cost-benefit calculations

The cost-benefit calculations in Section 7 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 USD 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.

C.7 Resilience

Construction might affect resilience through two key engineering channels. First, voltage quality tends to worsen with distance from the central transformer.[30] 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 A21 shows no difference between funders in distance resilience.

Table A21: 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

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

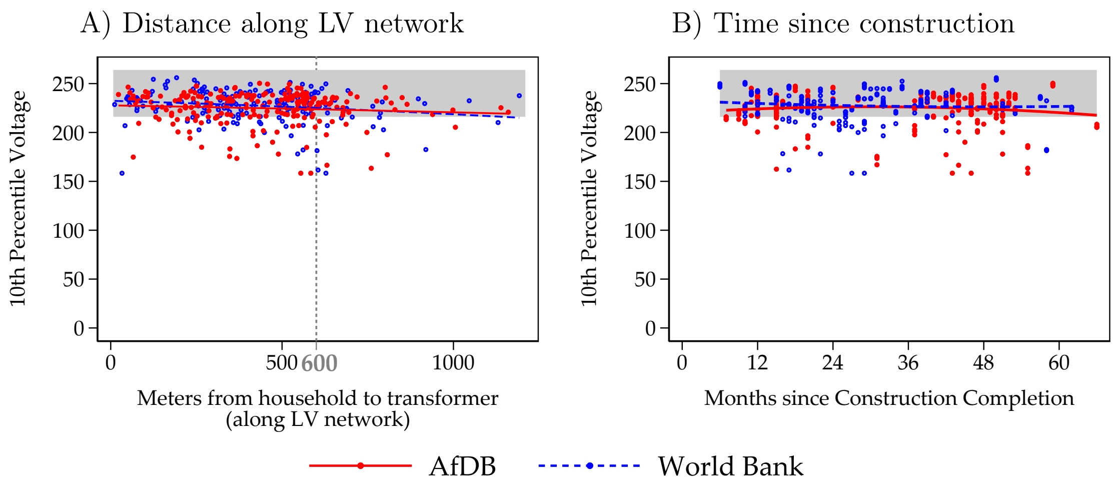
Panel A of Figure A1 explores the correlation between 10th percentage of voltage quality and distance to the transformer along the LV network.[31] There does not appear to be a significant or discontinuous decline after 600 meters, the eligibility cutoff for a subsidized LMCP household connection, suggesting greater returns to scale might have been achieved under a higher distance eligibility cutoff.

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 A1 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.

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

[31] 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.

Figure A1: Voltage quality resilience to distance and infrastructure aging



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.

D List of individuals engaged in qualitative informational interviews

Qualitative research included detailed in-person (or in 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 asterix (*) 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