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

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Abstract

There is limited causal evidence on the effects of different public procurement regulations on project quality and value-for-money for projects funded by national governments or foreign aid donors. This paper uses both policy and experimental variation to study how two key contracting features—namely, the bundling of contract components, and enhanced ex post monitoring—affect outcomes of a large economic development project. To implement Kenya's nationwide electrification program, the electric utility Kenya Power awarded and administered dozens of contracts with private contractors. We exploit an unusual program feature: different contracting procedures were often used across nearby villages, with Kenya Power awarding bundled contracts at African Development Bank (AfDB)-funded villages but unbundled contracts together with strengthened monitoring at World Bank (WB)-funded villages. To measure impacts, we collect on-the-ground engineering assessments, voltage and reliability data, household survey data on connection quality and usage, and analyze original contracts. The analysis suggests a stark trade-off: construction completion was delayed by 16 months on average at WB-funded sites relative to AfDB-funded sites but WB-funded sites saw a sizeable 0.6 standard deviation increase in construction quality. To disentangle the effects of contract bundling versus monitoring, we implement a randomized audits scheme. The audits improve household connectivity, network size, and voltage at AfDB-funded sites, but have no impact at WB-funded sites, suggesting monitoring and unbundling contracts may be substitutes. Given the apparent trade-off, we investigate how net benefits depend on policymaker time preferences and infrastructure longevity due to improved quality. Under plausible assumptions, WB processes could generate a net benefit ranging anywhere from +4% to -7% of total project value, indicating that neither procurement approach clearly dominates the other in this context.

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1 Introduction

Government agencies often rely on private firms to supply many goods and services: public procurement spending amounts to 12% of global GDP (Bosio et al. 2022). Procurement regulations can improve project outcomes but may also introduce bureaucratic inefficiencies or inhibit useful regulatory discretion (Williamson 1999; Hart et al. 1997; Bosio et al. 2022). Multilateral agencies face a similar procurement problem to governments: for instance, between 2000 and 2022 the World Bank financed more than 311,000 contracts with private sector contractors for the procurement of more than \$185 billion in works, goods, or services for more than 21,000 projects, many of them in infrastructure construction. Yet, writing 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," highlighting the importance of "contracts that bundle the design-and-build phase". And while a rich literature on foreign aid donors studies *policy* conditionality (Archibong et al. 2021; Andersen et al. 2022; Easterly 2002), much less is understood about the *procedural* conditions that recipient agencies face. These conditions are designed to strengthen and enforce institutional procurement processes, but as a result, "operations risk being overburdened with over-defined and intrusive step-by-step process conditions" (World Bank 2005). Causal inference in this area is hampered by the infrequency, endogeneity, politicization, and complexity of large infrastructure projects, as well as measurement challenges.

This paper uses natural policy variation and experimental variation to generate some of the first causally identified evidence on this topic. We do so in the context of the Last Mile Connectivity Project (LMCP), one of Kenya's largest public infrastructure projects at a cost of \$600 million. Kenya is a useful context in which to study public procurement as it is quite representative of low- and middle-income countries in terms of regulatory strictness, favoritism, corruption, and delays (Bosio et al. 2022).

For Phase I of the LMCP, the Government of Kenya selected 8,520 villages where all unconnected households within 600 meters of the existing grid would be connected. The program was implemented by Kenya Power—Kenya's majority government-owned electric utility. Kenya Power outsourced construction by independently running competitive auctions and subsequently awarding and administering dozens of contracts to private firms. All 8,520 LMCP villages were subject to identical eligibility, pricing, and network specifications, as was Kenya Power's eventual ownership and operation of the electricity network. However, two key features of the procurement procedures used by Kenya Power differed across the 3,200 sites funded by the World Bank (WB) and the 5,320 sites funded by the African Development Bank (AfDB). First, Kenya Power awarded 10 'bundled' contracts that included network designs, materials, and installation for villages funded by the AfDB. In contrast, Kenya Power awarded 29 specialized, heterogeneous (or 'unbundled') contracts for villages funded by the WB.[1] Second, Kenya Power conducted far more detailed ex post inspections of completed sites before handover to the utility. The impacts of these contract features were unclear

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

ex ante: based on in-person interviews we conducted, WB representatives argued at the time that they would improve construction outcomes, while Kenya Power representatives feared that they would lead to administrative costs and delays without adding substantive benefit.

In this paper's main contribution, we use both natural policy variation and experimental variation to identify the causal impacts of different procurement procedures on project outcomes, and organize the empirical analysis around a conceptual framework that highlights key mechanisms. First, we leverage a useful program feature: LMCP sites were assigned to be funded by either donor in a way that was arbitrary and can reasonably be thought of as quasi-random and without obvious regard to factors that would impact project outcomes. Neighboring villages were often funded by different donors: 95% of WB-funded sites in our sample are within 10 km (6 mi) of an AfDB-funded site. We conduct a battery of baseline balance tests using geographic, satellite, road, and census data to quantify any imbalance. WB- and AfDB-funded sites are balanced along most attributes and any selection appears uncorrelated with the outcomes of interest. Still, the econometric analyses include constituency fixed effects to account for local geographic or socioeconomic heterogeneity. Second, to disentangle contract bundling and monitoring we implemented a randomized auditing intervention (with the support of partners at the WB, the AfDB, and Kenya Power) designed to mimic Kenya Power's additional inspections at WB-funded sites. Through in-person meetings, contractors were informed that key aspects of the completed construction at a random subset of sites would be measured and reported back to the WB and AfDB.

An additional contribution of the paper is the collection of detailed and novel data on construction and electricity connection quality, building on a small but growing literature emphasizing the importance of detailed infrastructure measurement (Olken (2007) is an early example). We tracked construction progress over multiple years for 380 LMCP villages through in-person visits and phone calls to village leaders, and then collected three types of on-the-ground data. First, we measured construction quality for key infrastructure components such as electrical transformers, poles, and wires, following Kenya Power engineering standards. Second, we deployed state-of-the-art sensors to measure minute-by-minute site-level power outages and voltage quality. Third, we conducted socioeconomic surveys to understand connection experiences and energy usage among a representative household sample. We complement these data with the original Kenya Power procurement contracts and inspection reports. Finally, over the course of six years we conducted dozens of in-depth conversations with officials at Kenya Power, WB, AfDB, and private contractors to gain a deeper understanding about each funder's contracting, construction, and monitoring procedures.

The econometric analysis indicates that contracting procedures are highly consequential for project outcomes in terms of both costs and benefits. First, in terms of costs, construction at WB-funded sites is far slower and leads to fewer pole installations and household connections. By the end of tracking in May 2022, 70% of AfDB-funded sites had seen construction whereas only 62% of WB-funded sites had. Among sites where there had been construction, there are 12% fewer poles and 18% fewer customer connections per site at surveyed WB-funded sites, and household meter activation at WB-funded sites is completed on average 16 months later than at AfDB-funded sites. Second, in terms of benefits, the WB procedures improve on-the-ground construction quality by 0.6 standard deviations on average, and 77% of WB-funded sites have higher measured quality construction than the median AfDB site. Specifically, poles at WB-funded sites are 23% more likely to have all key attributes of a high quality pole: a pole cap, no crack, and a correctly installed strut and stay (when required). These improvements in construction quality are likely to have meaningful implications for pole longevity and long-term maintenance costs. There are no measured medium-run differences in electricity reliability and voltage quality, though, and the impacts of WB procedures on other outcomes such as household installation quality, cost, and energy usage are positive but modest in size and generally not statistically significant.

To disentangle the impact of inspections from the unbundled contracting, we turn to the randomized audit experiment. The data indicate the audits have no impact at WB-funded sites, in line with the fact that those sites already faced additional inspections as well as further constraints under the unbundled contracting approach. On the other hand, the audits cause significant improvements in construction quality at AfDB-funded sites. Contractors installed 18% more poles (and 4% more customer connections, though this is not significant), and households at these sites experience higher power quality: the audit treatment halves the average gap between experienced and nominal voltage. Treatment households further report higher household connectivity and energy usage. Importantly, the audits increase the number of connections while being relatively inexpensive to administer and incurring shorter delays than unbundled contracts. This suggests that additional monitoring can be an effective, low-cost way to increase quality for projects carried out using bundled contracts.

Finally, we compare the various procurement approaches' relative costs and benefits. The average cost per new household connection is \$563 at AfDB-funded sites and \$728 at WB-funded sites (approximately 30% higher), driven both by lower per-site costs and more new connections at AfDB-funded sites. The net impact of delayed construction and improved longevity depends on the foregone household benefit, the funder's discount rate and time horizon, and the impact of improved construction quality on longevity and long term maintenance plus replacement costs: engineering sources suggest the observed construction quality gains could extend equipment life by multiple years. Under a plausible range of assumptions, the net benefit could range anywhere from a net benefit at AfDB-funded sites worth 7% of project costs to a net benefit at WB-funded sites worth 4% of project costs. More speculatively, an alternative procurement procedure that combines contract bundling with enhanced ex post audits could reduce delays while achieving meaningful improvements in quality, and might therefore be preferred to both the real-world approaches (at least at the level of government institutional capacity in the Kenyan study context).

The empirical results point to a stark intertemporal trade-off. Policymakers may need to jointly evaluate the short-term administrative costs (in terms of added delays) and the long-term benefits (in terms of a more resilient grid) of a procurement approach featuring unbundled contracts and enhanced inspections. Those with a higher time discount rate or a shorter time horizon, or those implementing projects with compounding benefits, might prefer the timelier construction enabled by a streamlined bundled approach. Conversely, in situations where maintenance costs are expected to rise quickly with poor quality, a delayed start might be worth the improved long-term outcomes. This perspective can also explain why some political agents, facing electoral or other short-term domestic pressures, may prefer to match with donors whose procurement approach allows them to act with greater expediency.

Any relatively short- to medium-run analysis, like ours, has limitations. Procurement procedures may generate additional positive benefits over time that we cannot measure, such as strengthened government institutional capacity. Like most other research projects, we are also unable to directly measure leakage of funds across the projects supported by different donors, and this may have been an important concern. However, to the extent that increased leakage in AfDB projects (with their streamlined contracting and monitoring) would have reduced the quantity of completed construction, we find limited evidence of this—in fact, AfDB supported sites appear if anything to construct more completed connections at lower average cost than equivalent WB projects.

The broader scholarly debate about donor conditionality dates back at least to the 'Washington Consensus' era in the 1980s (Mosley 1987; Hermes and Lensink 2001; Easterly 2002; Williamson 2009; Temple 2010; Archibong et al. 2021, among many others). World Bank (2005) provides a thorough review of the evolution of donor conditions, which increasingly emphasize procedures and processes (rather than policy change), "promoting good governance, in the hope that more accountable, transparent, responsive, representative, and democratic government institutions will produce better actions, policies, and outcomes," with the resulting costs and benefits subject to significant debate. Recent research suggests procedural conditionality can cause politically motivated delays and incur costs that may exceed any benefits (Kersting and Kilby 2016; Kilby 2013). And concerns around political interference and corruption remain relevant (even if we cannot directly evaluate them in our setting): Andersen et al. (2022) find that up to 10% of WB financing is transferred to offshore financial havens in the months after a transfer. Related work that empirically evaluates on-the-ground construction of development projects in Africa includes Williams (2017), Marx (2018), Rasul and Rogger (2018), and Moscona (2020).

The Chinese government has stated that its approach when lending to low- and middle-income countries (LMICs) is one of non-interference in local policy-making and politics (State Council 2011), and highly streamlined procurement procedures. Its expediency may be preferred by politicians operating under short time horizons, but the limited oversight has generated concerns about both the quality of construction and rampant corruption (The Economist, 2017; Mihalyi et al. 2022; Dreher et al. 2021; Isaksson and Kotsadam 2018; Ping et al. 2022; Malik et al. 2021; The Africa Report, 2022). (While Chinese actors have made significant investments in Kenya's electricity sector, to the best of our knowledge they have not contributed to the LMCP per se.)

Mass government electrification programs are widespread in LMICs, especially in Sub-Saharan Africa. Poor construction quality can harm power quality: Blimpo and Cosgrove-Davies (2019) find that in some countries, most connected households "reported receiving electricity less than 50% of the time," potentially undermining the economic activity that household connections were designed to stimulate. Lee et al. (2020) find that transformer outages in rural Kenya frequently last more than four months, which may contribute to the low uptake and limited impacts of household electricity that they and Kassem et al. (2022) find. In India, Burlig and Preonas (2023) 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 reduces the economic benefits of electrification, identifying opportunities to improve construction quality—including through specific procurement contracting conditions—may lead to meaningful improvements in economic outcomes.

2 Framework for contract bundling and oversight

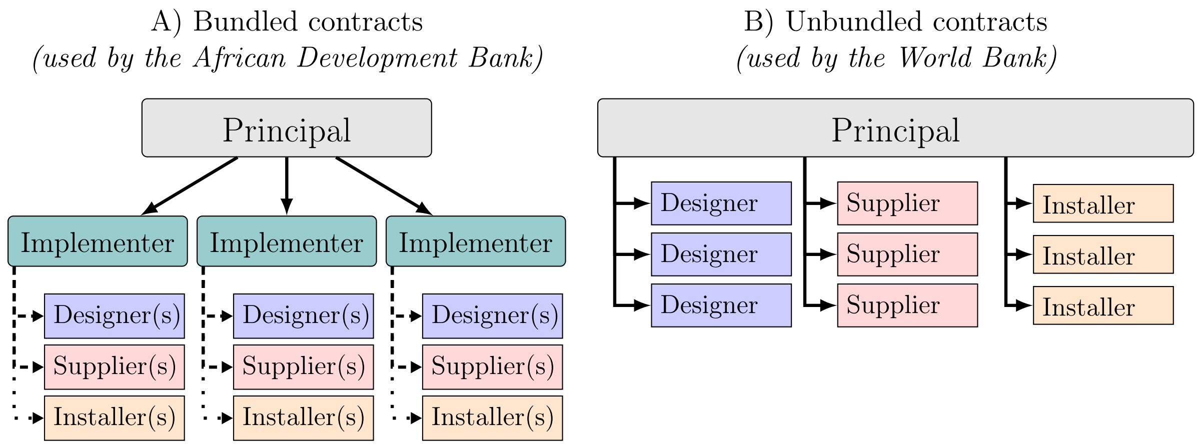
An extensive literature in contract theory studies the public procurement of goods and services (Hart et al. 1997; Bosio et al. 2022; Tadelis 2012; Levin and Tadelis 2010; Williamson 1999). However, relatively few papers have empirically studied the impacts of different procurement procedures or structures. One such structure is the bundling of components, such as in 'design-and-build' contracts. A rich theoretical literature has studied bundling problems, particularly in the context of the seller's problem (Daskalakis et al. 2017; Manelli and Vincent 2006; Rochet and Stole 2003), but empirical evidence from procurement auctions for major public infrastructure projects is scant, despite the ubiquity of these contract design issues. For instance, Makovšek and Bridge (2021) state 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." Few studies causally estimate the impact of bundling contracts (Hoppe et al. (2013)'s experiment among 400 university students is one exception). We contribute to this literature by empirically studying the bundling of the design, supply, and installation components of a major real-world infrastructure project in a high-stakes public procurement context using natural and experimental variation and granular, independently-collected construction quality data.

2.1 Contracting structure

To fix ideas, consider a principal (such as a government agency) who has a project consisting of separate components (such as design, specific supplies, or installation) which they want completed through contracts indexed i awarded to private firms indexed f, each endowed with quality γ_f. The principal tolerates a maximum fraction $\bar{p}$ of infrastructure with errors for a contractor to still be paid, set exogenously by a regulatory body. Infrastructure errors increase future annual maintenance (repair or replacement) costs $M(p_i)$.

The principal has two tools to disincentivize errors. The first is to create distinct contract types. Figure 1 shows two examples. 'Bundling' is the case with one contract type that includes all components (Panel A). Contractors are responsible for all components and either acquire components in-house or procure them through subcontracts. 'Unbundling' is the case where each contract contains one component (Panel B). To simplify the model, we assume there are two components—say, materials and implementation—which must be completed sequentially, and the contractor may choose to either award these as one bundled contract ($T = 1$) or as two unbundled contracts ($T = 2$).

Figure 1: Bundled and unbundled contracting structures



Schematic of the two types of contracting methods used for the Last Mile Connectivity Project (LMCP). In the bundled method (Panel A), the principal contracts with firms that implement components. In the unbundled method (Panel B), the principal procures components directly. Solid lines represent contracts issued by the principal. Dashed lines represent subcontracts issued by an implementer. Dotted lines represent implementer in-house activities. In our study setting, the principal (Kenya Power) used a bundled structure at African Development Bank sites (awarding 10 bundled contracts) and an unbundled structure at World Bank sites (awarding 35 heterogeneous contracts).

When $T = 2$, the principal can observe firm quality and limit eligibility to firms with $\gamma_f \geq \bar{\gamma}$ for each component (whereas when $T = 1$ it can not mandate the same for subcontractors), and can also heterogeneously mandate procedures for each component.

The second tool at the principal's disposal is to implement high or low ex post monitoring $m \in \{l, h\}$. The principal detects a fraction d_m of errors, with $d_l < d_h$, and only pays the contractor if $p_i d_m < \bar{p}$.

The implementation of heterogeneous contracts ($T = 2$) and high monitoring ($m = h$) increase administrative costs that delay project benefits B by a discount function $D(m, t) < 1$. The principal chooses T and m to maximize net benefits, weighing administrative delays against contract costs C_i and long-term maintenance costs:

$$NB = D_t(m,t)B - \sum_{t=1}^{t} C_t(m,t) - \sum_{y=1}^{Y} \delta^y M(p_i)$$

The realized error rate $p_i(e_i, \gamma_f)$ is determined by exogenous firm quality γ_f and endogenous firm effort e_i. Increased quality and effort reduce the error rate but increase contract costs.

2.2 Simplified auction game

The principal and the firms engage in a competitive auction, alternating actions as follows.

(P1) The principal chooses and announces two key auction parameters: the number of contract types $T \in \{1, 2\}$ and monitoring level $m \in \{l, h\}$. When $T = 2$, the principal not only faces time-consuming coordination across contractors, but the contracts must also be auctioned and implemented sequentially.

Empirical implication 1: Unbundling and monitoring incur delays:

$$\frac{\partial D(m,t)}{\partial T} > 0$$

(A1) Each firm decides whether or not to bid. If they choose to bid, they choose a bid amount.

(P2) The principal selects the cheapest bidder. However, limiting eligibility to $\gamma_f \geq \bar{\gamma}$ (when $T = 2$) decreases the number of eligible bids and thus increases the lowest bid in expectation.

Empirical implication 2: Unbundling increases aggregate cost $C = \sum_{t=1}^{t} C_t$:

$$\frac{\partial C}{\partial T} > 0$$

(A2) The bidder provides the good, realizing error rate p_i. If $T = 2$ the firm follows the mandated procedures, lowering the expected error rate.

Empirical implication 3: Unbundling lowers the error rate by mandating component-specific procedures:

$$\frac{\partial p_i}{\partial T} < 0$$

If $m = h$ the bidder will increase effort to decrease p_i, since $Pr(p_i d_l < \bar{p}) > Pr(p_i d_h < \bar{p})$.

Empirical implication 4: Strengthened monitoring lowers the error rate:

$$\frac{\partial p_i}{\partial m} < 0$$

(P3) The principal conducts monitoring to estimate the error rate. Setting $T = 2$ increases firm quality of the winning bid through eligibility standards, increasing $Pr(p_i d_m < \bar{p}|e_f)$ and thus reducing the impact of higher monitoring on meeting the error threshold.

Empirical implication 5: Monitoring and unbundling are substitutes:

$$\frac{\partial^2 p_i}{\partial m \partial T} > 0$$

(P4) The principal maintains the grid, incurring maintenance costs $\sum_{y=1}^{Y} \delta^y M(p_i)$ and realizing NB.

Empirical implication 6: Since discount rates and time horizons only enter the net benefit function through principals' valuation of maintenance costs, those with lower discount rates or higher time horizons will prefer unbundling and higher monitoring:

$$\frac{\partial T}{\partial \delta} < 0, \frac{\partial m}{\partial \delta} < 0, \frac{\partial T}{\partial Y} > 0, \frac{\partial m}{\partial Y} > 0$$

3 Background

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 achieve universal access by 2020, starting from 25% in 2009 (KNBS 2009). While these ambitious goals were not met, LMCP did lead to rapid progress and nationwide household electricity access was reported to have reached 70% in 2019 (KNBS 2019).

The LMCP was to be financed initially through loans from the AfDB and the WB, as well as supplemental funding from the Government of Kenya (GoK), and later support from the European Investment Bank, the Agence Française de Développement, and the European Union (Kenya Power 2016a). This paper focuses on the LMCP activities funded by the WB and by Phase I of the AfDB, which we refer to jointly as Phase I of the LMCP.

Construction was to be outsourced to private sector contractors: the WB financed $133 million in procurement contracts and the AfDB financed $154 million. Doing so is standard practice among international development banks; for instance, between 2000 and 2022 the WB financed more than 21,000 projects, including 2,315 projects related to energy or power (with 754 in Sub-Saharan Africa). Borrowers often contract out the procurement of works, goods, or services for each project to private sector contractors: the WB financed more than 311,000 procurement contracts during this period (with 100,000 in Sub-Saharan Africa). Extensive WB regulations detail the procurement, financial management, and disbursal of these funds, though certain procedures are allowed to vary across time, sectors and countries depending on circumstances:

> "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)

Over the past two decades, international donors have increased their efforts to moderate the cost of complying with these regulations by streamlining and harmonizing their policies. WB and AfDB regulations now have significant overlap (WB 2014).

One of the central goals of these procurement regulations is to curtail corruption and political abuse. In Kenya, for instance, there was widespread concern that political interference and corruption within Kenya Power could jeopardize LMCP project outcomes (The Star 2018; Kenya Power 2018b, 2020; ESI Africa 2020; Wolfram et al. 2022; Lee et al. 2020).[2] While funds leakage is notoriously hard to measure, and we are unable to identify specific instances of stolen or diverted funds in this paper, it remains an important concern that may have motivated the donors' different contracting decisions.

[2] 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 [$8 million]" (The Nation 2021).

3.1 Kenya Power auction and procurement procedures

While the LMCP was financed through multiple channels, it was a single nationwide project implemented by Kenya Power under a uniform set of specifications. There are around 60,000 electrical transformers across Kenya, which convert high- and medium voltage power lines to low voltage (LV) lines that can be connected to households. In rural areas, transformers are often located in villages where very few households were connected at the start of LMCP (Lee et al. 2016). Kenya Power and members of parliament selected 8,520 such transformers for the LMCP, targeting an equitable regional distribution across Kenya. The objective was to connect all unconnected households located within 600 meters of an LMCP transformer by extending the local LV network; at most LMCP sites, between 20 and 100 unconnected households were eligible. Connecting all unconnected households in a village at the same time—referred to as 'maximization'—was supposed to generate cost efficiencies by leveraging economies of scale. Eligible households benefited from a reduced electricity connection price, from the previous \$350 down to \$150, as well as from the ability to pay it off in monthly installments, with no upfront down-payment (Subsection 3.5 discusses this further). The program was also touted as reducing the red tape associated with new electricity connections by eliminating the laborious application process. Instead, Kenya Power contractors would proactively visit households to initiate the connection process, with minimal effort for households. Appendix C provides additional background information.

Kenya Power administered numerous competitive auctions with domestic and international private-sector firms to award contracts for the implementation of construction activities. Uniform tender documentation contained detailed technical specifications for the procurement and installation of poles, wires, conductors, fuses, and meters, harmonized across donors to simplify compliance. Requests for proposals were released widely through standard channels: many contractors routinely bid on contracts financed by different donors.

Importantly for this paper's empirical approach, the AfDB financed the maximization of 5,320 of the LMCP transformers and the WB financed the maximization of 3,200 (Kenya Power 2017, 2016a).[3] LMCP transformers were assigned to be funded by either the WB or the AfDB in a seemingly arbitrary and ad hoc manner, with neighboring villages often being funded by different donors; Section 4 discusses this assignment process in detail. While the technical environment established by Kenya Power was identical across contracts, and AfDB and WB procurement procedures were identical along most dimensions, there were two key differences between the donors: the degree of contract bundling, and the extent of monitoring. The next two sub-sections discuss these differences in turn.

WB and AfDB can both debar contractors with egregiously poor performance, and debarment generally applies globally: under-performance can lead to disqualification from contracts in other countries, and by other donors in different sectors. Independent audits can therefore be a meaningful business threat for contractors, which we exploit in the randomized audits treatment, discussed in Subsection 4.2.

[3] The WB funded new transformers at 1,000 additional sites. Those projects are excluded from this paper.

Separately from the contracts discussed below, Kenya Power awarded five separate contracts with external consultants to oversee construction and manage relationships with all contractors, and three nationwide contracts for customer electricity meters to facilitate integration with its existing operational systems.

3.2 Contract bundling

For sites funded by the AfDB, Kenya Power used 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 of the ten turn-key contracts comprised the entire construction process of all LMCP transformers in one of ten pre-defined geographical clusters of counties. This process included designing an efficient extension of the LV network to reach unconnected households, procuring the necessary materials, and final installation of these materials. Together with a metering contract and a consulting contract, Kenya Power awarded 12 contracts in all funded by the AfDB.

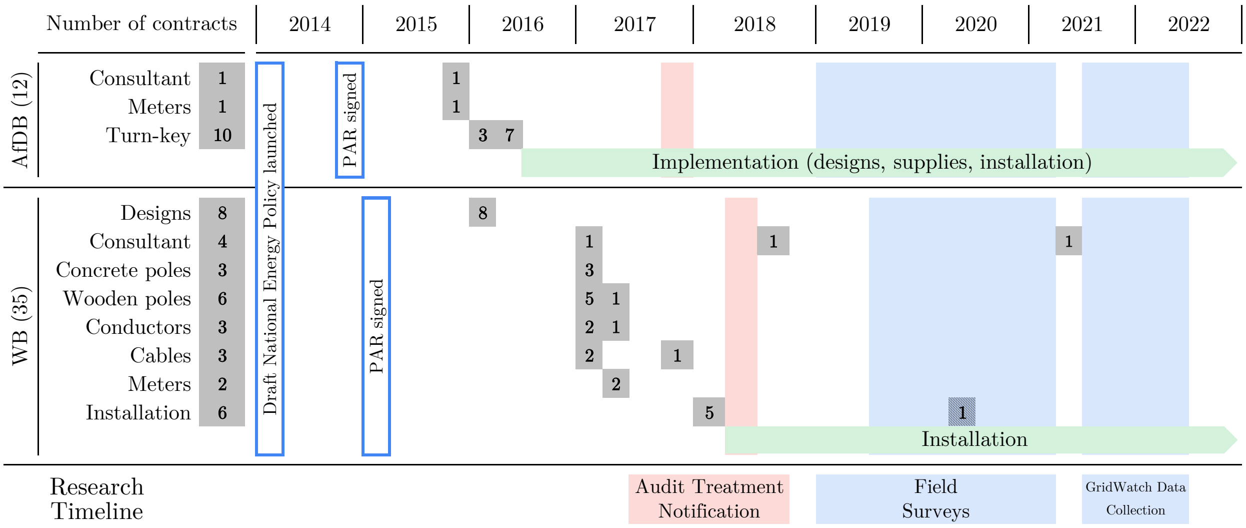
On the other hand, Kenya Power used an unbundled contracting approach for LMCP sites funded by the WB. Eight contracts were first issued for designs detailing the proposed LV network extensions across eight sets of sites. Kenya Power then issued 15 separate contracts to procure materials: six for wooden poles, three for concrete poles, three for conductors, and three for cables. Finally, they issued six different contracts for installation at all LMCP sites located in one of six geographic clusters of counties. Kenya Power also included two metering contracts and four consulting contracts, for a total of 35 contracts funded by the WB.[4]

These procurement structures are not fixed by donor, and may depend on project circumstances. The AfDB and WB decisions to use bundled and unbundled contracting, respectively, for the LMCP were made independently ex ante, informed by extensive discussions with Kenya Power and by the donors' previous experiences in Kenya. In other sectors and countries, the WB may require bundled contracting, and vice versa for the AfDB. 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]". 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 presents a timeline of these activities. The Draft National Energy Policy (2014) outlines the GoK goal to "increase rural electrification connectivity to at least 40% by 2016 and 100% by 2020," adding that they would "seek funding from development partners." According to the WB and AfDB Project Appraisal Reports (PARs), signed October 2014 and March 2015, respectively, contract signing was to take place early 2016 (AfDB 2014; WB 2015). By mid-2016, Kenya Power

[4] There was one contract for meters and one for metering accessories (e.g. boxes, circuit breakers), both with the same company.

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



Timeline of contracting and research activities. The Draft National Energy Policy (2014) spurred government discussions with the African Development Bank (AfDB) and the World Bank (WB). The WB and AfDB signed Project Appraisal Reports (PARs) in October 2014 and March 2015, respectively, signalling the official project launches. AfDB sites that had been completed prior to the audit treatment notification in late 2017 were excluded from the RCT sample. Surveys were conducted after construction completion. The date of one consulting contract is unknown.

had signed all 12 AfDB contracts (Kenya Power 2015a). WB design contracts were signed by March 2016, but WB contracting proceeded more slowly after this: materials and installation contracts were only signed starting February and November 2017, respectively. Both appraisal documents indicate expected project end dates at the end of 2019.

3.3 Monitoring and oversight

In the context of the LMCP, oversight can be split into four channels (listed out below). While WB and AfDB procedures were largely similar across the first three channels, WB's procedures were more onerous than the AfDB for the fourth.

In terms of largely comparable channels, first, each donor required similar materials inspections. A team representing Kenya Power (including members from its LMCP management team, supply chain department, and operations & management department) would visit the contractors' factories to inspect materials. One difference here was that the WB required that each pole be physically marked such that they could be easily verified upon arrival at Kenya Power storage facilities. Still, WB and AfDB spot checks at these facilities both approved more than 99% of procured poles.

Second, each funder engaged in direct monitoring of contractor activities. 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 one or two days of site visits in nearby regions. The information collected in each mission was recorded in a Supervision Mission Report, which was generally similar for the two donors.

Third, to ensure compliance with Kenya Power technical requirements, the AfDB and WB both required 'no objection' approvals at key stages. Interviews with staff suggest that the WB's checks were somewhat more onerous than those of the AfDB, but that the AfDB checks sought to achieve the same compliance goals.

Fourth, each donor required a consultant to coordinate, monitor, and supervise all contractors. Once construction at a 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 construction was complete and that the site could be handed over to Kenya Power for activation. However, WB and AfDB inspection procedures contained one notable difference. Prior to the joint inspection that would produce the JMC, the consultant managing WB-funded sites conducted an additional on-site inspection with the contractor (but without a Kenya Power representative) to produce an "Inspection Report" (IR), listing any observed construction errors or oversights.[5] IRs were almost always conducted ahead of the JMC, allowing the contractor to fix remaining issues before the JMC visit.

3.4 Contractor and subcontractor selection

Kenya Power awarded 10 bundled contracts to eight unique contractors, with two contractors winning two turn-key contracts each. It awarded unbundled contracts to 31 unique contractors, with four contractors winning two contracts each. Other than a harmonized metering contractor, there was no overlap between the bundled and unbundled contractors.[6]

As is common under bundled contracting, turn-key contractors often procured designs, materials, and installation from subcontractors. There was partial overlap between the contractors awarded goods contracts for WB-funded sites, and the subcontractors from which turn-key contractors procured goods or services (as described in more detail in Section 8). While this overlap in contractors could have affected the timing or quality of procured supplies, this does not appear to have been a meaningful issue in practice.[7]

Donor practices may also affect contractor self-selection. Firms with certain characteristics may be more likely to bid on contracts financed by a specific donor, depending on the nature of the procurement process. Speculatively, projects with more stringent requirements could attract firms with more efficient operations, or better compliance teams. This can be viewed as a mechanism through which procurement regulations could affect project outcomes rather than necessarily as a threat to econometric identification.

[5]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.

[6]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.

[7]For instance, one could conjecture that there could be problems supplying high-quality poles for WB-funded sites if all the good poles were already allocated to the initial AfDB-funded contracts, which were issued sooner. However, securing these supplies does not appear to have been a source of delay (based on conversations with Kenya Power staff), and in the case of poles in particular, as shown below the WB-funded sites tend to have higher quality poles.

3.5 Household investments

To use electricity, a household also needs to make investments in the home, in particular, the wiring needed for power sockets or light switches. The household surveys we administered indicate that households who were connected prior to the LMCP spent an average of $125 on such internal wiring. During the initial months of the LMCP roll-out, households were responsible for installing (typically by hiring a handyman, in practice) internal wiring between the electricity meter and their appliances. For many households, this posed a significant financial and logistical barrier, given the scarcity of electricians in rural areas. To address this, Kenya Power decided to provide low-income households who could not afford internal wiring with a 'ready board', a standard electrical panel that would satisfy basic wiring requirements. Yet the roll-out of ready boards was not perfect. Of the 160 households we surveyed who were physically connected to the grid but where electricity had never actually flowed, 45% said it was because they had not yet completed their internal wiring.

Note that while informal or illegal electricity connections are common in urban Kenya, they are rare in the low-population density rural areas where the LMCP was implemented (see Appendix C).

4 Research Design

The nationwide distribution of LMCP sites is presented in Panel A of Figure 3. We exploit the quasi-random assignment of sites to WB or AfDB funding to estimate the causal impact of donor procurement structure on project outcomes. To examine how monitoring affects project outcomes, we then implement a randomized audits scheme. We discuss these in turn.

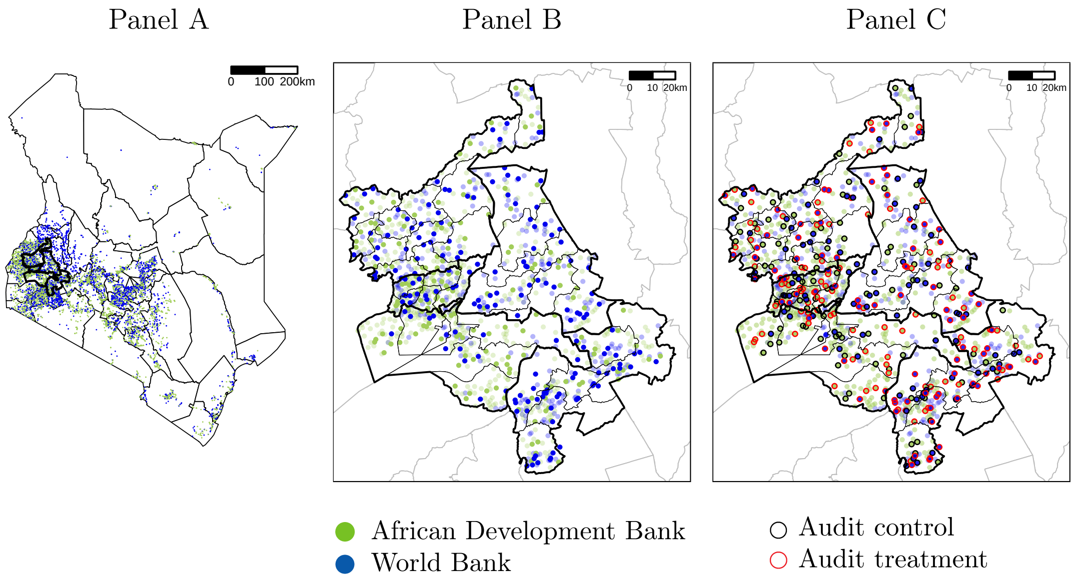
4.1 Quasi-random assignment of sites to aid donors

Each LMCP transformer was assigned to be financed by either the WB or the AfDB. To avoid the appearance of political bias, each funder sought to fund sites nationwide. Of Kenya's 290 constituencies, 265 contain at least one LMCP site and 210 at least one AfDB and one WB site.[8]

From June 2016 through July 2022, members of the research team met extensively with key Kenya Power personnel, including the General Manager for Connectivity, responsible for all of Kenya Power's activities connecting new households to power, and the two Project Managers who oversaw the nationwide construction of the LMCP. We were allowed to read correspondence between Kenya Power and dozens of members of parliament deciding which transformers each phase of the LMCP would include. Overall, we consistently observed that the assignment process among the donors appeared to be ad hoc and did not follow any particular allocation rule. Given that the overall mandate was identical—to connect all households within 600 meters of a transformer—regardless of which donor funded a site, Kenya Power and the GoK did not appear to see any strategic benefit in having a particular transformer funded by one donor or the other. Of course, this perspective was based on interviews and anecdotal evidence, but the same pattern emerges

[8] A constituency is a relatively small geographic unit with average population of approx. 185,000.

Figure 3: Sites by funding source and audit treatment status



Panel A maps sites selected for the Last Mile Connectivity Project nationwide, with the five counties where we conduct engineering and socioeconomic surveys—Kakamega, Kericho, Kisumu, Nandi, and Vihiga—marked in bold. Panel B enlarges these five counties and adds within-county constituency boundaries. There appears to be no spatial clustering by donor. Dark (light) sites are (not) included in our sample. Panel C shows audit treatment and control sites circled in red and black respectively. Uncircled sites are not in the RCT sample. See Subsection 4.2 for detail.

using systematic data.

The causal identification strategy leverages this quasi-random allocation of each LMCP site to a funder. Of the 8,520 nationwide LMCP sites shown in Panel A of Figure 3, 1,099 are located in the five study counties where we collected detail on-the-ground assessments, magnified in Panel B. These counties—Kakamega, Kericho, Kisumu, Nandi, and Vihiga—comprise 36 constituencies, of which 35 have at least one WB site and at least one AfDB site: we therefore include constituency-level fixed effects in regressions to account for local differences. In line with explanations provided by the electric utility, there does not appear to be spatial clustering by donor. 95% of WB-funded sites in this sample are located within 10 km of an AfDB site (and vice versa).

The deliberate allocation of sites to WB or AfDB funding by Kenya Power employees—for example, to speed up construction or improve construction quality in some areas relative to others—would be a threat to the econometric identification strategy. While we have no evidence of this, possible reasons could include partisan influence, local economic growth expectations, or personal bias and favor. We conduct numerous balance tests to quantify any underlying differences between WB- and AfDB-funded sites. First, Table 1 tests for balance using three independent datasets. 80% of sites are between 13 and 58 kilometers in driving distance, or between 28 and 108 minutes drive time, from the nearest large town, and columns (1) and (2) show that the degree of remoteness is balanced across WB- and AfDB-funded sites. Columns (3) and (4) show that pre-LMCP nighttime radiance ("night lights") levels were statistically indistinguishable. WB- and AfDB-funded sites furthermore have indistinguishable nighttime radiance trends prior to the LMCP (see Figure A1). Table 2 tests

Table 1: Geographic balance of World Bank- and African Development Bank-funded sites

	Road Distance		VIIRS Radiance		Land Gradient	
	(1)	(2)	(3)	(4)	(5)	(6)
World Bank (=1)	-0.23	-1.25	-0.01	-0.03	0.99***	0.57**
	(2.29)	(1.38)	(0.06)	(0.06)	(0.31)	(0.24)
Observations	347	347	51214	51214	347	347
Month FE	No	No	No	Yes	No	No
Constituency FE	Yes	Yes	No	Yes	No	Yes
Control Mean	60.49	33.64	.41	.41	4.36	4.36
Outcome variable	Minutes	KM				

Columns (1) and (2) estimate distance in driving minutes and in kilometers, respectively, from each site to the nearest 'major town' (WRI 2007) as calculated by HERE (2022). Columns (3) and (4) estimate monthly average site-level nighttime radiance measured using VIIRS averaged across the 600 meter radius (Elvidge et al. 2017). Standard errors are clustered by site (Figure A1 shows the time series). Columns (5) and (6) estimate average site-level land gradient recorded using the 90-meter Shuttle Radar Topography Mission Global Digital Elevation Model. Month and constituency fixed effects included where indicated. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

for balance in socioeconomic characteristics measured before the LMCP announcement. The fraction of WB-funded sites in a ward is not correlated with the ward's socioeconomic characteristics relating to roof quality, electricity access, education, age, or consumption.

Despite these similarities, there are some modest observed differences between WB- and AfDB-funded sites. First, column (6) of Table 1 indicates that WB-funded sites have a 13% higher average land gradient (When including constituency fixed effects). Second, Table 2 suggests that there is a slight difference in the fraction of households with an electricity connection pre-program, though the magnitude is minor: a large shift of 25% in the proportion of local LMCP sites funded by the WB (rather than AfDB) is associated with an approximately 1.1 percentage point (= 4.49 x 0.25) higher baseline household electricity connection rate. Finally, most transformers had been connected as part of a push by Kenya's Rural Electrification Authority (REA) between 2005–2013 to electrify public facilities like schools, religious buildings and markets, and there appear to be some differences in the likelihood of transformers located near specific types of facilities to be assigned to one funder or the other (Table A1). The largest difference is that 23% of AfDB-funded sites versus 8% of WB-funded sites were located near a secondary school. Extensive robustness checks confirm that delays and construction quality are uncorrelated with land gradient and local facility type, and that the main results presented below are constant across the entire support of land gradient and facility type (Subsection 6.6). Still, where relevant, regressions below control for variables where there are some baseline differences across WB- and AfDB-funded sites (i.e. land gradient, facility type, and ward-level connectivity).

4.2 Randomized audits

We implemented a randomized audit treatment closely mirroring the WB's Inspection Reports (discussed in Subsection 3.3), to disentangle the impacts of bundling and inspections. After construction at a site was completed, enumerators hired by the research team visited each site to inspect crucial

Table 2: 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)
Population	563.90	170	22801.28
	(2194.68)		(6158.08)
Land Area (sq km)	16.94*	170	62.70
	(9.89)		(44.15)
Joint F-test	p-value = .05		

This table tests for correlations between the share of Last Mile Connectivity Project (LMCP) sites in a ward allocated to World Bank (WB) funding and baseline characteristics, at the ward level, among wards with at least 1 LMCP site. Row 1 shows population share aged 14 years or younger. Row 2 shows monthly consumption expenditures per capita in Kenya Shillings (Ksh). Rows 3 and 4 show percentage of individuals who completed primary and secondary school education, respectively. Rows 5 through 8 shows percentage of households with solar, electricity, a high quality wall, and a high quality roof, respectively. All regressions include constituency fixed effects. Data source: 2006 Household Budget Survey and 2009 Census data. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

details of the electricity network according to specifications developed in collaboration with retired Kenya Rural Electrification Authority electrical engineers. Of the 1,099 LMCP sites in the region, we randomly selected 380 sites for the randomized audits experiment, stratifying selection by constituency and funder to improve statistical power.[9] We randomly assigned 190 to treatment and 190 to control, again stratifying assignment by constituency and funder. Panel C of Figure 3 maps treatment and funder assignments.

The randomized audits were implemented in collaboration with the funders and Kenya Power, as follows. During in-person meetings set up for this purpose, senior Kenyan research personnel notified contractors that an independent, international team of engineers would audit specific sites once construction was complete. They provided a written notice to this effect, signed by senior management at Kenya Power, the WB, and the AfDB (Figure A3), and attached a list of sites in their contract region that would be audited. The letter also specified four technical aspects of construction that would be inspected: the distance between poles, line sag, the quality of connection between transformer and LV wiring, and power reliability.

[9]This follows the Pre-Analysis Plan submitted to the AEA RCT Registry, available here (Berkouwer et al. 2019).

Unbeknownst to the contractor, the list of sites that they were told would be audited was a randomly selected subset of the full set of sites where our research team conducted the endline engineering surveys, which we describe in more detail in Subsection 5.1. Given the random selection of sites communicated to the contractors, any difference in construction outcomes between the sites about which contractors were notified and the control sites can be attributed to contractors' response to the audits. The bottom panel of Figure 2 displays the timeline of audit treatment notification and the engineering field surveys.

In communications with WB officials (in both Washington D.C. and Nairobi), the WB indicated they would take contractor-level outcomes at both WB- and AfDB-funded sites 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 beyond this particular project. Many contractors depend on their ongoing relationships with international donors, which incentivizes high-quality performance in order to win future contracts. To remind contractors of this incentive, the notification letter emphasizes the issue of future contracts.

Audit treatment effect estimates could be biased downward if contractors believed (correctly) that control sites might also be audited. While the research team did not widely share its activities and plans, some contractors may have learned that audits were also taking place at sites not on the audit list they were provided. 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. Conversely, audit effects may be overestimated if contractors shifted construction effort from control sites to the audit treatment sites. However, such spillovers are likely to be small: on average, only 7.6% of all sites awarded to a contractor were randomly selected for audits.[10]

4.3 Treatment interactions

The interaction of experimental and natural policy variation allows us to empirically investigate some of the empirical implications discussed in Section 2. Comparing AfDB-funded sites in the audit control with AfDB-funded sites in the audit treatment allows us to directly estimate the effect of additional monitoring in a low m, low t baseline environment. Comparing WB-funded sites in the audit control with WB-funded sites in the audit treatment allows us to estimate the effect of enhanced monitoring in a high m, high t environment. We can thus test whether the impact of additional monitoring is heterogeneous. Finally, the effect of the WB's unbundled contract component can be recovered by subtracting the audit treatment effect among AfDB-funded sites from the overall WB versus AfDB difference. Figure 4 provides a schematic to illustrate the design. Section 6 discusses the estimation strategy used to leverage these two sources of variation to separately identify the impacts of increased monitoring m and of greater contract unbundling t.

[10]Note that treatment effect estimates do not vary meaningfully by whether a below- or above-median fraction of an individual contractor's sites were audited.

Figure 4: Project research design and conceptual mechanisms

		Monitoring (m)	
		Low	High
Contract type (t)	Bundled	AfDB + Audit Control	AfDB + Audit Treatment
	Unbundled	[Not observed in this project]	WB (Both Audit Groups)

Notes: Schematic relating both the natural policy variation (World Bank and African Development Bank) and the experimental variation (Audit Control and Audit Treatment) to the theoretical mechanisms of contract bundling (t) and monitoring (m).

5 Data

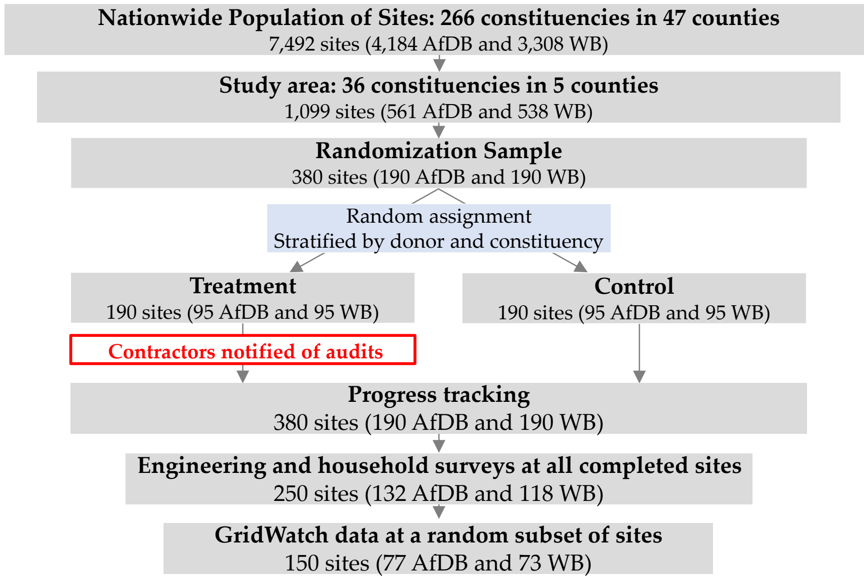
We used the utility's official nationwide list of LMCP locations to select sites for in-depth data collection, focusing on the five study counties listed above. In particular, we conduct detailed data collection at all 380 sites in the randomized audit sample. Enumerators employed by the research team conducted frequent short surveys with village representatives—over the phone or in person—at all 380 sites to track construction progress over time. This yields a site-level panel dataset of construction progress. Reassuringly, nighttime radiance increases noticeably in the 12 months after the completion of household electricity metering but not after the start of construction and stringing alone (Figure A2).

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. There are nearly equal numbers of sites funded by both donors: 47% of the surveyed sites are WB-funded sites and 53% AfDB-funded sites. Construction had not been completed—and usually not even begun—in the remaining 130 sites, limiting surveying activities there to the short progress assessments. We aimed to conduct the field surveys between six to twelve months after construction was reported to have begun at a site (although due to logistical constraints surveys were conducted a few months earlier or later in some cases). Figure 5 provides an overview of these study design elements.

5.1 Engineering assessments

The engineering surveys conducted at these 250 sites were developed in collaboration with recently retired Kenya Rural Electrification Authority engineers with expertise on the technical specifications of Kenya's electricity grid. Data collection consisted of two main parts. In the initial infrastructure census, enumerators recorded the locations of all poles in the low-voltage network, as well as their connectivity, up to 700 meters from the central transformer. Only households within 600 meters of the transformer were eligible for a free LMCP connection: the 700 meter radius allows us to test whether construction was completed beyond the eligible region, for example, if contractors did so

Figure 5: Project design



Sample selection and randomization, starting with the nationwide sample of African Development Bank (AfDB) and World Bank (WB) sites selected for the Last Mile Connectivity Project. We randomly select 380 sites out of the 1,099 sites located in the five study counties, stratifying selection on donor and constituency to improve statistical power, and then randomly assign each of the 380 sites to control or treatment, again stratifying by donor and constituency. Contractors were notified in 2017-2018 and assessments and surveys were carried out in 2018-2021. Engineering assessments and household surveys were completed at the 250 sites where meaningful construction had been carried out by the end of surveying activities in mid 2021. Additional tracking of construction progress at the remaining sites continued through mid 2022.

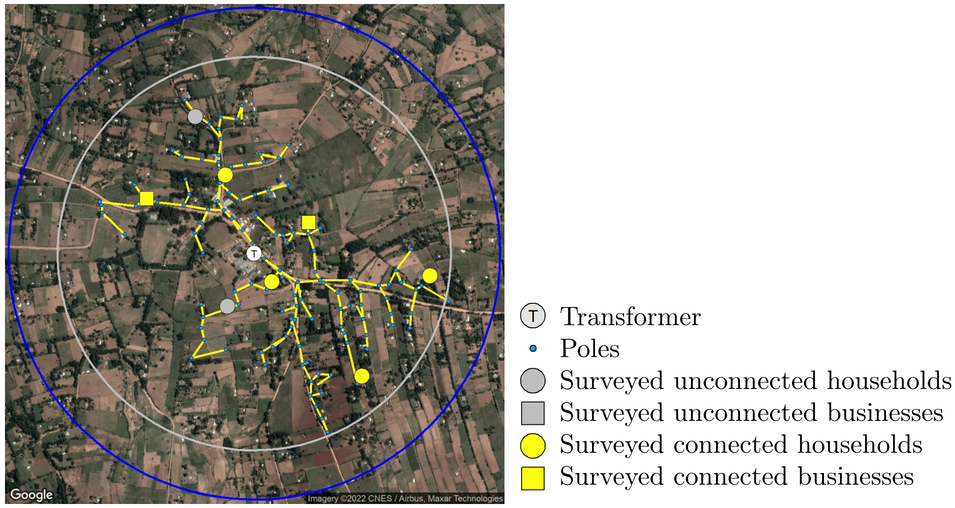
in exchange for informal side payments from households. Figure 6 displays network data recorded in this first part of the engineering assessment at an example site. Enumerators also recorded the number of drop-down cables (connections between an electricity pole and a customer) connected to each pole, whether drop-down cables connected to a household or a firm, and any unconnected compounds located near the pole. This provides a measure of the total numbers of connected and unconnected households and firms at each site.

If the LV network was too large for the data collection team to map in a single day, enumerators would select a random subset of pole branches to assess. At such sites, scaling measured quantities up proportionally by the inverse of the fraction of the grid that was surveyed yields an unbiased estimate of the total number of household connections at that site.[11]

In the second part of the engineering assessment, enumerators recorded characteristics of every pole and the conductors that connect them, focusing on the outcomes most likely to affect the quality and longevity of the grid. For instance, pole measurements included angle relative to the ground, whether it was wood or concrete, whether it was firmly placed in the ground, whether it had a pole cap, whether it had any visible cracks, and whether it had the appropriate grounding

[11]This can be seen for example in the bottom right site shown in Figure A4, 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 was to survey, in the time that was allocated for the site.

Figure 6: Infrastructure data collected (example site)



Construction data collected at an example site. Figure A4 presents additional examples of sites. The grey line denotes 600 meters and the blue line denotes 700 meters from the central transformer. The engineering surveys record the locations of poles (marked with blue dots), pole connection wires (marked with yellow lines), and infrastructure quality. At each site, between 4 to 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 preserve respondent anonymity.

wires, stay wires, and struts. For a random subset of poles, enumerators collected additional data on pole height, circumference at various points, and characteristics of each strut or stay supporting that pole.[12] Measurements of conductors included whether it had appropriate ground clearance and clearance from other objects (such as trees, brush, or structures) and whether any electric lines crossed. Measurements of drop-down cables included the distance between the pole and the customer's structure and whether the cable ended at a meter. Enumerators also noted whether it appeared to be an illegal connection, although this is very rare in the rural study setting (in contrast to some urban and peri-urban settings in Kenya and elsewhere). Finally, measurements of the central transformer at each site included whether the poles on which the transformer was mounted were leaning excessively, the number of missing or bypassed fuses, and whether the transformer had any other visible defects.

Overall project construction quality is mixed in the study sample. At least one fuse was missing or had been bypassed in around a quarter of transformers surveyed: this could reduce transformer longevity as it is exposed to events with excessively high current. We surveyed an average of 87 poles per site, of which about a quarter had a large crack, and 47% of poles were missing a cap. 95% of surveyed households were connected in 2016 or later, and the median year in which households

[12]The rate at which poles were sampled for more detailed measurements varied by the size of each site. At smaller sites, enumerators would conduct detailed measurements of every third or fourth pole, while at larger sites (of 120 or more poles) enumerators 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 team.

were connected was 2019 (Table A2 provides additional detail).

Of the 250 transformer sites surveyed, 26 were located within 1,200 meters of each other (Figure A5 shows an example). This raises two potential concerns. First, poles or respondents located within 600 meters of two different surveyed transformers might be double counted. The survey methodology is robust to this potential source of error: LV networks in this area are constructed using a radial structure where electricity flows unidirectionally away from the transformer. Since the survey team starts at the central transformer and then tracks LV wiring outward, they never survey the LV network emanating from a nearby transformer.[13] Second, if construction took place earlier at one transformer, then a neighboring transformer with later construction might require less expansion of the LV network to reach all remaining unconnected households located between them. We therefore conduct a set of robustness checks dropping the limited number of sites where this may be relevant (Subsection 6.6); the main results reported below do not change.

5.2 Household and firm survey data

After completing the infrastructure census, enumerators invited a random subset of connected and unconnected compounds and firms to complete a socioeconomic survey about the timelines and costs of construction, their own electricity connection quality and usage, their knowledge about future costs, experiences around safety and power reliability, and socioeconomic outcomes related to income and well-being. The survey also asked about manual labor: 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. 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 create inflated public perceptions of program progress. To disentangle this phenomenon from compound residents' genuine preference for having multiple electricity meters (for instance, if two separate households shared the residential structure), the survey asked not just how many meters were installed in the compound but also how many they had requested.

5.3 Power quality: outages and voltage

Improved construction quality could reduce local power outages and increase reliability, which could have tangible benefits for household well-being and firm performance. To measure reliability and voltage we deployed the GridWatch technology (Klugman et al. 2021; Klugman et al. 2019) in a subset of surveyed households and firms. GridWatch measures minute-by-minute power state and voltage and can be installed by plugging a PowerWatch device (Figure A6) 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 consolidates data to detect patterns in power outages and reduce noisy signals. We aggregate these high-frequency

[13] We confirm this manually by visually inspecting all the sites where two transformers are less than 1,200 apart, using field collected GPS locations of households and firms.

measurements up to an hourly measure of average voltage and a measure of hours of electricity per day. We collected these detailed power and voltage quality data across 150 sites for two months each, staggered between June 2021 and June 2022, deploying four PowerWatch devices per site at a time.[14]

6 Results

To estimate the impacts of different procurement procedures, and of bundling (t) and monitoring (m) in particular, we use the following regression specification:

$$y_i = \beta_0 + \beta_1 \mathrm{WB}_i + \beta_2 \mathrm{Treat}_i \cdot \mathrm{WB}_i + \beta_3 \mathrm{Treat}_i \cdot \mathrm{AfDB}_i + \mathbf{\Gamma} + \epsilon_i, \tag{1}$$

where WB_i and AfDB_i indicate whether site i is WB-funded or AfDB-funded. β_1 measures outcomes at WB sites relative to AfDB sites, among audit control sites. Treat_i indicates whether the site is an audit treatment site, such that β_2 and β_3 allow us to estimate the impact of enhanced monitoring (m) among WB sites and at AfDB sites, respectively, following Figure 4. Assuming additivity of effects, the pure impact of bundling (t) is captured by $\beta_3 - \beta_1$. $\mathbf{\Gamma}$ is a vector of fixed effects which vary across specifications. Standard errors are clustered by site in all regressions except those run at the site level.

Subsection 6.1 first documents patterns in construction delays. Subsection 6.2 then analyzes the quantity of construction. The next two subsections examine the quality of construction: Subsection 6.3 examines power outages and voltage quality, and Subsection 6.4 presents results that use the on-the-ground household and engineering assessments.

We identify three key patterns in the data that speak to the empirical implications of the model discussed in Section 2. First, construction completion delays are significant at WB sites, and are modest but still meaningful at audit treatment sites. Second, WB sites see a lower quantity but considerably higher quality of construction. Third, audit treatments improve both the quantity and quality of construction along some dimensions at AfDB sites but not at the WB sites.

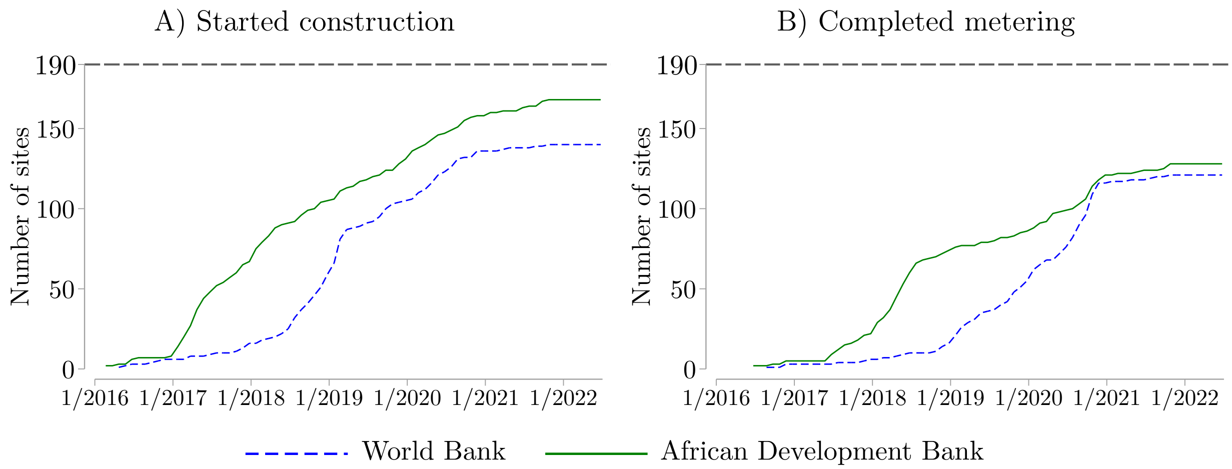
6.1 Construction timing and site completion

Of the 380 LMCP sites tracked by the survey team, 250 saw significant pole construction by the end of field surveying in May 2021. Construction varies significantly by funder: 70% of AfDB sites saw construction whereas only 62% of WB sites did, and this difference remains significant even when including constituency fixed effects. Sites with higher baseline nighttime radiance or with a higher land gradient (steeper sites) were also less likely to be completed (Table A3). While WB sites also have on average a higher land gradient (Table 1), all of the primary outcome regressions presented below control for land gradient.

Even conditional on completion, construction progress at WB sites lagged significantly behind

[14] The sample was reduced from 250 to 150 sites due to delays, logistical challenges, and cost increases associated with the COVID-19 pandemic.

Figure 7: Construction progress by funding source



Notes: Data for 190 African Development Bank sites and 190 World Bank sites located in the five study counties collected through phone surveys with village representatives. Appendix Figure A7 displays progress for pole installation and stringing.

AfDB sites. Figure 7 Panel A demonstrates that this lag is driven by the initial delay in starting construction, likely driven by the ex ante administrative burden involved with contract unbundling. Construction at WB sites started on average 10.2 months later than at AfDB sites (Table A7): in mid-2018, as construction at WB sites was just beginning, AfDB sites reached 50% metering completion.[15] However, once construction started, it proceeded more quickly at WB sites than at AfDB sites, possibly because by that time all designs had been completed and materials supplied. The delay in stringing completion is therefore slightly less, at 9.5 months. However, the delay is then again exacerbated at the final household metering stage, at which the average lag is 16 months. Recall that the AfDB teams did not always inspect whether meters were functioning prior to issuing a JMC (Subsection 3.3). The more stringent WB inspection reports, which happened between stringing completion and metering activation, may explain why the delays were exacerbated at this final stage. Finally, AfDB and WB sites all lagged significantly behind the initial envisioned contract timelines: for instance, final commissioning for all AfDB sites had originally been planned for June 2017.

There are delays caused by the audit treatment but they are substantially smaller than the average delay at WB sites: metering is completed on average 4.7 months later at audit treatment sites than at audit control sites. To isolate the impact of the WB's unbundling (t) directly, as distinct from its monitoring activities, we estimate the impact of WB contracting subtracting off the audit treatment component ($\beta_1 - \beta_3$). This analysis indicates that unbundling per se caused a delay of 11 months (p-$val < 0.001$; see Table A7). These results suggest that administrative delays from unbundling and on-the-ground delays caused by enhanced monitoring activity can both be substantial.

[15]The timeline in our study counties is thus in line with Kenya Power's own nationwide progress metrics, which reported that 49% of the AfDB household connections targeted had been achieved by mid-2018 (Kenya Power 2018a).

Table 3: Connections and poles installed per site

	Entire site				Outside 600 meter boundary			
	Poles		Connections		Poles		Connections	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
β_1: World Bank (=1)	-11.9**	-2.2	-12.8**	-19.3*	-2.2***	-1.1	-1.4***	-0.9
	(5.9)	(10.1)	(6.2)	(10.7)	(0.7)	(1.1)	(0.5)	(0.9)
Treatment (=1)	6.3		4.9		-0.0		-0.1	
	(5.8)		(6.1)		(0.6)		(0.5)	
β_2: Treatment (WB sites)		-3.3		6.8		-0.7		-0.6
		(8.5)		(9.0)		(0.9)		(0.7)
β_3: Treatment (AfDB sites)		16.3*		2.8		0.8		0.6
		(8.3)		(8.8)		(0.9)		(0.7)
Observations	250	250	250	250	244	244	244	244
Control Mean	92.26	92.26	72.25	72.25	3.65	3.65	2.85	2.85

Counts account for the fact that the grid was often too large to be fully covered by enumerators, and instead only a randomly selected subset was surveyed; note that we surveyed at least 50% of the entire LV network at 93% of sites. The mean and median portion surveyed were both two-thirds. $\beta_1, \beta_2, \beta_3$ are estimated as per Equation 1. All regressions include constituency fixed effects. Standard errors shown in parentheses. The sample size in columns 5–8 is slightly lower due to field logistical complications. We calculate the quantities of poles and connections at these sites using the engineering survey, but since we do not have their GPS coordinates, we exclude them from columns 5–8. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

6.2 Quantity of construction

Household metering had been completed at 71% of both AfDB and WB sites at the end of survey data collection in July 2022, more than five years after the start of contracting. At that point, a key remaining difference by funder was that construction had been only partially completed at 24% of AfDB sites where construction had started, compared with only 14% of equivalent WB sites. The large share of partially completed public projects in contexts with limited resources and administrative capacity is in line with previous evidence from low- and middle-income countries (Williams 2017; Rasul and Rogger 2018).

Household access to electricity requires the construction of poles to carry electricity throughout the LV network, as well as customer connection cables to connect households to these LV wires. Table 3 shows that WB sites saw fewer poles and fewer customer connections (the equivalent regression coefficients from Equation 1 are marked β_1, β_2, and β_3). There are on average 99 poles at AfDB sites and 88 poles at WB sites (*p-val* = 0.055), and on average 76 new LMCP customer connections at AfDB sites and 61 at WB sites (*p-val* = 0.041). There are several potential explanations for these differences; one possibility is that WB installers might have been constrained by the quantity of materials that had earlier been purchased through the separate WB supply contracts, whereas AfDB contractors could procure additional materials as needed during the installation phase.

Column (2) of Table 3 indicates that the audit treatment increased the number of poles constructed at AfDB sites but not at WB sites. This indicates that unbundling contracts and monitoring may be substitutes, such that monitoring will have a larger impact for bundled contracts. In the context of the LMCP, the substitution could arise from the from the fact that AfDB contractors had more discretion in changing site designs or supplies in response to the audit treatment, whereas

WB installers were constrained by their assigned designs and previously procured supplies. Alternatively, the audit treatment may have had a limited impact at WB sites due to the diminishing impact of enhanced inspections, above and beyond what the WB had already carried out.

Columns (5) through (8) indicate that there was some construction between 600 to 700 meters from the transformer, despite the official guidelines indicating that construction was supposed to have extended only up to 600m.[16] WB sites saw significantly less construction outside the boundary, possibly due to more stringent adherence to official LMCP rules. This could be viewed as a positive outcome (especially if some of these connections are made in exchange for bribes), but does contribute to fewer connections per site. That said, the household survey data indicate similar rates of requests for informal side payments—at approximately 8%—for households and firms inside versus outside the 600 meter boundary. Voltage decreases with distance from the transformer, as expected, but this decrease is not correlated with the funder (Subsection C.9).

We estimate $\beta_1 - \beta_3$, the impact of WB contracting approach removing the additional audit treatment component, to isolate the impact of the WB's contract unbundling directly, as distinct from its enhanced monitoring activities. Using this method, unbundling decreased the number of poles by 18.5 ($p\text{-}val = 0.06$) and the number of connections by 22 ($p\text{-}val = 0.04$). However, we do interpret these numbers with some caution, as the WB inspection reports differed from the audit treatment in some nuanced but important ways (as we discuss in Subsection 6.4 below), and thus they may not be fully equivalent.

Despite the LMCP mandate to connect all households and firms within 600 meters of the central transformer, at least 10% of households in each village where construction was completed did not have a physical electricity connection.[17] Several factors likely contributed to the reduced construction. Among both WB and AfDB sites, 30% of unconnected households noted that they were absent on the day on which Kenya Power enrolled households or when construction happened. While the official Kenya Power policy stated that no upfront payment was required to get connected, 22% of households who did not get connected reported the key barrier as up-front costs—primarily internal wiring (16%) or fees required by Kenya Power or the contractor (9% of connected households report having been asked to pay a bribe). This is noteworthy because, according to LMCP media information campaigns during this period, there was not supposed to be any up-front cost (Kenya Power 2016a): ready boards were supposed to have been made available to households who were unable to pay the upfront wiring costs, and of course bribes are illegal.

6.3 Power outages and voltage quality

The GridWatch devices recorded an average of 61 minutes of power outage per day, a substantial amount. Users also experience poor voltage quality: Kenya's nominal voltage is 240V, but voltage

[16] Similarly, Kassem et al. (2022) find that almost 30% of LMCP households are located more than 600 meters from the transformer. Our numbers may be lower because enumerators only surveyed households and firms out to 700m.

[17] This is an underestimate since we systematically recorded connected firms but not all unconnected firms, and since approximately 13% of households with a physical electricity connection have never seen electricity actually flow through this connection.

Table 4: Donor and audit impacts on power and voltage

	Hours of power		Average voltage	
	(1)	(2)	(3)	(4)
β_1: World Bank (=1)	-0.19	-0.31	1.72	2.87
	(0.21)	(0.22)	(2.34)	(2.72)
β_2: Treatment for WB Sites	-0.00	0.33*	3.45	1.39
	(0.24)	(0.17)	(2.22)	(1.77)
β_3: Treatment for AfDB Sites	-0.15	0.10	4.35**	4.95*
	(0.18)	(0.18)	(2.01)	(2.59)
Observations	9906	9906	654541	645665
Fixed effects	No	Yes	No	Yes
Control Mean	23.10	23.10	232.63	232.63

Columns (1) and (2) display daily hours of power per site. Columns (3) and (4) display hourly voltage per respondent. Nominal voltage in Kenya is 240V. Column (2) contains week of sample by constituency fixed effects (interacted) and Column (4) contains day of sample by hour of day by constituency fixed effects (all interacted). $\beta_1, \beta_2, \beta_3$ are estimated as per Equation 1. Power quality is measured using GridWatch devices. $^* \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

in the audit control group is on average only 233V.[18] This could affect day-to-day appliance use and damage appliances in the long run.

Table 4 suggests that WB procedures did not cause statistically or economically meaningful reductions in power outages or improvements in voltage quality over the time period we study. The results are similar when estimating daily or monthly coefficients (Figure A8).

The audit treatment had no measurable impacts on power outages or voltage at WB sites. However, audits had a statistically and economically meaningful effect on voltage quality at AfDB sites: AfDB sites that received the audit treatment experienced average voltage of 238V, significantly closer to nominal voltage of 240V than the control mean of 233V. This again speaks to the substitutability of contract unbundling and enhanced monitoring in this context.

6.4 Engineering assessment and survey results

While we just showed that WB procedures had no impact on electricity quality, they appear to have improved construction quality in ways that could generate long-term benefits. Table 5 presents results using primary outcome indices of the engineering measurements and socioeconomic outcome surveys.[19] Outcomes 1–3 use site level observations (largely from the engineering assessments) while outcomes 4–8 use respondent level observations (largely from the household and firm surveys). All indices are standardized to have a mean of zero and a standard deviation of one.

In one of the central results of this study, Column (1) of Table 5 (β_1) shows that overall construction quality (Outcome 1) was on average 0.64 standard deviations higher at WB sites. This is driven by increased presence of pole caps, struts, and stays on poles at WB sites (Table A5): recall that these are the technical components emphasized in the WB inspection reports. While Subsection 6.3 shows that these features apparently had limited impacts on power quality over the five

[18] In some contexts, average voltage as a metric might conceal important spikes and sags. In Kenya, however, the data indicate that when households experience poor voltage, it is almost exclusively low voltage.

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

Table 5: Primary engineering and socioeconomic outcomes

	(1) WB Effect Estimate β_1	(2) Audit Treatment Effect, WB Sites β_2	(3) Audit Treatment Effect, AfDB Sites β_3	(4) N
Outcome 1: Construction quality index	0.64***	0.10	-0.03	250
	(0.21)	(0.20)	(0.18)	
Outcome 2: Network size and configuration index	0.00	0.27	0.02	244
	(0.18)	(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,	0.13	0.05	0.11	944
bribery index	(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)	

Each row presents coefficient estimates from a separate regression. Outcome variables are indices constructed from groups of variables standardized to have mean 0 and standard deviation 1. $\beta_1, \beta_2, \beta_3$ are estimated as per Equation 1. Column (1) displays the impact of World Bank (WB) funding relative to African Development Bank (AfDB) funding. Columns (2) and (3) display the audit treatment effect among WB sites and among AfDB sites, respectively. In rows 1–3, observations are transformer sites; standard errors are shown in parentheses. For rows 4–8, observations are occupants of connected compounds. All regressions control for site land gradient and public facility type (given some baseline imbalance along these dimensions). Standard errors are clustered by transformer site and shown in parentheses. Table A4 reports the version with interaction terms. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$. The sub-components for each index are presented in Table A5, Table A6, Table A7, Table A8, Table A9, Table A10, Table A11, and Table A12. Table A13, Table A14, and Table A15 present results on three additional secondary outcomes specified in the pre-analysis plan (Berkouwer et al. 2019).

years we observe, they can reasonably be expected to increase the lifetime of the poles—and thus the entire local LV network—over the long-term. 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" (UPRC 2018).

Columns (2) and (3) of Table 5 estimate the audit treatment effect among WB and AfDB sites, respectively (β_2 and β_3). The estimate in Column (3) corresponds to the impact of enhanced monitoring among sites with bundled contracts, as shown in Figure 4. Additional audits did not affect outcomes at WB sites. However, they did increase household installation quality among AfDB sites (Outcome 4), driven by earlier meter activation and higher likelihood of having a working meter (Table A8). This substitutability is in line with the extensive margin effects discussed in Subsection 6.2 and the positive impact on voltage quality result presented in Subsection 5.3. The improvements in voltage quality and household installation quality likely contributed to the increase in household electricity access and usage estimated here (Outcome 8; Table A12). Outcomes 5, 6, and 7 (household cost and experience; reliability and safety; and knowledge) show little difference across WB and AfDB sites or due to the audit treatment (Table A9, Table A10, Table A11).

To isolate the impact of contract unbundling, we estimate the impact of WB contracting subtracting off the audit treatment component ($\beta_1 - \beta_3$). This yields an increase of 0.67 standard deviations ($p\text{-}val = 0.001$) on the construction quality index and a –0.61 effect ($p\text{-}val < 0.001$) on the timing index. This suggests that unbundling contracts has substantial impacts on project outcomes. However, we interpret this result with some caution, as the audit treatment differed from the WB inspection reports somewhat. For example, the inspection reports (described in Subsection 3.3) investigated more technical components of LV network construction (such as pole quality) whereas the audit treatment (described in Subsection 4.2) emphasized the quality of household connections. This could explain why the WB procedures affect the core engineering components (Outcome 1) whereas the audit treatment at AfDB sites primarily improved household installation quality (Outcomes 4 and 8), and why the WB did not have an impact on the voltage quality experienced by households while the audit treatment did improve voltage quality at AfDB sites (Subsection 6.3).

6.5 Discussion

These results are broadly in line with empirical implications 3, 4, and 5 outlined in Section 2.

WB-funded sites had higher overall construction quality than AfDB-funded sites, and that the experimental audits had a positive impact on installation quality among AfDB-funded sites. These patterns indicate that both contract unbundling and enhanced monitoring are policy levers that can improve project outcomes.

The experimental audits were found to improve construction quality at AfDB-funded sites but have limited impacts at WB-funded sites. The finding that the audit treatment increased installation quality at AfDB-funded sites is at least consistent with the assertion that t and m are substitutes, as enhanced monitoring (through the randomized audit) appears to have offset some of the reduction in construction quality caused by the AfDB's use of bundled contracts (at the cost of some delay).

Audit effects were limited at WB-funded sites however, likely for two reasons. First, this could be because t (unbundled contracts) and m (monitoring) are substitutes rather than complements, and the WB procurement approach is characterized by higher t than the AfDB process. Second, this could also in part be due to the diminishing marginal benefits of increased monitoring, since the WB already mandated an additional layer of inspections beyond that used at AfDB-funded sites.

6.6 Robustness

We conduct numerous robustness tests to confirm the results above (Subsection C.7). All results in Table 5 control for land gradient and facility type, but doing so does not qualitatively affect the results. Construction outcomes are generally not correlated with land gradient (Table A16 and Figure A10) or by the facility type that each transformer was originally built to connect (Table A1, Table A17, and Table A16). We also explore heterogeneity in the time between construction and power measurement (Figure A13), omit a complex and ambiguous ready board question in the survey (Table A8), exclude one particular contractor that experienced unusual financial circumstances and a legal case (Table A18), and drop sites that are located within 1,200 meters of another site (Table A19). None of these adjustments qualitatively affects the results described above.

7 Cost effectiveness

The improvement in overall construction quality at WB sites is a central finding of this study. We next examine the financial cost of the WB procurement procedures that generated these gains, and their cost effectiveness. One argument given by WB officials for contract unbundling in this context is that they could generate cost efficiencies, specifically in that pooling the procurement of materials would generate purchaser market power that could lead to cost savings. Subsection 7.1 therefore investigates program costs, and Subsection 7.2 then investigates the trade-off discussed in Section 2, between the costs of short-term construction delays versus the potential long-term benefits from greater infrastructure resilience.

7.1 Cost analysis

Kenya Power awarded $154mn in AfDB contracts and $133mn in WB contracts.[20] Table 6 presents project costs by donor. The original roll-out planned to maximize 5,320 AfDB sites and 3,200 WB sites, but only 71% of LMCP sites actually saw construction, according to survey data and conversations with Kenya Power personnel. The survey team identified on average 72 new LMCP household connections at AfDB sites and 58 at WB sites, implying that the average cost per household connection is $563 for AfDB contracts while it is $728—30% higher—for WB contracts.[21] Furthermore, these cost estimates exclude any additional Kenya Power staff labor hours associated with the WB's administrative and monitoring costs (i.e., in setting up additional contracts and bidding processes, etc.), which could exacerbate this cost difference. In sum, it does not appear that the WB was able to carry out lower-cost projects overall: contract unbundling appears to have led to higher average costs per connection in this setting.

These cost estimates are slightly lower than the $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 about rural electrification construction that occurred between 2014–2018. In line

[20]This excludes a $2.0mn contract awarded for the procurement of 1,000 new WB transformers. Since these 1,000 sites received similar shares of the remaining contracts, we include these sites in the aggregate cost calculations, accounting for the fact that they were designed to have approximately 21% more new household connections.

[21]The average cost per connection would have been $687 at AfDB sites and $571 at WB sites when using Kenya Power's initial public targets, which would have required on average 59 new connections at AfDB sites and 74 new connections at WB sites (Kenya Power 2016a). Note that assuming a uniform 80 households connected per site would yield a construction cost of approximately $506 per household connection at AfDB sites and a nearly identical $528 at WB sites.

Table 6: Site, connection, and materials costs by donor

		African Development Bank	World Bank	Percent Difference
(1)	Sites planned	5,320	4,200	–21%
(2)	Sites completed	3,800	3,000	–21%
(3)	New household connections per site	72	58	–19%
(4)	Contract amount per site completed	40,513	42,249	+4%
(5)	Contract amount per household connection	563	728	+30%
(6)	Contract amount per wooden pole	159	99	–38%
(7)	Contract amount per concrete pole	240	199	–17%

Aggregate connection and pole procurement quantities and costs, per the contracts signed between Kenya Power and contractors under World Bank and African Development Bank funding tranches.

with Lee et al. (2020), the observed LMCP connection costs exceed the value of rural electrification as measured through both stated willingness-to-pay ($293) and revealed preference willingness-to-pay ($147) approaches.[22]

Taken at face value, the cost per pole enumerated in rows (6) and (7) of Table 6 would suggest that WB contracts did secure poles more cheaply than the AfDB. However, the contract amounts listed in bundled contracts may not reflect true procurement costs: based on our conversations with contractors, implementation contractors sometimes shift labor costs onto materials in their accounting records, as these invoices are paid sooner, providing them with much needed liquidity. Due to imperfect accounting transparency, these practices are not observable to the principal. This is in sharp contrast to the case of unbundled contracting, where the principal can observe each component's purchase cost. This is an example of the opacity that bundled contracting can create for the principal.

As another example of gaps between reporting to the principal and reality, there also appear to be large disparities between contracted and built quantities. 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 of all poles in our sample sites, only 3% of poles at WB sites and 25% of poles at AfDB sites were concrete. We interpret this result with some caution since 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. That said, our sense is that majority of poles for the local LV network were built for LMCP. Moreoever, our sample sites are only a subset of all LMCP construction sites where contractors worked.

7.2 Cost-benefit analysis

The 30% higher cost per electricity connection for WB contracts documented above might be worth it if the gains in construction quality are sufficiently large. We thus next evaluate the gains in

[22] The Lee et al. (2020) survey was conducted 4-5 years before LMCP in two counties bordering our study counties.

quality against both the cost per connection and the estimated costs of construction delays, to shed light on the key conceptual trade-off presented in Section 2.

AfDB sites reached construction milestones 8 to 16 months earlier than WB sites on average, increasing the net present value of new connections. WB sites saw improved pole and pole installation quality, potentially increasing pole longevity by 5–15 years and reducing long-term repair and replacement costs for Kenya Power (UPRC 2018). We also factor in that only 71% of sites were completed, and assume that households discount delayed provision of electricity services at a 10% annual discount rate while the social planner discounts future maintenance costs at 5% per year (alternative scenarios are presented in the appendix). This analysis focuses on audit control sites to avoid confounding these differences with the audit treatment's heterogeneous impacts; we separately assess the costs and benefits of the audit treatment below.

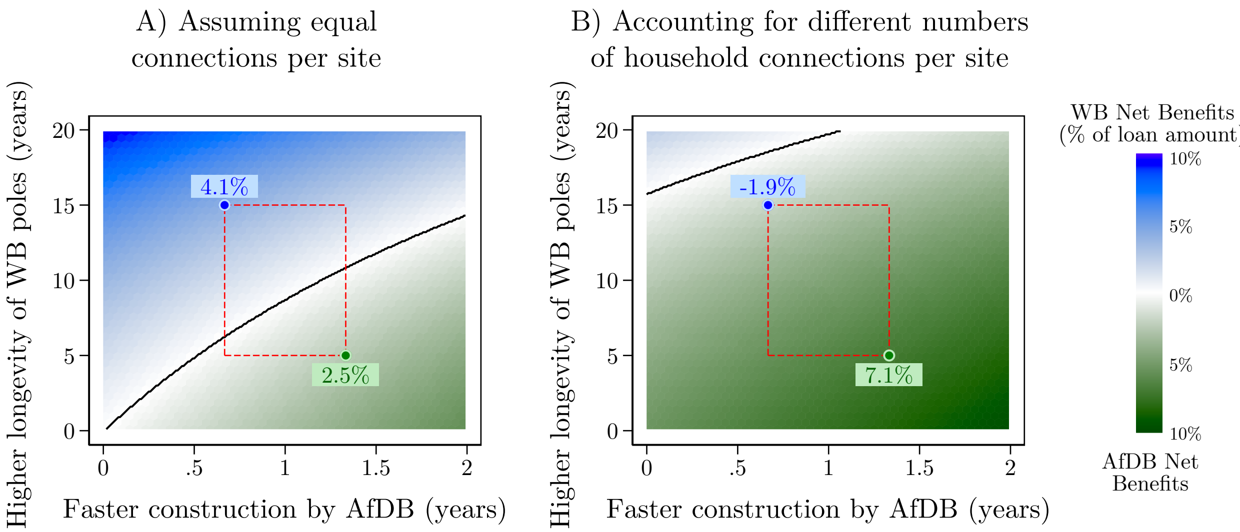
Figure 8 presents the results in two panels to emphasize the role of one important attribute. Panel A assumes that WB and AfDB sites both benefit from 80 new household connections, as had been planned by the agencies. Panel B reflects our count of actual LMCP household connections on the ground, which average 72 at AfDB sites and 58 at WB sites among audit control sites. The value of these additional household connections sway the net benefits calculations heavily in favor of the AfDB. To illustrate the uncertainty in these estimates, the red box marks 8 to 16 months faster construction and 5 to 15 years improved service life for poles, consistent with the data and with Muthike and Ali (2021). Using plausible estimates of the gains in construction speed and in quality of poles, the overall net benefits of either set of procurement policies are ambiguous, ranging anywhere from WB procedures having a net benefit worth 4% of total project costs to AfDB procedures having a net benefit worth 7% of project costs. (Figure A12 displays similar results under a range of alternative assumptions.)

Under a shorter time horizon, or if the value of a connection to households were larger, the relative benefits of AfDB contracting would be more pronounced, up to 16% of the total. Conversely, under a lower discount rate the relative benefits of WB contracting would be more pronounced, up to 5% of the total. However, in the aggregate, it appears unlikely that WB procurement procedures would have generated the 30% improvement required to make up for the increased costs per connection.[23]

While this exercise focuses on rural residential electrification in Kenya, these calculations illustrate the trade-offs influencing the suitability of different procurement contracting approaches 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 bundling contracts may be more attractive. Conversely, if such an approach is expected to cause 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 featuring unbundled contracting with enhanced monitoring may be better suited.

[23]This result is not specific to any assumptions we make. Even uniformly assuming 80 households and 112 poles per site for both funders, and assuming only 8 months of delay and 15 years of improved pole longevity, with a 40 year time horizon and 5% discount rates (all favoring WB), WB net benefits add up to 5.4% of the loan.

Figure 8: Costs versus benefits of different contracting approaches



Households are assumed to value a connection at $147 (Lee et al. 2020) and have an annual discount rate of 10%. The social planner is assumed to have a time horizon of 20 years and an annual discount rate of 5%. The horizontal axis represents the gains from timelier construction, with households benefiting sooner. The vertical axis 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 red box marks 8–16 months faster construction (consistent with the results above) and 5–15 years improved service life for poles (following Muthike and Ali 2021). Panel A assumes that 80 new household connections are constructed per site at both World Bank (WB) and the African Development Bank (AfDB) sites, as had been planned by the agencies. Panel B reflects our count of household connections on the ground, which average 72 at AfDB sites and 58 at WB sites. Figure A12 explores additional assumptions.

We showed above that the additional audits improved some household installation outcomes at AfDB sites. The audits were conducted at an average cost of approximately $500 per site.[24] While Column (4) of Table 3 suggests that the audit treatment did not increase the number of drop-down cables, the household installation quality index shown in Table 5 (detailed in Table A8) indicates that electricity actually flowed through those connections for approximately 8% more households, and that the audit treatment increased the fraction of households with a working meter by 11%. Valuing each additional working connection conservatively at $147, the total value of $1,029 far exceeds the cost of the audit treatment per site, despite the fact that the costs of the audit treatment included household and firm surveys, far exceeding the activities included in the standard WB inspection reports (IRs). While we do not have cost estimates of the IRs per se, the exercise above suggests that they could likely pay for themselves in terms of reduced long-term infrastructure repair and maintenance expenditures.

These results come with important caveats. The cost calculations do not consider the additional staff time incurred by the WB, Kenya Power, and other government agencies due to increased paperwork and processing necessary to implement WB procurement contracting procedures. The benefit calculations also do not consider spillovers like increased knowledge of oversight mechanisms within Kenyan government agencies, which could affect other programs. We also do not consider possible

[24] We spent $125,000 on data collection at 250 sites. $500 per site is 1.2% of the average per-site LMCP cost.

degradation of electricity service quality and reliability over time due to lower quality construction. Perhaps most importantly, we do not directly observe the leakage of funds. It is possible that WB contracting requirements meaningfully reduce leakage of funds, which were recently observed to be substantial for WB lending, for example, by Andersen et al. (2022). However, to the extent that WB procedures did reduce leakage (relative to AfDB) and would have increased the availability of funds for intended construction, this does not appear to have positively affected construction outcomes in the short to medium run in terms of the numbers of connections completed.

8 Empirical implications

Section 6 quantitatively evaluated empirical implications 3, 4, and 5 of Section 2, while Section 7 evaluated the cost-benefit trade-off outlined in implication 6. Next, we evaluate implications 1 and 2 by combining the insights from the quantitative results with qualitative data gathered during interviews with officials at Kenya Power, the WB, and the AfDB over several years.[25]

Empirical implication 1: Unbundling and monitoring incur delays. Kenya Power's administrative burden under the WB procurement approach was significantly higher than under the AfDB process. The larger absolute number of contracts and the substantial heterogeneity in legal text across different types of contracts required more Kenya Power staff time to write, issue, review, and award bids. 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 processes used by AfDB implementers for those same goods and services. Despite these substantial differences in staffing requirements for work across the two donors, Kenya Power employed one full-time staff member to manage the WB contracting procedures and one full-time 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.

The WB's unbundled contracting also created coordination frictions, exacerbating costs and delays. The lack of coordination between the design and installation contracts meant that construction designs were sometimes out of date by the time construction began, requiring costly adjustments to the designs or a change in needed materials. Similarly, a lack of coordination between materials and installation contracts meant that materials were often physically transported into Kenya Power custody before installation contractors were ready, accruing expensive storage fees.

This caused an average delay of 16 months between when connected AfDB households received a working meter and when connected WB households received one (Table A7). At AfDB-funded sites, the audit treatment alone caused an average metering delay of 5 months. Taking the difference between these two (subject to the caveats noted above) suggests that the upfront delays caused by unbundling alone could account for approximately 11 months of delay.

[25] Appendix D provides an anonymized list of individuals that our research team interviewed for this research.

Empirical implication 2: Unbundling increases aggregate contract cost. In interviews, we learned that one of the WB's reasons for choosing unbundled contracting was the belief that having coordinated nationwide contracts for major materials purchases would enable them to secure lower prices through auction. This turns out to have been true on paper: at first glance, as noted above, the cost per wooden and per concrete pole was 38% and 17% lower, respectively, in the WB contracts when compared with the AfDB contracts.

However, the aggregate costs per site and per successful connection are in fact substantially *lower* at AfDB-funded sites. This is in line with a reduction in the number of bidders as a result of the more stringent selection procedures used for contractors than for subcontractors.

In theory, these increased costs should be worth it if they led to the selection of higher-quality firms. The selection process for AfDB subcontractors featured significantly less oversight than the process of selecting contractors for WB-funded sites. We investigate whether these different selection mechanisms led to differences in the types of providers that were selected. We focus on poles, cables, and conductors, which were procured through competitive auctions for segregated WB contracts, but almost always subcontracted out by AfDB implementers.

Provider selection does not appear to differ substantially across the two contracting structures. Twenty-one companies were directly awarded at least one supplier contract by the WB and 29 companies were listed as a subcontractor for an AfDB implementer.[26] We see considerable overlap between the WB bidders and AfDB subcontractors. Over half of the AfDB subcontractors (15 out of the 29) had bids reaching the evaluation stage of the WB selection process, indicating that many firms actively sought to be funded by both donors. There was also a non-trivial degree of direct overlap between selected firms: seven of 21 World Bank contractors were also selected as AfDB subcontractors. While information about firms is limited, especially about subcontractors, the selected providers under AfDB and WB regulations appear to be similar. Among firms that only contracted or subcontracted with either the AfDB or the WB, approximately two-thirds of (sub)contractors were from Kenya, 10% were from China, and 10% were from India (Figure A11), and these proportions are similar for those awarded contracts with either WB or AfDB. 48% of WB contractors and 22% of AfDB subcontractors had also been awarded at least one other WB procurement contract prior to the start of the LMCP.

9 Conclusion

Public procurement regulations can have important implications for the costs, timeliness, and quality of infrastructure construction, a major source of spending for governments and aid donors. However, causal inference has been hampered by the infrequency, endogeneity, and complexity of infrastructure projects. We use natural policy and experimental variation to study how two key features—contracting bundling and monitoring—affect construction quality in the context of the

[26] Implementing firms were not required to comprehensively disclose subcontractor relationships, but only to get approval to use a certain subcontractor. In many cases the implementer obtained approval for multiple contractors, and did not disclose which subcontractor they eventually opted to contract with.

Last Mile Connectivity Project (LMCP), one of Kenya's largest public infrastructure construction projects. A key feature of the program is the arbitrary assignment of contracting requirements across neighboring villages to different funders within the same government program.

We find that WB-funded sites experience significant delays in project implementation, with households receiving electricity on average 16 months later than households in AfDB-funded sites. Yet there is a stark trade-off: we estimate a 0.6 standard deviation improvement in construction quality at WB sites, driven by increased presence of pole caps, stays, and struts, which were key components examined during the WB's additional inspection round, and which can have long-term impacts on the longevity of the local infrastructure network. To disentangle the effects of two important components of the WB approach – contract bundling and monitoring – we implement an additional randomized audit treatment at a subset of sites. The audits have no impact at WB sites, but generate a 0.2 standard deviation improvement in household installation quality and a 0.3 standard deviation improvement in electricity usage at AfDB sites, while causing significantly shorter delays than those experienced at WB sites.

We develop a stylized conceptual framework to shed light on the mechanisms through which contract bundling and monitoring may operate. First, enhanced monitoring can be an effective substitute for contract bundling, achieving significant improvements in construction quality. Second, unbundling contracts greatly increases the principal's administrative burden, which—in contexts where staff time and human capital are constrained—can generate sizeable implementation delays. Taken together, these results suggest that combining bundled contracting with more rigorous ex post audits could reduce delays while maintaining construction quality standards.

Comparing the distinct procurement processes used by the WB and AfDB in the LMCP highlights a key intertemporal trade-off: the policymaker may need to weigh the short-term benefits of achieving earlier access to electricity (under the AfDB approach) versus the longer-term benefits of lower maintenance and upgrading expenditures due to improved project quality (under the WB approach), according to their time preferences. We evaluate this trade-off under a plausible range of assumptions and find that neither approach definitively dominates the other in this context: the results imply anything from a net benefit of +7% of project value under the AfDB approach to a net benefit of 4% of project value under the WB approach.

Several important limitations are worth noting. First, the more stringent WB procurement conditions could generate additional longer term benefits that are hard to measure, including improved institutional capacity or accounting practices in Kenya public sector organizations. Second, while we carry out data collection over a relatively long five years after construction (in some cases), some of the outcomes of interest may only emerge after longer time horizons, including possible differences between WB and AfDB sites in terms of the longevity of the local grid network and the reliability of power experienced by households, with gains in WB sites potentially growing over time. 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 the additional WB procurement requirements. It is possible that the results would not hold in a setting with weaker institutional capacity, like some of its regional neighbors (as argued for instance by Bosio et al. 2022). Additional research is needed to understand the potentially heterogeneous impacts of donor conditionality and procurement processes over time and in other settings.

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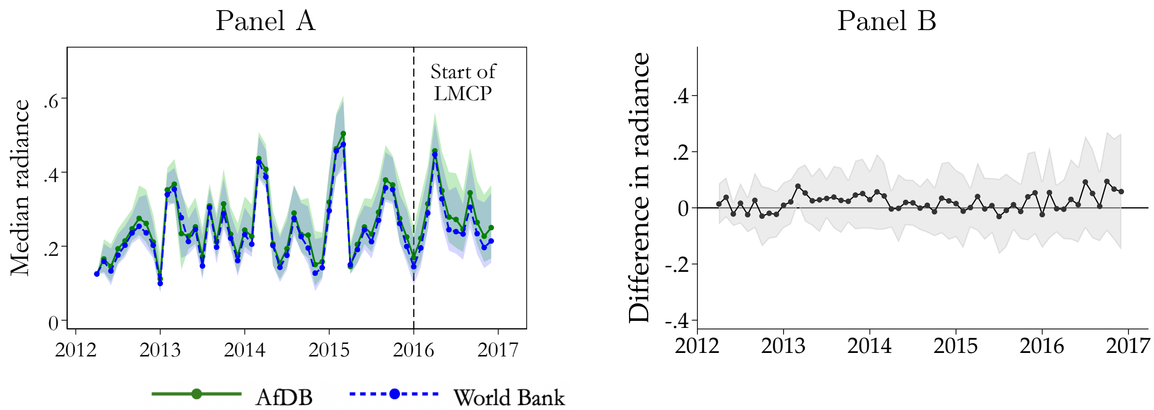
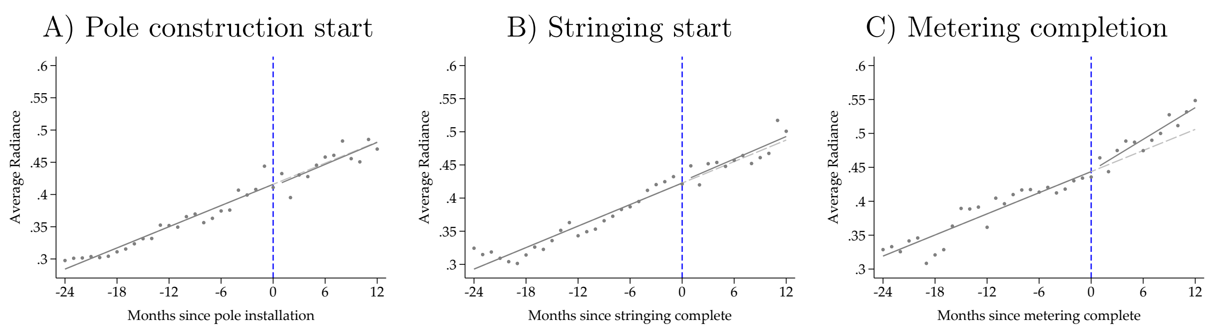
A Appendix Figures

Figure A1: 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 month, with bands showing the 25th to 75th percentile across sites, before and after the start of the Last Mile Connectivity Project (LMCP). Panel B confirms that radiance is statistically indistinguishable across World Bank and African Development Bank-funded sites (estimates include constituency fixed effects). Table 1 confirms baseline balance using a pooled regression of these data.

Figure A2: Event study: nightlights after construction progress



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

Figure A3: Monitoring Intervention

THE WORLD BANK
IBRD • IDA

Kenya Power

BANQUE AFRICAINE DE DEVELOPPEMENT
AFRICAN DEVELOPMENT BANK

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.

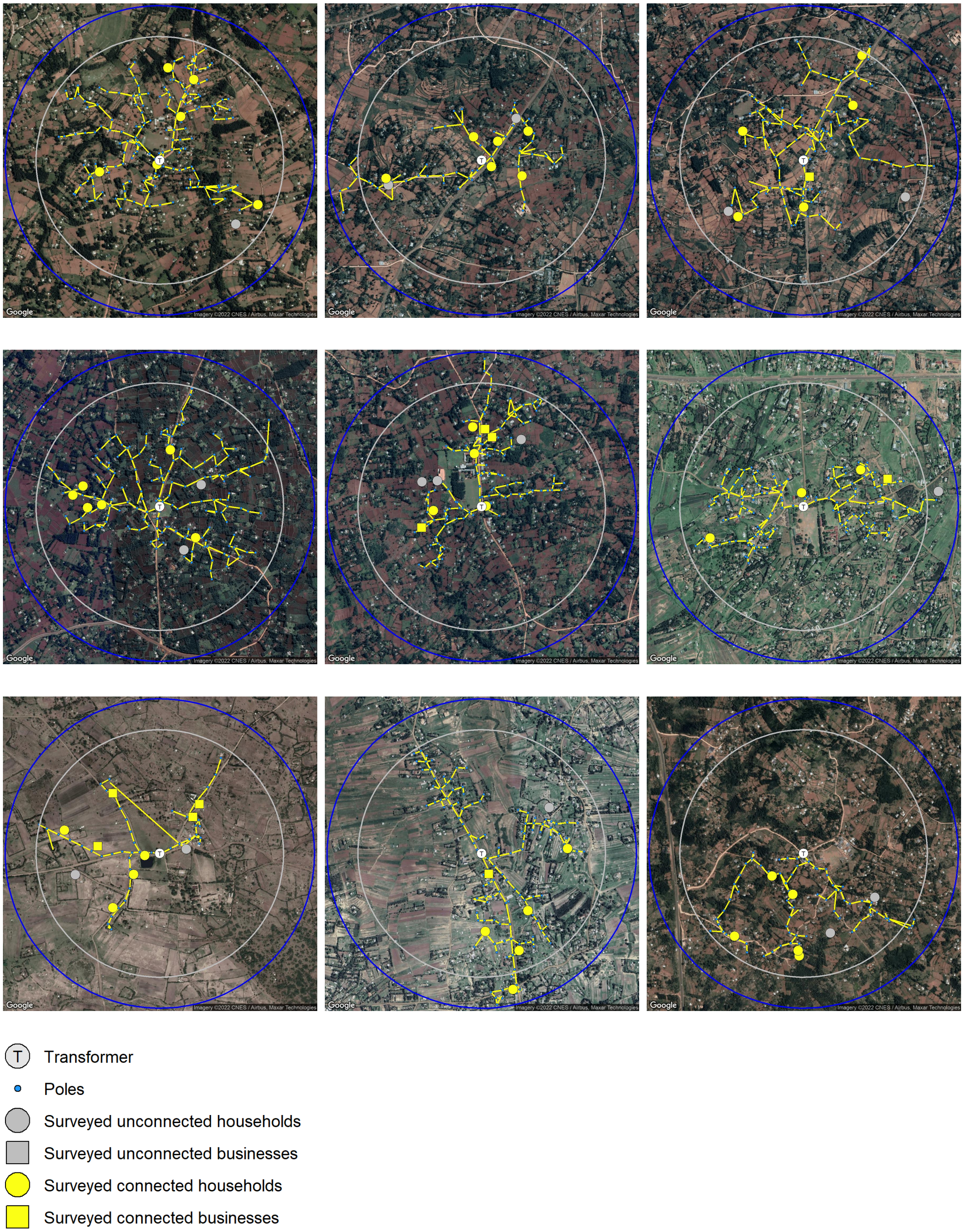
Sincerely yours,

[redacted] [redacted] [redacted]

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

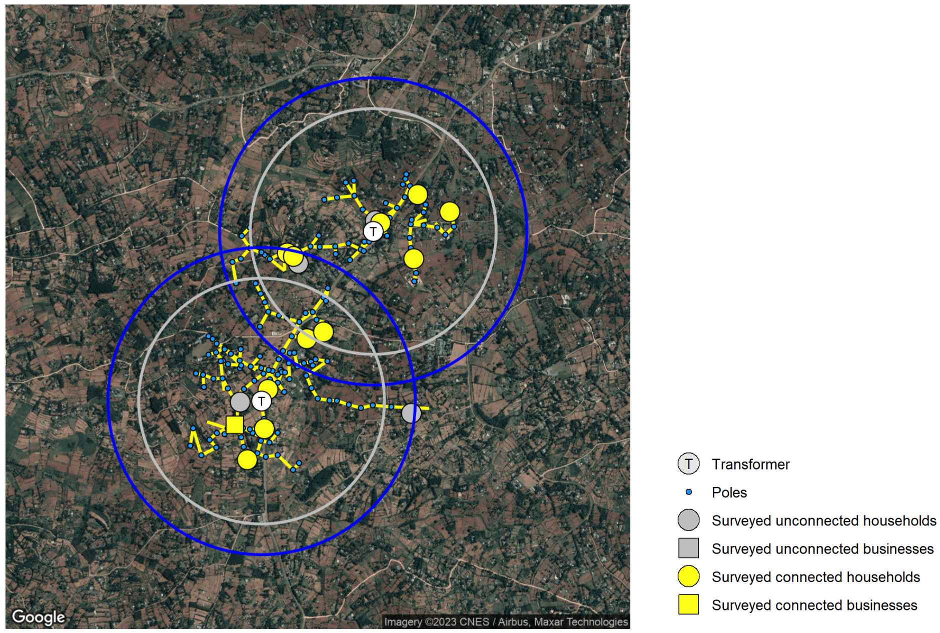
This figure displays the monitoring intervention sent to contractors. All letters were signed by relevant representatives from Kenya Power, the World Bank, and the African Development Bank, with their names and positions listed below. Each letter specified the contractor's name and contact information. 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 A4: Engineering data collected (additional example sites)



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

Figure A5: Two sites located less than 1,200 meters apart

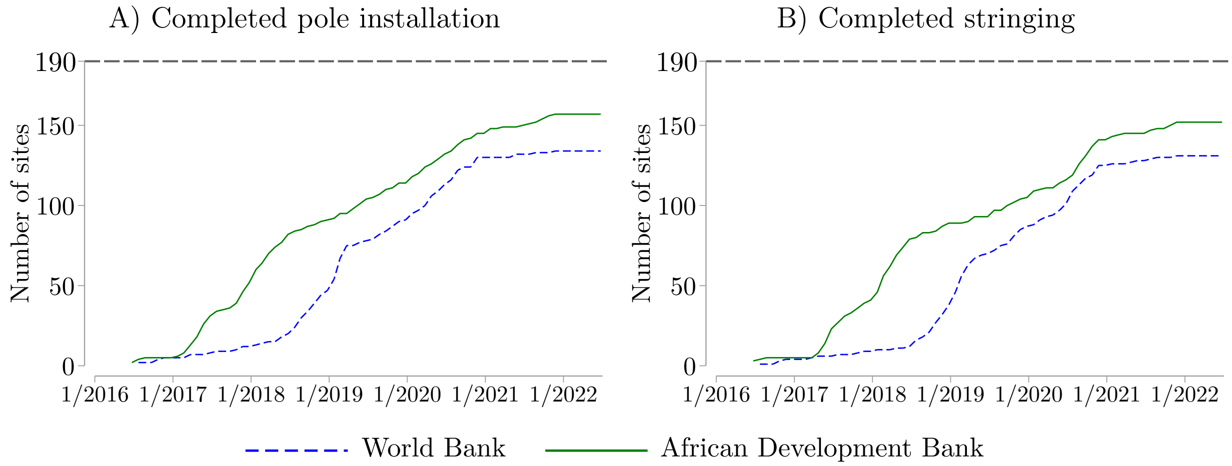


This map displays two sites whose transformers are located 990 meters apart, such that the 600 and 700 meter radius eligibility areas overlap. See Subsection 5.1 for a discussion on this issue. To preserve anonymity, random spatial noise has been added to household and business locations.

Figure A6: A PowerWatch device

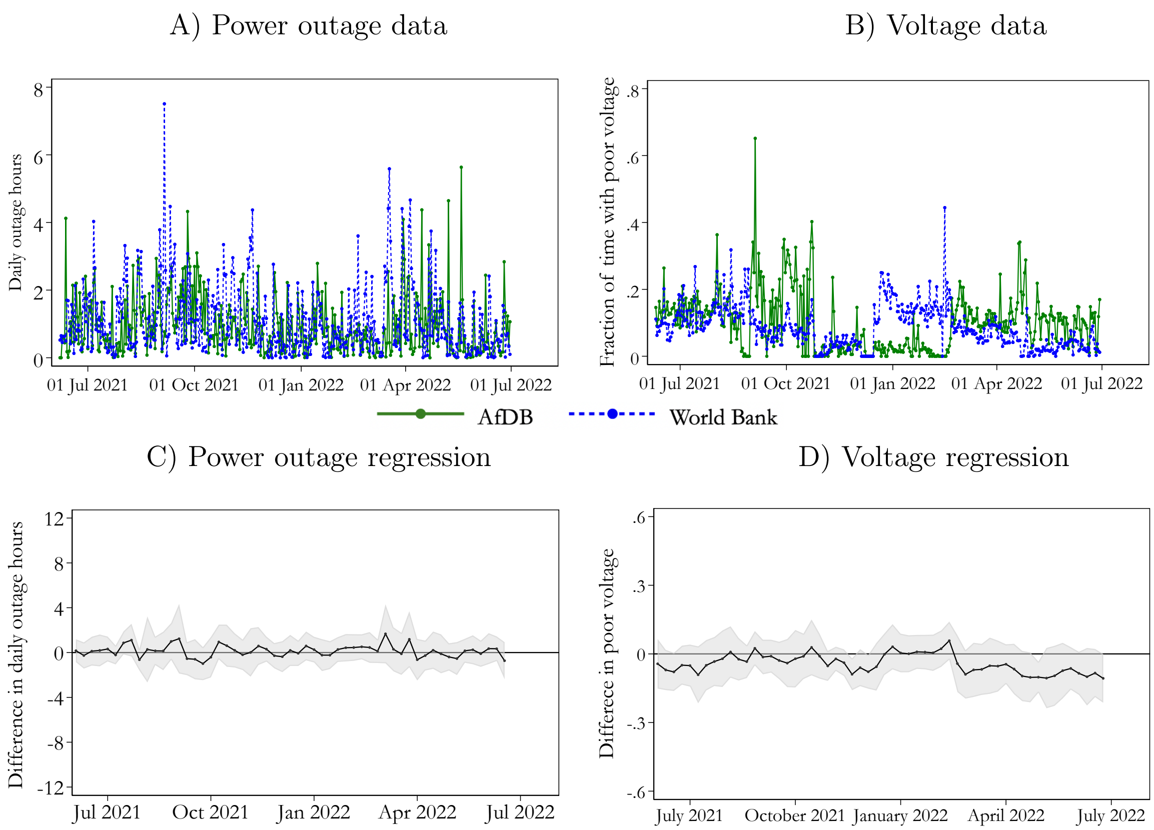
A PowerWatch device, part of nLine's GridWatch technologies used to measure household-level power outages and voltage.

Figure A7: Construction progress by funding source



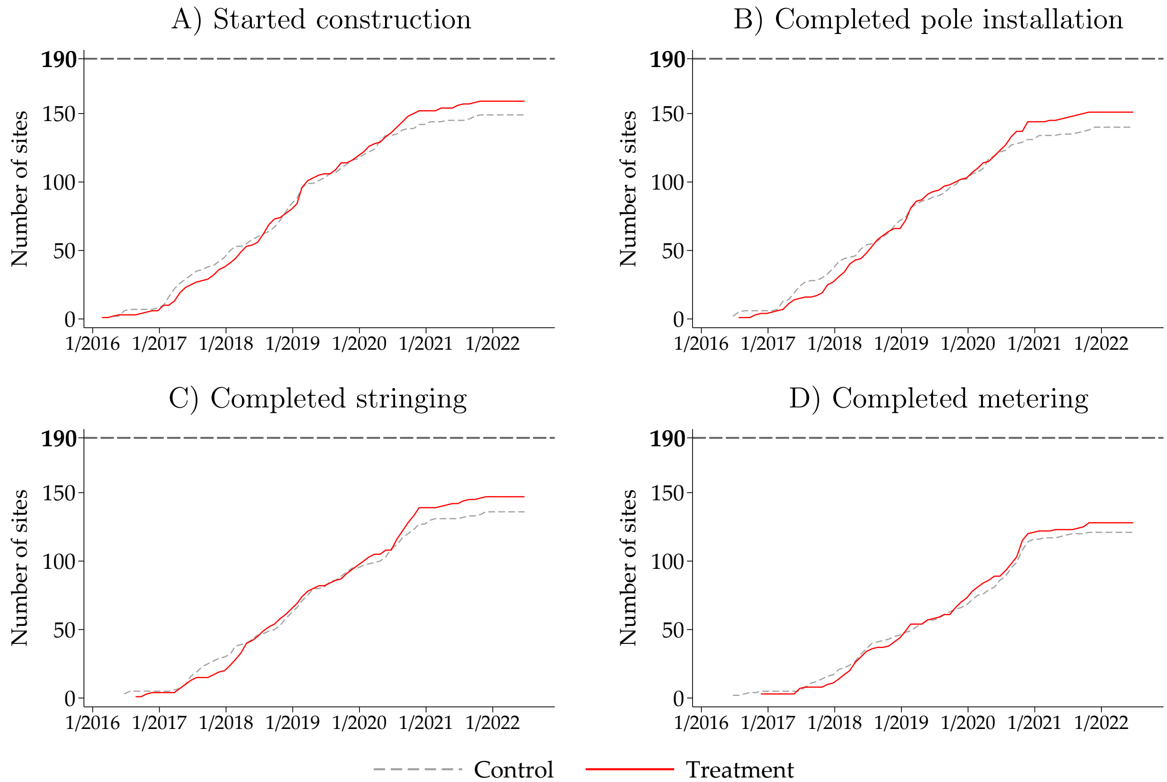
Data for 190 African Development Bank sites and 190 World Bank sites located in the five study counties collected through phone surveys with village representatives. Appendix Figure 7 displays progress for pole installation and stringing.

Figure A8: Reliability and voltage quality by funding source



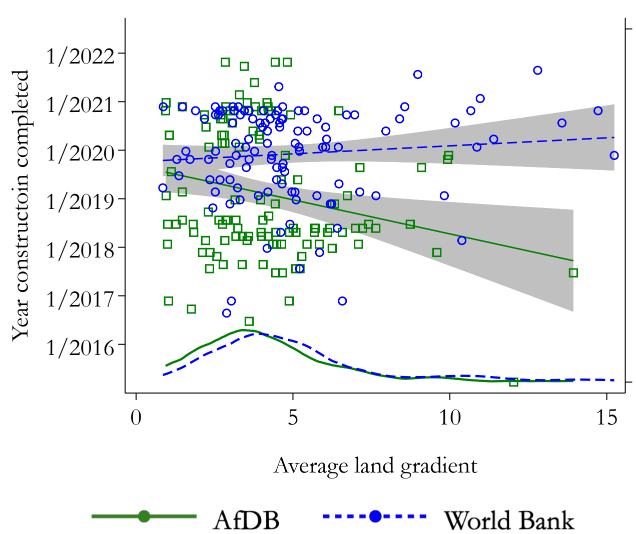
Panels A and B present the hours of power outage per day and fraction of time experiencing poor voltage quality, respectively, for World Bank and African Development Bank sites. Panels C and D estimate a separate coefficient for each week of the sample, with constituency fixed effects and standard errors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

Figure A9: Construction progress by audit treatment status



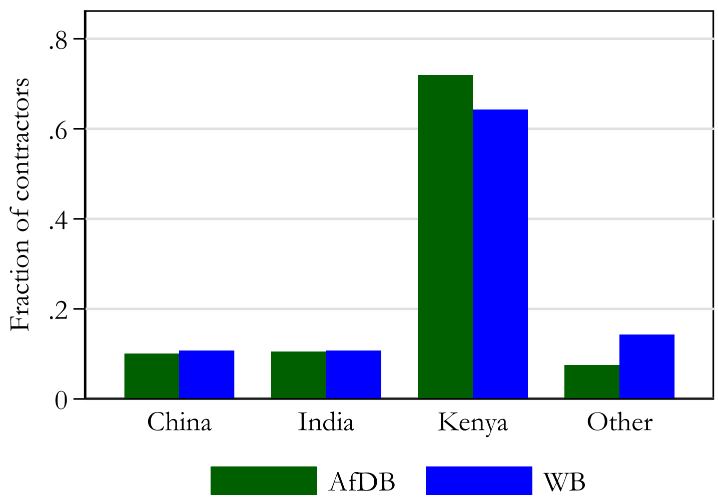
Data for 190 control sites and 190 treatment sites located in the five study counties collected through phone surveys with village representatives.

Figure A10: Construction delays and land gradient



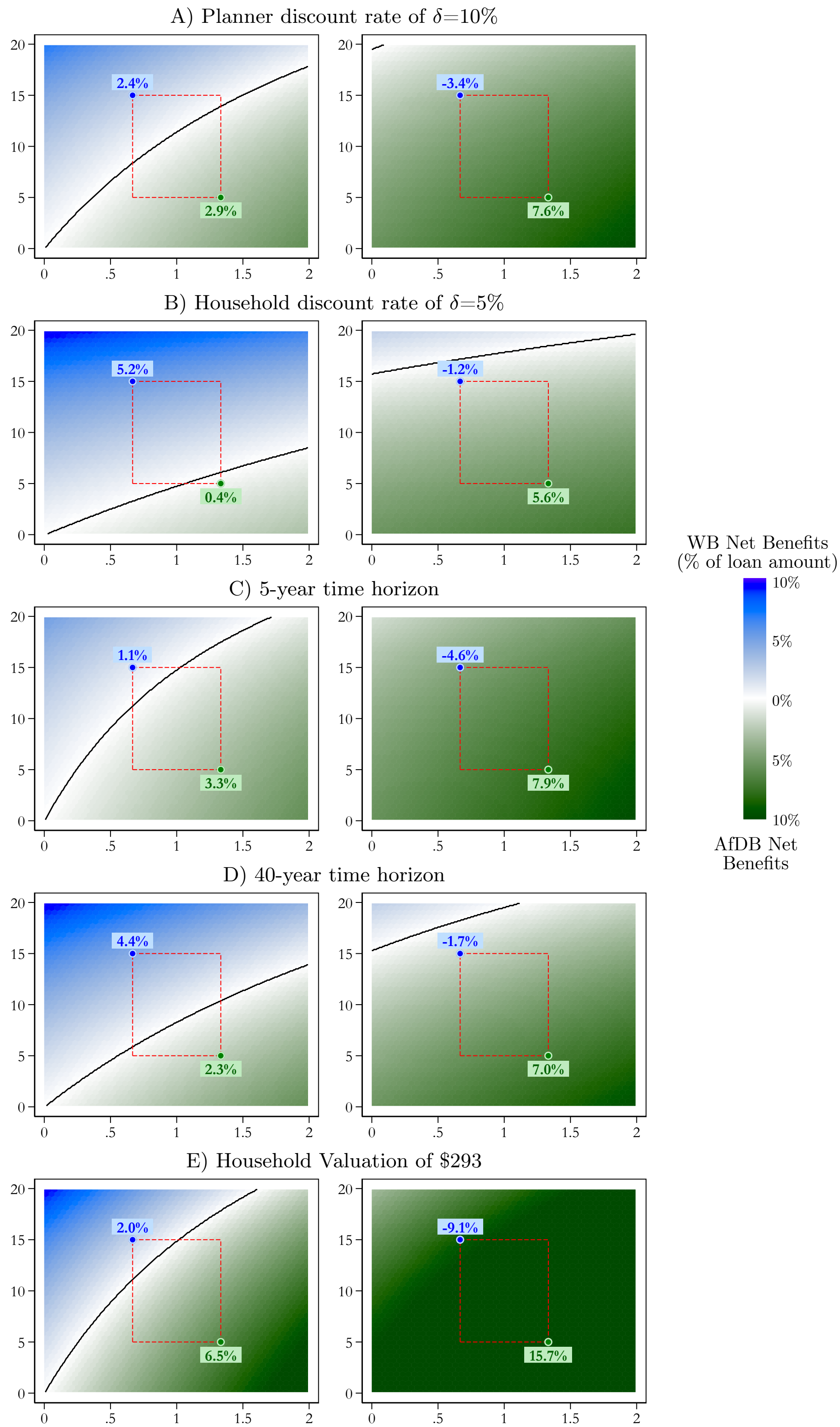
Average land gradient is calculated for each site over the 600 meter radius around its transformer. Land gradient is uncorrelated with construction delays, both unconditionally and conditional on funder. The lag between WB and AfDB is approximately constant across the entire land gradient support. Data 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 A11: World Bank contractors and African Development Bank subcontractors by country of origin



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

Figure A12: Costs versus benefits on various assumptions



Variations on the assumptions used for Figure 8, which presents results using our preferred assumptions. Each sub-title indicates the one aspect that has been changed relative to Figure 8.

B Appendix Tables

Table A1: 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 fixed effects.

Table A2: Summary statistics

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

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

Table A3: Impact of transformer characteristics on construction at site

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

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

Table A4: Primary engineering and socioeconomic outcomes with funder–audit interaction

	WB Effect Estimate	Audit Treatment Estimate	Interaction Estimate	N
Outcome 1: Construction quality index	0.64***	-0.03	0.14	250
	(0.21)	(0.18)	(0.28)	
Outcome 2: Network size and configuration index	0.00	0.02	0.25	244
	(0.18)	(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 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. In rows 4–8, observations are individual respondents. Table 5 presents a version with separate treatment effects. 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 A5: Construction quality

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

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. An F-test of $H_0 : \beta_1 - \beta_3 = 0$ for the metering completion date has a p-val< 0.001. $^{*} \leq 0.10$, $^{**} \leq .05$, $^{***} \leq .01$.

Table A6: Network configuration

	(1) AfDB Mean	(2) World Bank Effect Estimate β_1	(3) Audit Treatment Effect, WB Sites β_2	(4) Audit Treatment Effect, AfDB Sites β_3	(5) N
Outcome 2: Network size and configuration index	-0.00	0.00	0.27	0.02	244
	[1.00]	(0.18)	(0.17)	(0.18)	
Deviation in Pole Count (relative to design)	70.16	3.26	6.87	4.68	197
	[62.89]	(12.20)	(11.94)	(12.43)	
Deviation in Drop Cables (relative to design)	39.11	3.75	-2.79	-1.80	178
	[26.21]	(6.92)	(7.95)	(5.49)	
Fraction of compounds at site, within 100m of LV line, electrified	0.89	-0.02	0.04	-0.01	244
	[0.13]	(0.02)	(0.03)	(0.02)	
Fraction of poles ≤600m from transformer	0.95	0.02	0.01	0.00	244
	[0.08]	(0.01)	(0.01)	(0.01)	

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 A7: Construction timing

	(1) AfDB Mean	(2) World Bank Effect Estimate β_1	(3) Audit Treatment Effect, WB Sites β_2	(4) Audit Treatment Effect, AfDB Sites β_3	(5) N
Outcome 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 A8: Household installation quality

	(1) AfDB Mean	(2) World Bank Effect Estimate β_1	(3) Audit Treatment Effect, WB Sites β_2	(4) Audit Treatment Effect, AfDB Sites β_3	(5) N
Outcome 4: Household installation quality index	-0.00	0.05	0.02	0.23*	944
	[1.01]	(0.12)	(0.11)	(0.12)	
Outcome 4 (omitting ready board question)	-0.01	0.15	-0.03	0.23*	944
	[1.00]	(0.12)	(0.12)	(0.12)	
Electricity has flowed to this household (=1)	0.81	0.05	0.04	0.08	944
	[0.39]	(0.06)	(0.04)	(0.05)	
Household has ≥1 meter (=1)	0.86	0.09**	0.01	0.08*	944
	[0.35]	(0.04)	(0.04)	(0.04)	
Household has meter that has worked (=1)	0.77	0.06	0.07	0.11**	943
	[0.42]	(0.06)	(0.05)	(0.05)	
Household has a ready board (=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 ready board question as the absence of a ready board is not strictly an indication of poor quality. All outcomes are measured at the household level and collected in the household and firm survey data (described in Section 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 A9: Household cost, experience, and bribery

	(1) AfDB Mean	(2) World Bank Effect Estimate β_1	(3) Audit Treatment Effect, WB Sites β_2	(4) Audit Treatment Effect, AfDB Sites β_3	(5) N
Outcome 5: Household cost, experience, bribery index	0.02	0.13	0.06	0.11	944
	[0.99]	(0.12)	(0.11)	(0.10)	
Days given to fulfill paperwork reqs (of LMCP hh)	42.29	21.09	0.30	3.16	828
	[79.87]	(14.35)	(13.54)	(11.70)	
Did not require own wiring before connection (=1)	0.77	-0.03	-0.04	0.01	855
	[0.42]	(0.05)	(0.05)	(0.05)	
(-) KSH spent on wiring (of hh that did wiring)	7774.45	-925.05	645.25	-741.25	708
	[6779.96]	(718.32)	(666.29)	(739.09)	
(-) Up-front connection payment (Ksh)	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)	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 A10: Household and firm reliability and safety

	(1) AfDB Mean	(2) World Bank Effect Estimate β_1	(3) Audit Treatment Effect, WB Sites β_2	(4) Audit Treatment Effect, AfDB Sites β_3	(5) N
Outcome 6: Reliability and safety index	0.01	-0.11	0.03	-0.01	944
	[0.99]	(0.13)	(0.14)	(0.11)	
Had power in past 7 days (=1) (of electrified hh)	0.88	0.06	-0.02	0.11***	787
	[0.32]	(0.04)	(0.04)	(0.03)	
No regular blackouts (=1) (of electrified hh)	0.58	-0.11**	0.03	-0.05	787
	[0.49]	(0.06)	(0.06)	(0.06)	
No blackout in past 7 days (=1) (of hh w/ power last 7 days)	0.40	0.01	0.01	0.07	703
	[0.49]	(0.07)	(0.07)	(0.07)	
(-) Hours power not working in past 7 days (of hh w/ power last 7 days)	7.12	1.74	-2.86*	0.56	700
	[15.04]	(1.91)	(1.66)	(1.86)	
No blackouts ≥30 days in past year (=1) (of electrified hh)	0.95	-0.06	0.01	-0.02	787
	[0.23]	(0.04)	(0.04)	(0.03)	
No injury from 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 from 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 A11: Knowledge

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

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 A12: Electricity Usage

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

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 A13: Household Socioeconomic Outcomes

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

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 A14: Firm Performance

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

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 A15: Household Political and Social Beliefs

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

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 A16: Impact of gradient and facility type on construction delays

Panel A) Months to stringing completion

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

Panel B) Months to metering completion

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

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

Table A17: 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 A1) this does not drive heterogeneity in the impact of WB conditionality on construction delays when compared with AfDB sites. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A18: Primary engineering and socioeconomic outcomes excluding Lots 3 and 5

	(1) WB Effect Estimate	(2) Audit Treatment Effect, WB Sites β_1	(3) Audit Treatment Effect, AfDB Sites β_2	(4) N β_3
Outcome 1: Construction quality index	0.57	0.13	0.05	161
	(0.50)	(0.49)	(0.19)	
Outcome 2: Network size and configuration index	0.69*	0.08	0.06	156
	(0.40)	(0.35)	(0.21)	
Outcome 3: Construction timing index	-1.13***	-0.15	-0.36**	161
	(0.38)	(0.39)	(0.17)	
Outcome 4: Household installation quality index	-0.55**	0.79***	0.23*	592
	(0.26)	(0.23)	(0.13)	
Outcome 5: Household cost, experience, bribery index	0.39**	0.11	0.11	592
	(0.19)	(0.18)	(0.10)	
Outcome 6: Reliability and safety index	-0.12	-0.18	-0.08	592
	(0.16)	(0.17)	(0.10)	
Outcome 7: Knowledge index	0.31	-0.09	0.10	592
	(0.20)	(0.20)	(0.10)	
Outcome 8: Electricity Usage index	-0.24	0.53***	0.25*	592
	(0.31)	(0.19)	(0.14)	
Outcome 9: Household socioeconomic outcomes index	0.13	0.10	0.25*	592
	(0.25)	(0.21)	(0.13)	
Outcome 10: Firm Performance Index	-0.27	0.08	0.02	256
	(0.42)	(0.43)	(0.17)	
Outcome 11: Political and Social Beliefs index	0.01	-0.02	0.02	592
	(0.16)	(0.13)	(0.09)	

This table replicates Table 5 but excludes Lots 3 and 5 and then retains only a balanced panel of constituencies. Subsection 6.6 provides more detail. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A19: Connections and poles installed per site excluding nearby sites

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

This table replicates Table 3 but excluding sites that are less than 1,200 of another site, as the areas within 600 meters of such sites would overlap (see Subsection 5.1 for a discussion of this problem). If anything, this version more strongly supports our results. All regressions include constituency fixed effects. Standard errors shown in parentheses. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

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

This barrier was not only a significant financial hurdle, but one that was unanticipated and poorly understood. According to Kenya Power, households should have been informed of the payment structure as part of the consent process, which was the very first step in the construction process, but it is unclear whether this consent process was regularly implemented in practice. To verify whether this process was correctly implemented, and to test whether donor conditionality and monitoring can improve adherence to these guidelines, the household survey (described in 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 ready boards. In a May 2015 address, President Kenyatta described this policy as follows: *"The Ministry of Energy has also come up with designs that will enable households that do not have internal wiring in their houses to use electricity by providing a 'ready board'... [it] has switches, sockets and bulb holders and those who do not have wiring in their houses will be able to use electricity as soon as they are connected*" (Kenya Presidency 2015).

C.2 Informal and illegal connections

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

C.3 Unconnected households

The LMCP's objective was to connect all unconnected households to electricity, however, in practice connectivity was not universal. At the average site at least 7% of compounds were not connected to the grid, and at the 90th percentile site at least 25% of households were not connected.[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 ready boards to low-income households, the cost of household wiring remained a barrier that prevented some households from getting connected.

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

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

[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.

C.4 Experiences with bribery

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

C.5 Contractors

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

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

There is no blanket provision preventing firms from submitting—or being awarded—bids with both donors simultaneously. Indeed, many of the AfDB contractors named above have in the past bid on—and in many cases been awarded—WB contracts. International procurement can be thought of as a repeated game: poor contract performance can have serious ramifications on long-term outcomes. Several LMCP contractors have been debarred at least once by the WB or the AfDB (Kenya Power 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.6 Oversight

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

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

C.7 Robustness tests

We begin by assessing potential endogeneity concerns related to the assignment mechanism raised in Subsection 4.1. First, WB-funded sites have a 13% higher average land gradient. It is plausible that hilliness slows construction and that this difference explains the WB delays. We therefore examine whether land gradient hay have caused any of the difference in construction delays by funder assignment. Land gradient is uncorrelated with construction delays, both unconditionally and conditional on funder: the WB delays persist in a stable manner when controlling for land gradient (Table A16). Furthermore, lag between WB and AfDB is approximately constant across the entire land gradient support (Figure A10). 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 A1). The gap in timing between WB and AfDB sites is not significantly different across facility types (Table A17), and the gap in timing between WB and AfDB sites persists when controlling for facility type (Table A16). All results in Table 5 control for facility type, which do not qualitatively affect the results. Evaluated together, these analyses make it unlikely that baseline differences in facility type contribute meaningfully to the results.

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

For Outcome 4 measuring household installation quality (Table A8) we replicate the index omitting the question asking the respondent whether they have a ready board, since it is not obvious whether the presence of a ready board is a positive or negative component. Its presence simultaneously indicates Kenya Power provisions and a lack of household preparedness (see Subsection 3.5 for more detail).

Of the 250 sites that we surveyed, 26 are located less than 1,200 meters from another site. Given that AfDB sites saw construction on average earlier than WB sites, this could reduce construction at WB sites, as the subset of that site's unconnected households that lie within the 600 meter radius of the nearby site might already have been connected. This could explain why Table 3 indicates less construction at WB sites. To test this, we replicate this table excluding the 26 sites—12 AfDB and 14 WB—that are within 1,200 of another site. Table A19 shows the results. If anything, the gap between construction at WB and AfDB sites is even larger.

Finally, the private contractor awarded lots 3 and 5 of the WB construction contracts[30] experienced unusual financial circumstances and this may have interfered with the timeliness and quality of their construction. We therefore repeat the analysis from Table 5 excluding these contracts, and then only keeping a balanced panel of counties. This does not affect results: if anything, household installation quality and reliability and safety were slightly worse at the remaining WB sites, although the results are noisier (Table A18).

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

C.8 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 $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.9 Resilience

Construction might affect resilience through two key engineering channels. First, voltage quality tends to worsen with distance from the central transformer.[31] 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 A20 shows no difference between funders in distance resilience.

Table A20: 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

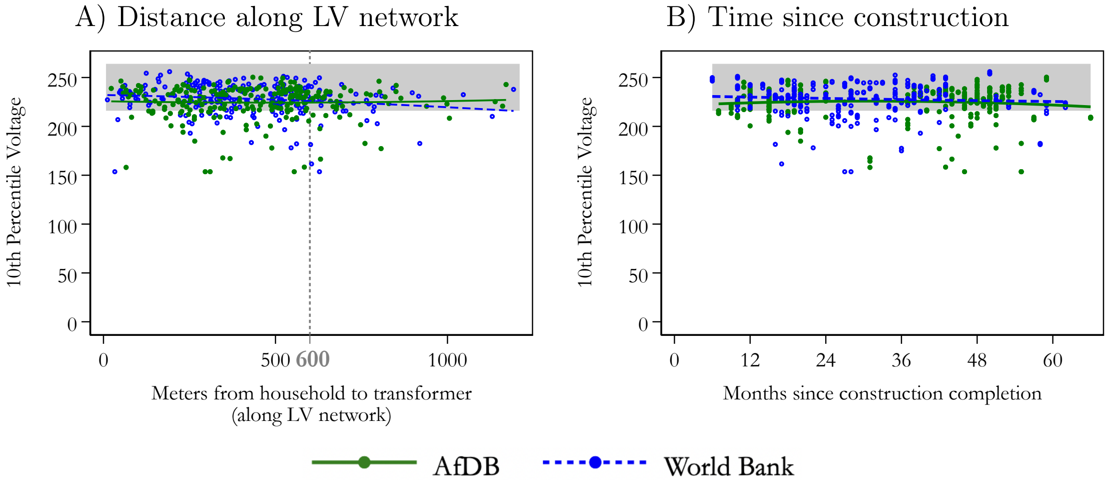
Standard errors are clustered by respondent and shown in parentheses. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Panel A of Figure A13 explores the correlation between 10th percentage of voltage quality and distance to the transformer along the LV network.[32] There does not appear to be a significant

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

[32] 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 A13: 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.

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 A13 examines the correlation between voltage quality and time since construction. At both AfDB and WB sites, the grid appears resilient to aging for the first five years after the completion of stringing.

D List of individuals engaged in qualitative interviews

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

- World Bank employees:
  - Practice manager, Global energy and extractives practice, Africa region
  - Senior energy specialist, Kenya country team
  - Energy finance specialist, Kenya country team
- African Development Bank employees:
  - Principal power engineer*
  - Principal power engineer*
- Kenya Power employees:

  - General manager of connectivity
  - General manager of infrastructure development
  - LMCP Contract Project Manager (AfDB Phase I)
  - LMCP Project Leader (AfDB Phase I)
  - LMCP Contract Project Manager (WB)
  - LMCP Project Leader (WB)
  - LMCP Project Leader for (AfDB Phase II)
- Project Management Consultant employees:
  - Senior Manager