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

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Abstract

Public procurement regulations often aim to improve quality and value-for-money, but causal evidence on the effects of such regulations is limited due to the endogeneity and homogeneity of regulations across projects. Similarly, multilateral donors impose conditions when financing public construction, but again, their impacts are fiercely debated. This paper uses policy and experimental variation to generate causal evidence on how two key contract features—bundling and monitoring—affect economic development project outcomes. We leverage an unusual feature of Kenya's nationwide electrification program: the quasi-random allocation of multilateral funding sources across nearby villages. African Development Bank villages used bundled contracts while World Bank villages used unbundled contracts and strengthened inspections. We collect on-the-ground engineering assessments of the electricity network, minute-by-minute outage and voltage data, household survey data on connection quality and usage, procurement contracts, and inspection reports. The analysis shows that WB procedures delayed construction by almost 16 months on average relative to AfDB sites but improved construction quality by 0.6 standard deviations. To disentangle the two mechanisms, we implement a randomized audits scheme. Audits improve network size, voltage, and household connectivity at AfDB sites, but have no impact at WB sites, in line with the WB's already strong inspections. Net benefits depend on time preferences and infrastructure longevity: plausible assumptions indicate anywhere from 4% of contract value in net benefits for WB processes to 7% of contract value in net benefits of AfDB processes. In this context, streamlining contract structures while strengthening audits could improve outcomes while avoiding delays.

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1 Introduction

Government agencies often rely on private firms to supply goods and services: public procurement spending amounts to about 12% of global GDP (Bosio et al. 2022). Procurement regulations can improve project outcomes, but 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: between 2000 and 2022 the World Bank awarded 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, 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 "contracts that bundle the design-and-build phase"—a key focus of this paper. And while a rich literature on foreign aid donors studies *policy* conditionality (Archibong et al. 2021; Andersen et al. 2022; Easterly 2002), public procurement often faces *procedural* conditions. These 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 is hampered by the infrequency, endogeneity, politicization, and complexity of large infrastructure projects.

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): at a cost of $600 million, one of Kenya's largest public infrastructure projects. Kenya is a useful context in which to study public procurement as it is representative of low- and middle-income countries in terms of regulatory strictness, favoritism, corruption, and delays (Bosio et al. 2022). The Government of Kenya selected 9,520 under-grid villages for the LMCP, where all unconnected households within 600 meters of the existing grid would be connected.

Construction was outsourced to dozens of private contractors selected through harmonized competitive bidding. The program's key features—the contract principal (the electric utility, Kenya Power), eligibility, pricing, and network specifications—were identical across all LMCP villages, as was Kenya Power's eventual ownership and operation of electricity networks. However, processes used at the 4,200 sites funded by the World Bank (WB) and the 5,320 sites funded by the African Development Bank (AfDB) differed in two crucial ways. First, the AfDB awarded 10 'bundled' contracts that included network designs, materials, and installation. In contrast, the WB awarded 29 specialized, heterogeneous contracts.[1] Second, the WB required more detailed ex post inspections of completed sites before handover to the utility. The impacts of these contract features were unclear ex ante: WB representatives argued they would improve outcomes, while Kenya Power representatives argued that they would lead to administrative costs and delays without adding benefit.

In this paper's main contribution, we use both natural policy variation and experimental variation to identify the causal impacts of contracting procedures on project outcomes. First, we leverage

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

a useful program feature: LMCP sites were assigned to be funded either by the WB or the AfDB in a way that was arbitrary and can reasonably be thought of as quasi-random and without obvious regard to factors that would impact the project outcomes this paper studies. Different funders often supported literally neighboring villages: 95% of WB sites in our sample are within 10km (6mi) of an AfDB site. The econometric analyses include constituency fixed effects to account for geographic or socioeconomic heterogeneity. We conduct a battery of baseline balance tests using geographic, satellite, road, and census data to quantify the extent of imbalance between WB and AfDB sites across a range of covariates: they appear balanced along most attributes, and any selection appears uncorrelated with the outcomes of interest. Second, to disentangle two key procedural differences—bundling and monitoring—we implement a randomized auditing intervention (with the support of partners at the WB, the AfDB, and Kenya Power) designed to mimic the WB's additional inspections. A subset of sites was randomized into the audit intervention: through in-person meetings, contractors were informed that key aspects of the completed construction at these sites would be measured and reported to the WB and AfDB.

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

The 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 was delayed and led to fewer pole installations and household connections, partly due to onerous administrative hurdles. Metering at WB sites was completed on average 16 months later than at AfDB-funded sites, though after four years the share of completed sites is nearly identical across the two funders, and there were 12% fewer poles and 14% fewer customer connections per site at surveyed WB sites. Second, in terms of benefits, the WB requirements improved on-the-ground construction quality by 0.6 standard deviations: 77% of WB sites had higher quality construction than the median AfDB site. These improvements manifested across many dimensions: poles at WB sites were 23% more likely to have all indicators of a high quality pole including a pole cap, no crack, and a correctly installed strut and stay when required. There are no differences in electricity reliability and voltage quality, 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 not generally statistically significant. The improvements in construction quality likely have more meaningful implications for pole longevity and long-term maintenance costs.

To disentangle the impact of WB inspections from the WB's unbundled contracting, we examine the results of the randomized audit experiment. The audits have no impact at WB sites, in line with the fact that WB sites already faced additional inspections, and that contractors at WB sites faced additional constraints under the unbundled contracting approach. On the other hand, the audits cause significant improvements in construction quality at AfDB sites. Contractors installed 20% more poles (and 11% more customer connections, though this is not significant), and households at these site experience higher power quality: the audit treatment halves the average gap between experienced and nominal voltage. Households furthermore report higher household connectivity and energy usage. Importantly, the audits came at relatively low cost and caused a shorter delay, generating large positive net benefits.

Finally, we compare the various approaches' costs and benefits. The average cost per new household connection was \$563 at AfDB sites and \$728 at WB sites (30% higher), driven both by lower per-site costs and larger numbers of new connections at AfDB sites. The net impact of improved longevity but delayed construction will depend on the foregone household benefit, the funder's discount rate and time horizon, and the impact of improved construction quality on long term maintenance and replacement costs: engineering sources suggest these gains could extend equipment life by multiple years. Under even a modest range of assumptions, the net benefit could range anywhere from a net benefit at AfDB sites worth 7% of project costs to a net benefit at WB sites worth 4% of project costs. In theory, a third structure that combines bundled contracts with enhanced ex post audits could reduce delays while achieving similar improvements in quality, and might therefore be preferred to both approaches—at least in contexts with relatively strong domestic institutions such as Kenya (relative to many of its East African neighbors).

These results point to a trade-off between short-term costs and long-term benefits. For policymakers or individuals with a higher discount rate or a shorter time horizon, or for projects with compounding benefits, timelier construction might increase net benefits. Conversely, in situations where maintenance costs are expected to rise more quickly with poor quality, a delayed start might be worth the improved long-term outcomes. This framework can also explain why some political agents, facing electoral or other short-term domestic pressures, may prefer to match with donors who can act with the necessary degree of expediency.

Any relatively short- to medium-run analysis focusing on project outcomes, like ours, has empirical limitations. Procedures may generate additional positive benefits in ways we cannot measure, such as strengthened institutional capacity. We are unable to measure leakage, and this may have been an important concern—however, to the extent that leakage would have reduced construction quality or quantity, we find limited evidence of this.

The debate about donor conditionality dates back to the 'Washington Consensus' era in the 1980s (Archibong et al. 2021; Williamson 2009; Easterly 2002; Mosley 1987; Hermes and Lensink 2001; Temple 2010, among many others). World Bank (2005) provides a thorough review of the evolution of donor conditions, which increasingly emphasize procedures and processes, "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 costs and benefits subject to significant debate. Research suggests procedural conditionality can cause politically motivated delays and incur costs that exceed the benefits (Kersting and Kilby 2016; Kilby 2013). And, concerns around political interference remain relevant: Andersen et al. (2022) find that up to 10% of WB financing are transferred to offshore financial havens in the months after a transfer. In empirically evaluating on-the-ground construction of development projects in Africa we relate to Moscona (2020), Marx (2018), Williams (2017), and Rasul and Rogger (2018).

The recent growth of Chinese state lending to low- and middle-income countries has been subject to recent debates (Mihalyi et al. 2022; The Africa Report, 2022). The Chinese government states its approach is one of non-interference in local policy-making and politics (State Council 2011). Its expediency may be preferred by politicians operating under shorter time horizons, but the limited oversight generates concerns about the quality and resilience of construction (Dreher et al. 2021; The Economist, 2017). There is recent evidence that Chinese aid projects increase reports of local corruption substantially in African settings (Isaksson and Kotsadam 2018; Ping et al. 2022; Malik et al. 2021). While China has made significant investments in Kenya's electricity sector, to the best of our knowledge they have not contributed to the LMCP.

Mass government electrification programs are widespread and ongoing in LMICs, especially in Sub-Saharan Africa. Poor construction quality can harm power quality, and Blimpo and Cosgrove-Davies (2019) find that in some countries in Sub-Saharan Africa, most connected households "reported receiving electricity less than 50% of the time," potentially undermining the economic growth that household connections were designed to generate. 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 (2021) find that improved electricity reliability increases the impacts of rural electrification in larger villages. To the extent that low quality infrastructure exacerbates poor power quality and slows economic growth, identifying opportunities to improve construction quality—including through donor contracting conditions—may lead to meaningful improvements in economic outcomes.

2 Framework for contract bundling and oversight

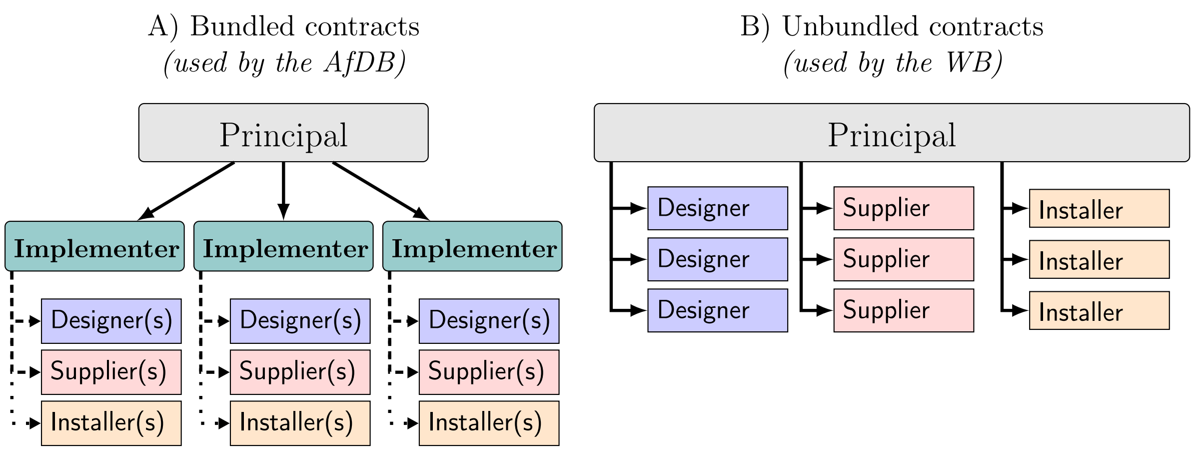
An extensive literature in contract theory studies the public procurement of goods and services (Bosio et al. 2022; Tadelis 2012; Levin and Tadelis 2010; Williamson 1999; Hart et al. 1997). However, relatively few papers have empirically studied the impacts of different procurement structures. One such structure is the bundling of components, such as 'design-and-build'. 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 is scant, despite this being a common design choice in procurement auctions for major public infrastructure projects. In Glaeser and Poterba (2021), 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." Very few paper causally estimate the impact of bundling contracts (Hoppe et al. (2013), an 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 infrastructure project in a high-stakes public procurement context using natural and experimental variation and granular, independently-collected construction quality data.

To fix ideas, consider a principal (such as a government agency) who has a project that they want completed. The project consists of $\kappa > 1$ components, such as design, supplies, or installation, completed through N contracts. Denote contract i's cost as C_i, and denote the aggregate amount contracted out as $\bar{C}$. The principal can choose the number of types of contracts t, with $N \geq t$. Increasing t enables closer oversight but at administrative cost $A(t)$. After contract signing, the principal can exert monitoring effort e at cost $c(e)$ to improve quality $Q_i(e,t)$. Increasing t or e incurs a delay, reducing the net present value of project benefits by a discount function $D(e,t) < 1$.

Figure 1 shows two contracting structures. Define a bundled contracting structure (Panel A) to be the special case where $t = 1$: there is only one type of contract, namely N_b implementer contracts awarded to implementers who procure components in-house or through subcontracts. Define an unbundled contracting structure (Panel B) to be the case where $t = \kappa$ and the principal procures components directly.

The principal weighs quality- and delay-adjusted project benefits against effort, administrative, and financial costs. They prefer an unbundled structure if the net benefits of the optimal unbundled

Figure 1: Bundled and unbundled contracting structures



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 the case of the LMCP, the principal Kenya Power used a bundled structure at AfDB sites (awarding 10 bundled contracts) and an unbundled structure at WB sites (awarding 35 heterogeneous contracts).

contracting structure exceed the net benefits of the optimal bundled contracting structure (where e^* denotes the optimal monitoring effort conditional on bundling structure):

$$\underbrace{\sum_{j=1}^{N_u}\big[D_u(e_u^*,\kappa)Q_j(e_u^*,\kappa)-C_j\big]-c(e_u^*)-A(\kappa)}_{\text{Net benefit of unbundled contracting}} > \underbrace{\sum_{i=1}^{N_b}\big[D_b(e_b^*,1)Q_i(e_b^*,1)-C_i\big]-c(e_b^*)-A(1)}_{\text{Net benefit of bundled contracting}} \quad (1)$$

Rewriting this, the principal prefers an unbundled structure *if and only if* it yields sufficiently large benefits in the form of cost savings or quality improvements:

$$\underbrace{D_u(e_u^*,\kappa)\sum_{j=1}^{N_u}Q_j(e_u^*,\kappa)-D_b(e_b^*,1)\sum_{i=1}^{N_b}Q_i(e_b^*,1)}_{\substack{\text{Delay-adjusted quality}\\ \text{benefits of unbundling}}} - \underbrace{\big(\bar{C}_u-\bar{C}_b\big)}_{\substack{\text{Cost savings}\\ \text{of unbundling}}} > \underbrace{A(\kappa)-A(1)}_{\substack{\text{Relative}\\ \text{administrative cost}\\ \text{of unbundling}}} + \underbrace{c(e_u^*)-c(e_b^*)}_{\substack{\text{Relative}\\ \text{effort cost}\\ \text{of unbundling}}} \quad (2)$$

This conceptual framework helps identify several mechanisms that our conversations with policy makers have suggested are at play when they administer procurement contracts. Section 4 will discuss how we leverage experimental and natural policy variation to investigate how bundling and monitoring effort affect project outcomes. Section 6 will present quantitative and qualitative analyses to shed light on the empirical implications of these mechanisms in the context of Kenya's LMCP. Intuitively, the preferred method in any particular context will depend on the levels and functional form of the variables and functions described above. For example, improvements in public sector institutional capacity may lower effort or administrative costs (Bosio et al. 2022; Muralidharan et al. 2016; Williams 2021).

Empirical implication 1: Bundling affects provider selection, with ambiguous effects on quality. If the principal and the implementer employ different procedures (either by choice or by regulation) then bundling may affect (sub)contractor selection and contracting. For example, the principal may be subject to more stringent regulations than the implementer. This might improve quality by removing the option to cut costs by choosing lower quality providers, or it could limit valuable discretion if the implementer has information about subcontractor characteristics that are difficult to contract on (Carril 2021; Carril et al. 2022; Fazio 2022; Decarolis 2014). Bundling also reduces the principal's influence over component provider selection. This could generate benefits if, for example the implementer has private information about subcontractors that would benefit the project's quality or timeliness (Bosio et al. 2022; Duflo et al. 2018). On the other hand, the principal may want to exert influence for unrelated reasons, such as supporting small, domestic firms.

Empirical implication 2: Bundling lowers administrative costs: $A(1) < A(\kappa)$. Increasing t increases administrative cost in two ways. First, it may increase the upfront costs of contract administration. Each additional contract type t incurs a fixed cost of bid solicitation, review and selection, contract writing and structuring, donor approval, contract signing, possible negotiations after signing, and required reporting. Second, it may increase the principal's ongoing informational (as when designs inform material requirements) or physical (as when materials must be physically transferred to installers) cost of coordinating contracts. Imperfect coordination could cause temporal or physical frictions that increase costs or delays. If the principal lacks (has) in-house expertise, coordination costs may be higher (lower) than when delegated to an implementer.

Empirical implication 3: marginal increases in either t or e should increase quality. Increasing t increases quality by allowing the principal to prescribe more detailed and tailored quality control measures for each component, and to more easily observe the actions of component providers, such that $\frac{\delta Q_i(e,t)}{\delta t} > 0$. Increased monitoring effort e has been shown to improve state performance in LMICs (Olken 2007; Ferraz and Finan 2008; Finan et al. 2017; Duflo et al. 2018), such that $\frac{\delta Q_i(e,t)}{\delta e} > 0$. It follows that an unbundled project with high t and high e should have unambiguously higher quality than a bundled project with low t and low e: $Q_i(e_H, t_H) > Q_i(e_L, t_L)$ for $e_H > e_L$ and $t_H > t_L$.

Empirical implication 4: t and e may be substitutes. By more strongly tying providers' hands, t may lower the benefit from additional monitoring, such that $\frac{\delta Q_i(e,t)}{\delta e}$ is higher when t is lower. In other words, monitoring effort and unbundling may be substitutes: $\frac{\delta^2 Q_i}{\delta t \delta e} < 0$. As a result, holding all else constant, bundling increases the principal's optimal effort levels: $e_b^* > e_u^*$.

Empirical implication 5: marginal increases in t should increase delays, but the effect of e is ambiguous. If $A(\kappa) > A(1)$, and the principal is unable to compensate for this by increasing staffing appropriately, then unbundling could generate substantial administrative delays, both ex ante (as contracts are being signed) and during construction (as the principal needs to coordinate the various components). An increase in monitoring e could increase delays, if it holds up construction, or it could reduce delays if the inspections helps ensure contractors stay on time. Furthermore, bundling could introduce new delays if principal appropriately chooses to increase monitoring, since $e_b^* > e_u^*$. The aggregate effect of bundling on timing is therefore ambiguous. Delays may be limited if the principal can dedicate additional human capital to administrative or monitoring activities, or be larger if human capital is limited.

Empirical implication 6: Bundling may increase contract costs: $\bar{C}_b > \bar{C}_u$. For example, bundling may limit the principal's monopsony power generated by procuring key components in aggregate. Bundling may also increase prices if more stringent eligibility requirements usually applied to larger implementer contracts, reduce the number of bidders. If the principal has regulations mandating lowest-cost bidder wins, but implementing contractors do not face such regulations, then bundling could increase costs if implementing contractors expect to choose more expensive subcontractors. Finally, to the extent that bundling moves administrative or effort costs onto implementers, these costs may passed through to the principal through increased bid amounts.

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. Nationwide household electricity access was reported to have increased from 25% in 2009 to 70% in 2019 (KNBS 2009, 2019). The LMCP was to be financed by the AfDB, the WB, the European Investment Bank, the Agence Française de Développement, the European Union, and the Government of Kenya (Kenya Power 2016a). This paper focuses on the portion of the LMCP 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. This is standard practice among international development banks. Between 2000 and 2022 the WB financed more than 21,000 projects, at an average cost of \$74.2 million per project. This included 2,315 projects related to energy or power, including 754 in Sub-Saharan Africa. The procurement of works, goods, or services for each project is often contracted out to private sector contractors: the World Bank awarded more than 311,000 procurement contracts during this period, more than 100,000 of which for projects in Sub-Saharan Africa. Extensive WB regulations—detailing the procurement, financial management, and disbursal of funds—apply widely and homogenously across sectors and countries:

> "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 20 years international donors have increased their efforts to moderate the cost of complying with regulations by streamlining and harmonizing their policies. WB and AfDB regulations now have significant overlap (WB 2014).

One of the goals of these regulations is to curtail corruption and political abuse. In Kenya, 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] That said, leakage is notoriously hard to measure. We are unable to identify specific instances of stolen or diverted funds in this paper, but it is an important concern that may have motivated the donors' different contracting decisions. Section 7 compares aggregate costs with construction quantity and quality to evaluate spending efficacy.

3.1 Harmonized procedures

While the LMCP was financed through various channels, it was a single nationwide project implemented by Kenya Power under a uniform set of specifications. As of 2017 there were 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 are connected (Lee et al. 2016). Kenya Power

[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).

and members of parliament selected 8,520 such transformers for the LMCP, targeting an equitable 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 at a site at the same time—referred to as 'maximization'—generated cost efficiencies by leveraging economies of scale. Eligible households benefited from a reduced electricity connection price, from $350 down to $150, and from the ability to pay it off in monthly installments, with no upfront cost. The program was also touted as reducing the red tape associated with new electricity connections by eliminating the laborious process of applying for electricity, which can take months and often requires significant paperwork. Instead, Kenya Power contractors would proactively visit households to initiate the connection process, with minimal effort for households. Appendix C provides additional information about the LMCP.

AfDB Phase I financed the maximization of 5,320 of these transformers and the WB financed the maximization of 3,200 (Kenya Power 2017, 2016a).[3] Importantly for this paper's empirical approach, 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.

Funding was disbursed through contracts awarded to domestic and international private-sector contractors through competitive bidding. The tender documentation for both WB- and AfDB-funded contracts contained detailed technical specifications for the procurement and installation of poles, wires, conductors, fuses, and meters, specifications which were 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. WB and AfDB can both debar contractors with egregiously poor performance, and debarments generally apply globally: under-performance can lead to disqualification from contracts in other countries by other donors in different sectors. Independent audits can therefore be a meaningful economic threat for contractors, which we exploit in our randomized audits treatment, discussed in Subsection 4.2.

Both funders financed several contracts with external consultants to oversee construction and manage relationships with contractors. They also coordinated nationwide contracts for the procurement of meters to facilitate integration with Kenya Power's operational systems.

While the two funders' procedures were largely identical, there were two key differences between the donors: bundling and monitoring. The next two sections discuss these differences.

3.2 Contract bundling

The AfDB imposed a bundled contracting approach often referred to in this context as 'turn-key', which "provides for full design, supply, erection and commissioning of the works by a single contractor at a fixed lump sum price" (AfDB 2018). Each of the ten AfDB turn-key contracts comprised the entire construction process of all LMCP transformers in one of ten pre-defined clusters of counties.

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

This process included designing an efficient extension of the LV network to reach unconnected households, procuring the necessary materials, and installing these materials. Together with a metering contract and a consulting contract, Kenya Power awarded 12 AfDB contracts.

The WB on the other hand opted for an unbundled approach for the LMCP. Eight contracts were first issued for designs detailing the proposed LV network extensions across eight sets of sites. Once designs had been completed, 15 contracts were issued to procure materials: six contracts for wooden poles, three for concrete poles, three for conductors, and three for cables. Kenya Power then issued six contracts for installation, with each contract including all LMCP sites located in one of six geographic clusters of counties. The WB component also included two metering contracts and four consulting contracts, for a total of 35 contracts.[4]

Figure 2 shows that initial funding approvals from the AfDB and WB were finalized around the same time: November 2014 and March 2015, respectively. Project appraisal reports for both funders (released in October 2014 and March 2015 respectively) indicate that initial contract signing was planned for early 2016 (AfDB 2014; WB 2015). By mid-2016, Kenya Power had signed all 12 AfDB contracts (Kenya Power 2015a). The WB initially followed a similar timeline, with design contracts signed by March 2016. However, contracting proceeded more slowly after this. Materials contracts were signed starting in February 2017 and installation contracts in November 2017, a substantial delay relative to the project timeline at the time of approval (Kenya Power 2017). The AfDB turnkey contracts specified that construction would start June 2016 and commissioning would take place by June 2017. The WB installation contracts specified that installation would commence between January and August of 2018 and site commissioning would take place by June 2019. In practice, the timing for both WB and AfDB activities slipped relative to these plans, as we document below.

These structures are not fixed by donor: the AfDB and WB decisions to use bundled and unbundled contracting for the LMCP were made independently, ex ante, informed by discussions with Kenya Power and the donors' previous experiences in Kenya. In other sectors and countries the WB often awards bundled contracts, and vice versa. The WB Procurement Regulations for Borrowers (2020) states that the "selection of contract types and arrangements takes into account the nature, risk, and complexity of the procurement, and [Value for Money]". 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.

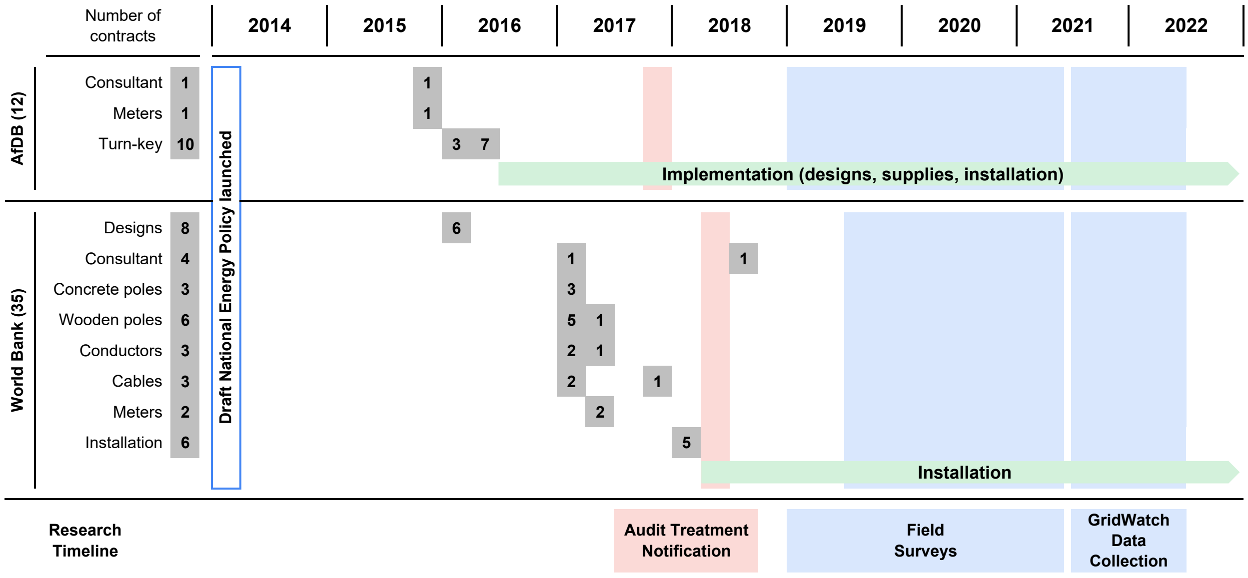
3.3 Monitoring and oversight

In the context of the LMCP, oversight can be split into four channels. Across the first three channels, the similarities between WB and AfDB procedures overwhelmingly outweigh the differences. For the fourth channel, as we discuss below, the WB's procedures are more onerous than the AfDB.

First, each donor required similar materials inspections. A team representing Kenya Power

[4] One for the 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 activities and research components. GoK discussions with WB and AfDB started after the release of the Draft National Energy Policy in 2014. 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.

(including members from Kenya Power's LMCP management team, supply chain department, and operations & management department) would visit the contractors' factories to inspect the materials. The WB furthermore required that each pole be physically marked such that these could be easily verified upon arrival at Kenya Power storage facilities.

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

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

Fourth, each donor required a consultant be hired 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.

Despite these similarities, WB and AfDB inspection procedures contained one notable difference. Prior to the joint inspection that would produce the JMC, the WB consultant did an 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 usually conducted

[5]Comments from the IRs include, for example, "pole caps are poorly installed" and "the strut pole bolt is not

in advance of the JMC, allowing the contractor to fix any issues before the JMC visit, but in some cases the JMC and IR visits were conducted concurrently to reduce travel costs. Since the IR was not required at AfDB sites, it was common for a JMC to be issued even when no new household meters had been installed yet—before the local community was actually receiving power. This had important important on the timing of households electricity connections, as we will see later on.

3.4 Contractor and subcontractor selection

The 12 AfDB contracts were awarded to 10 unique contractors, with two contractors winning two turn-key contracts each. The 35 WB contracts were awarded to 31 unique contractors with four contractors winning two contracts each. Other than a harmonized metering contractor,[6] there was no overlap between AfDB and WB contractors.

As is common under bundled contracting, AfDB contractors procured much of the design, materials, and installation from subcontractors. There was overlap between the WB contractors and the subcontractors from which AfDB turnkey contractors procured goods or services (Section 8 describes this in more detail). This overlap could have affected the timing or quality of poles supplied if firms supplied high-quality poles to initial AfDB contracts, leaving lower quality poles for WB sites. However, if anything WB sites had higher quality poles, and conversations with Kenya Power suggest that the timing of pole delivery was not a source of delay. In fact, pole storage became an issue at some WB sites, as materials arrived before installers were ready to begin work.

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

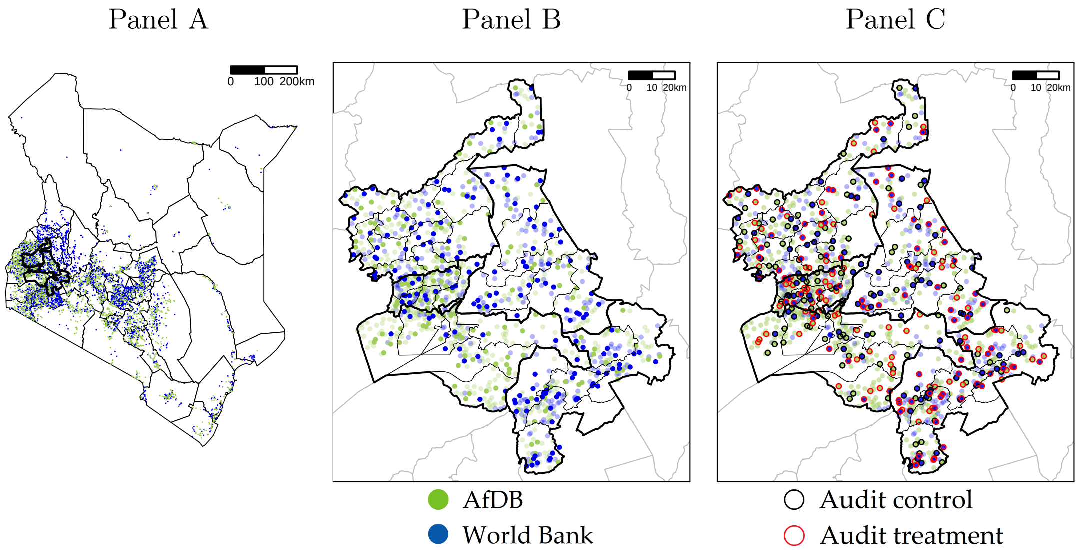
3.5 Household involvement

A correctly installed electricity connection is of little benefit to a household without power sockets or light switches. Household wiring is crucial. During the initial LMCP rollout, households were responsible for installing—or hiring a handyman to install—internal wiring between the meter and the final appliance. Our household surveys indicate that households who were connected prior to the LMCP spent on average \$125 on internal wiring. For many households, this posed a significant financial and logistical barrier. To address this, Kenya Power decided to provide low-income households who could not afford internal wiring with a 'readyboard': an electrical panel that would satisfy the wiring requirements. However, the rollout of readyboards 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.

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.

Figure 3: Sites by funding source and audit treatment status



Panel A maps LMCP sites 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.

While common in urban Kenya, informal or illegal electricity connections are rare in the low-population density rural areas where the LMCP was rolled out (see Appendix C for detail).

4 Research Design

Panel A of Figure 3 displays the nationwide distribution of LMCP sites. To estimate the causal impact of donor procurement structure on project outcomes we exploit the quasi-random assignment of sites to the WB or the AfDB, which prescribed different procedures. To examine how monitoring affects project outcomes, we then implement a randomized audits scheme.

4.1 Quasi-random assignment of sites to international financing

Each LMCP transformer was assigned to be financed by either the WB or the AfDB. To avoid appearing to have political biases, each funder aimed to fund a nationally distributed set of sites. 265 of Kenya's 290 constituencies contain at least one LMCP site and 210 contain at least one AfDB and one WB site.[7]

From June 2016 through July 2022 members of the research team held extensive private meetings with key Kenya Power personnel. This included meetings with 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 read correspondence

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

between Kenya Power and dozens of members of parliament deciding which transformers would be included in each phase of the LMCP. Overall, the pattern that we consistently observed was that assignment was ad hoc and did not follow any particular allocation rule. Given that the mandates were identical—to connect all households within 600 meters of a transformer—Kenya Power and the GoK did not appear to see any strategic benefit in having a transformer funded by one donor or the other.

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, 1,139 are located in the five study counties where we collected detail on-the-ground assessments, magnified in Panel B. The five study counties 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. In line with explanations provided by the electric utility, there does not appear to be spatial clustering by donor. 95% of WB sites in this sample are located within 10km 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 quality, would be a threat to our identification strategy. While we have no evidence of this, possible reasons could include political influence, economic growth expectations, or personal favor. We conduct several quantitative balance tests to examine whether there are any underlying differences between WB and AfDB sites. Table 1 tests for balance across AfDB and WB sites 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 this is balanced across WB and AfDB sites. Columns (3) and (4) show that pre-LMCP nighttime radiance levels were statistically indistinguishable. WB and AfDB sites furthermore have indistinguishable nighttime radiance trends prior to the LMCP (Figure A1). Table 2 tests for balance in socioeconomic characteristics measured before the LMCP announcement. The fraction of WB-funded sites in a ward is not correlated with the fraction of households with a high quality roof or electricity, the fraction of individuals with primary or secondary education, the

Table 1: Geographic balance of World Bank and African Development Bank 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. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

fraction of residents who are 14 years or younger, and average consumption.

Despite these similarities, there are modest differences between WB and AfDB sites. Columns (5) and (6) of Table 1 indicate that WB sites have a 13% higher average land gradient. Table 2 also suggests that there is a slight difference in the fraction of households with an electricity connection and the fraction of households with a solar panel, but these magnitudes are small (about 1 p.p. or less). Most transformers had been connected as part of a push by Kenya's Rural Electrification Authority (REA) between 2005 and 2013 to electrify public facilities like religious buildings and markets. Finally, 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 sites versus 8% of WB sites were were located near a secondary school. Extensive robustness checks confirm that delays and construction quality are uncorrelated with land gradient and facility type, and that the results are constant across the entire support of land gradient and facility type (Subsection 6.5). Still, all regressions control for land gradient, facility type, and baseline ward-level connectivity and solar panel ownership where relevant.

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 LMCP sites in a ward allocated to 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 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. All regressions include constituency fixed effects. Data source: 2006 Household Budget Survey and 2009 Census data. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

4.2 Randomized audits

To disentangle the impacts of bundling and inspections we implement a randomized audit treatment that closely mirrors the WB's Inspection Reports (discussed in Subsection 3.3). After construction at a site was completed, field officers hired by the research team visited each site to inspect crucial details of the electricity network according to specifications developed in collaboration with retired Kenyan electrical engineers. Of the 1,139 LMCP sites in the region, we selected 380 sites for the randomized audits experiment.[8] We randomly assigned 190 to treatment and 190 to control, stratifying 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 field staff 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 A2), and attaching 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 reliability.

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

Audit treatment effects could be underestimated if contractors believed (correctly) that other sites were also more likely to be audited. While the research team took efforts to conceal its activities, contractors may have learned that audits took place at sites not in the audit list. Similarly, if treatment impacted a contractor's general operations across treatment and control sites, this would cause us to underestimate the impacts of the audit treatment. Audit effects may be overestimated if contractors shifted effort from control sites to treatment sites, but such spillovers are likely small:

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

on average, only 7.6% of a contractors' sites were selected for audits.[9]

4.3 Treatment interactions

The interaction of experimental and natural policy variation allows us to empirically investigate the implications discussed in Section 2. Comparing AfDB sites in the audit treatment with WB sites in the audit control allows us to estimate the effect of bundling per se, as AfDB construction was done primarily through uniform implementation contracts ($t = 1$). Comparing AfDB sites in the audit control with AfDB sites in the audit treatment allows us to estimate the effect of monitoring in a low e, low t environment. Comparing WB sites in the audit control with WB sites in the audit treatment allows us to estimate the effect of monitoring in a high e, high t environment. Furthermore, we can test whether the impact of monitoring is different in a low e, low t environment than in a high e, high t environment. Figure 4 provides a schematic. Section 6 discusses the estimation strategy used to leverage these two sources of variation to identify e and t.

Figure 4: Project research design and conceptual mechanisms

<table>
<tr><td colspan="2"></td><td colspan="2">Monitoring effort (e)</td></tr>
<tr><td colspan="2"></td><td>Low</td><td>High</td></tr>
<tr><td rowspan="2">Contract type (t)</td><td>Bundled</td><td>AfDB +
Audit Control</td><td>AfDB +
Audit Treatment</td></tr>
<tr><td>Unbundled</td><td>[Not observed
in this project]</td><td>WB
(Both Audit Groups)</td></tr>
</table>

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

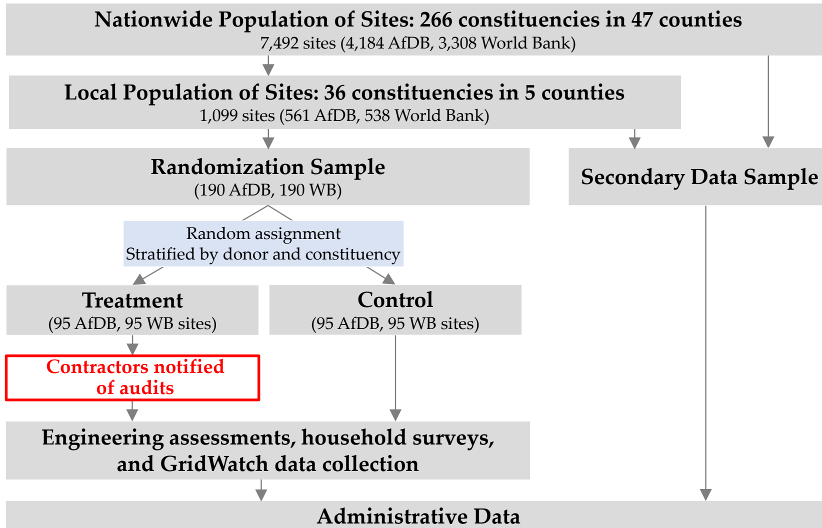
5 Data

We use the utility's official nationwide list of LMCP sites to conduct sample selection, focusing on five study counties: Kakamega, Kericho, Kisumu, Nandi, and Vihiga. Of the 1,139 LMCP sites in this region, we randomly select 380 for detailed on-the-ground data collection, stratifying by constituency and funder. Field officers (FOs) employed by the research team conduct 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 metering, when electricity begins flowing to LMCP households, but not after the start of construction and stringing, suggesting these reports accurately reflect on-the-ground activity (Figure A3).

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

[9]Treatment effects do not vary by whether a below- or above-median fraction of a contractor's sites were audited.

Figure 5: Project design



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

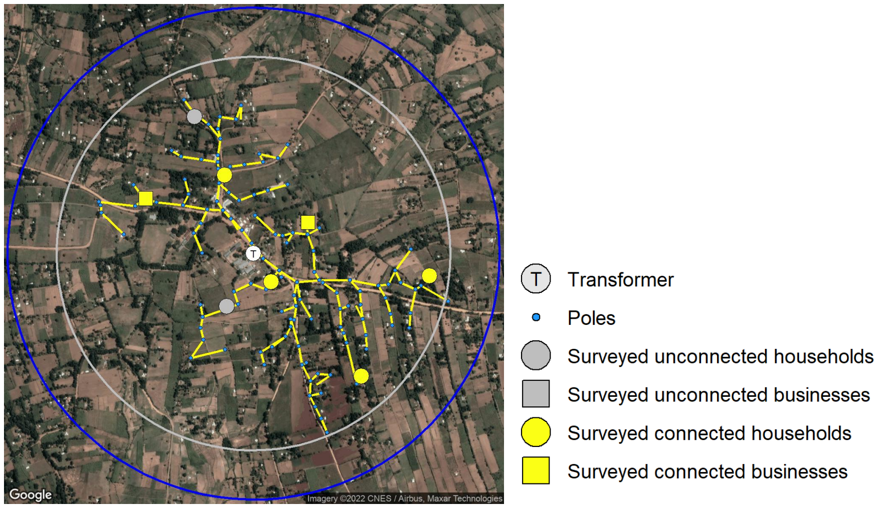
2021. Construction had still not been completed—and usually not even begun—in the remaining sites, limiting surveying activities there to short assessments of any initial planning activities. Field surveys are conducted between six and twelve months after construction is reported to have begun at a site.[10] Roughly half of the surveyed sites are WB sites and half are AfDB sites. Figure 5 provides an overview of these study design elements.

5.1 Engineering assessments

The engineering surveys conducted at these 250 sites were developed in collaboration with recently retired REA engineers with expertise on the technical specifications of Kenya's electricity grid. Data collection consists of two parts. In the initial infrastructure census, FOs record the locations of all poles in the low-voltage network, as well as their connectivity, up to 700 meters from the existing transformer. Kenya Power's LMCP regulations specified that only households within 600 meters of the transformers were eligible for a free connection: the 700 meter radius allows us to test whether construction was completed beyond the eligible region, for example in order to earn informal side payments. They also document the number of poles in the low-voltage network that are further than 700 meters from the transformer and are within sight. Figure 6 displays network data recorded in this first part of the engineering assessment at an example site. The FOs also record the number of drop-down cables (connections between a customer and an electricity pole) connected to each pole, whether the drop-down cable connected a household or a firm, as well as any unconnected compounds located near the pole. This provides a measure of the number of connected

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

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 4-9 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 to preserve respondent anonymity.

and unconnected firms and households across the entire site.

If the local network was too large to map in a single day, FOs would select a random subset of branches to assess. At these sites, scaling the surveyed connections proportionally to the fraction of the grid that was surveyed yields an unbiased estimate of the total number of household connections at that site.[11]

In the second part of the engineering assessment, FOs record characteristics of every pole and the conductors (wiring) that connect them. These measurements focus on outcomes that are most likely to affect the quality and longevity of the electricity grid. They include quality measurements of the pole itself, such as angle relative to the ground, whether it is wood or concrete, whether it is firmly placed in the ground, whether it has a pole cap, whether it has any visible cracks, and whether it has the appropriate grounding wires, stay wires, and struts. For a subset of poles, FOs collect additional data on pole height, circumference at various points, and characteristics of each strut or stay that provides support for that pole.[12] Measurements of the conductors that connect poles include whether it has appropriate ground clearance and clearance from other objects (such as trees,

[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 is able to complete in the time that was allocated for the site. To obtain site-wide estimates, we scale the on-the-ground measurements according to the fraction of the grid that was surveyed.

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

brush, or structures) and whether any electric lines cross. Measurements of the drop-down cables from the pole to the customer include the distance between the pole and the customer's structure and whether the cable ends at a meter. FOs also note whether it appears to be an illegal connection, although this is quite rare in this rural setting, in contrast to some urban and peri-urban settings in Kenya and elsewhere. Finally, measurements of the central transformer at each site include whether the poles on which the transformer is mounted are leaning excessively, the number of missing or bypassed fuses, and whether the transformer has any other obvious defects.

At around one quarter of the transformers at least one fuse was missing or had been bypassed (Table A2). We surveyed on average 87 poles per site, of which about a quarter had a large crack, and 40% of poles were missing a pole cap. 95% of surveyed households were connected in 2016 or later, and the median year in which households were connected was 2019.

Of the 250 transformers we 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. Our 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 would never survey the LV network of a nearby transformer.[13] Second, if one transformer was maximized first, then a nearby transformer might require less expansion of the LV network to reach all remaining unconnected households. We therefore conduct a set of robustness checks dropping these sites (Subsection 6.5). The results do not change.

5.2 Household and firm survey data

After completing the infrastructure census, FOs invited a random subset of connected and unconnected compounds and firms to complete a socioeconomic survey. The goal was to understand their own and their community's experiences with the construction process and electricity connections by asking about the timelines and costs they faced during construction, their connection quality and usage, their knowledge about future costs, experiences around safety and 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 exaggerate public perceptions of program progress. To disentangle this from compound residents' genuine preference for multiple meters, the survey asks not just how many meters are at the compound, but also how many they had requested.

[13]We confirm this manually by visually inspecting all the cases where two transformers are less than 1,200 apart.

5.3 Power quality: outages and voltage

Higher construction quality could potentially reduce local power outages and increase power reliability, which could have tangible benefits for household well-being and firm productivity and profits, especially in the medium- to long-run. To measure reliability and voltage we deploy the GridWatch technology (Klugman et al. 2021; Klugman et al. 2019) with a subset of households and firms that had completed the socioeconomic survey. GridWatch measures minute-by-minute power state and voltage and can be installed by 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 aggregates data to detect patterns in power outages and reduce noisy signals. We aggregate these high-frequency measurements to the daily level, as hours of power per site per day and average voltage per day.

We collect power outage and voltage quality across 150 sites for two months each, staggered between June 2021 and June 2022, deploying four PowerWatch devices per site at a time.[14] All power quality regressions include day-of-sample and constituency fixed effects to control for confounds such as weather and demand.

6 Results

To identify the role of bundling (t) and monitoring effort (e), we use the following estimating equation:

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

where WB_i and AfDB_i indicate whether site i is WB-funded or AfDB-funded. Following Figure 4, Treat_i indicates whether the site is an audit treatment site: β_2 and β_3 allow us to estimate the impact of additional monitoring e, among WB sites and at AfDB sites, respectively. β_1 measures outcomes at WB sites relative to AfDB sites, among audit control sites, such that the pure impact of bundling t is captured by $\beta_3 - \beta_1$.

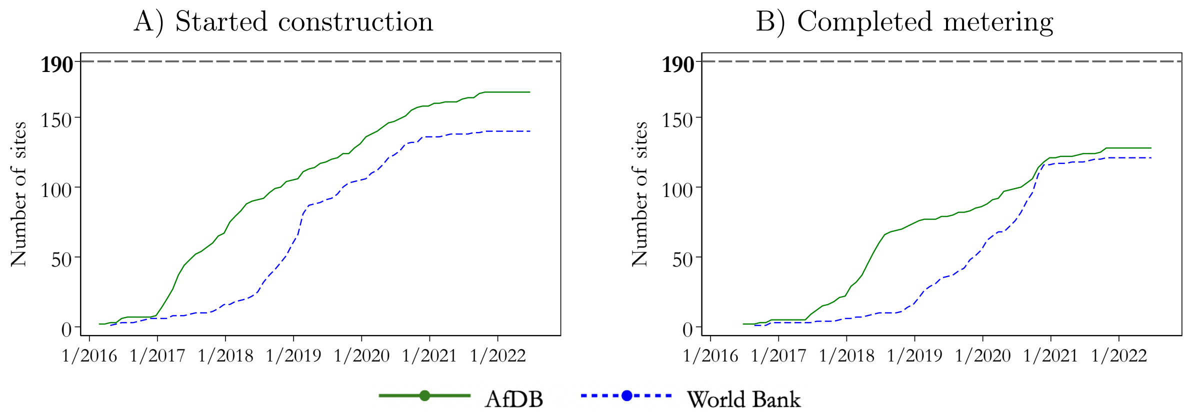
Γ are fixed effects which vary across specifications. Standard errors are clustered by site in all regressions except those run at the site level.

Subsection 6.1 first documents patterns in construction delays. Subsection 6.2 then analyzes the number of sites that saw construction, and the number of poles and household connections at sites that did see construction. The next two subsections examine construction quality: Subsection 6.3 examines power outages and voltage quality, while Subsection 6.4 presents results that use the on-the-ground household and engineering assessments.

Across these sections, we see three main patterns. First, delays are significant at WB sites, and are modest but meaningful at audit treatment sites. Second, WB sites see a lower quantity but higher quality of construction. Third, audit treatments improve quantity and quality at AfDB sites but not at WB sites.

[14] The sample was reduced from 250 to 150 sites due to Covid-19-associated delays and cost increases.

Figure 7: Construction progress by funding source



Data for 190 AfDB sites and 190 WB sites located in the five study counties collected through phone surveys with village representatives. Figure A7 displays progress for two intermediate milestones, pole installation and stringing.

6.1 Construction timing and site completion

Figure 7 demonstrates that construction progress at WB sites lagged significantly behind AfDB sites. Panel A demonstrates that this lag is driven by the initial delay in starting construction, likely driven by the ex ante administrative burden discussed in Section 2. Construction at WB sites started on average 10.2 months later than at AfDB sites (Table A6). 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–9.5 months. However, the delay is then again exacerbated at the final households metering stage, after which the lag is 16 months. Recall that the AfDB teams did not always inspect meters 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. Still, AfDB and WB sites all lagged significantly behind the contract timelines: commissioning had originally been planned for June 2017 and June 2019, respectively.

This matches the empirical implication 5 from Section 2, which suggests that administrative delays from unbundling and the on-the-ground delays caused by requiring monitoring activity can both be substantial.

6.2 Quantity of construction

At the end of surveying in July 2022, more than five years after the start of contracting, household metering had been completed at 71% of both AfDB and WB sites. At that point, a key remaining difference was that construction had been completed only partially at 24% of AfDB sites where construction had started, compared with only 14% of WB sites. The partial completion of public

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

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 field officers, and instead only a randomly selected subset was surveyed: at 93% of sites we surveyed at least 50% of the network. The mean and median portion surveyed were both two-thirds. All regressions include constituency FE. Standard errors shown in parentheses. The sample size in columns (5) – (8) is slightly lower due to field complications. We calculate the quantities of poles and connections at these sites using the engineering survey, but we do not have their GPS coordinates. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

projects in contexts with limited resources is in line with previous evidence (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, among sites where construction was completed, WB sites saw fewer poles and fewer customer connections. This may have been due to the fact that WB installers were constrained by the materials that had been purchased through the WB supply contracts, whereas AfDB contractors could procure additional materials as needed. The average number of poles is 99 at AfDB sites and 88 at WB sites ($p\text{-}val = 0.055$). The average number of customer connections is 76 at completed AfDB sites and 61 at completed WB sites ($p\text{-}val = 0.041$).[16]

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 and monitoring effort may be substitutes, such that monitoring will have a larger impact for bundled contracts (as discussed in empirical implication 4). In the context of the LMCP, the substitution could arise from the WB's existing increased inspections, or 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 supplies.

Columns (5) through (8) indicate that there was some construction 600-700 meters from the transformer, despite the official guidelines indicating that construction was supposed to have extended only up to 600 meters from the transformer. This is in line with Kassem et al. (2022), who find that almost 30% of LMCP households are located more than 600 meters from the transformer.[17]

[16]This excludes customers who had been connected before LMCP.

[17]Our numbers may be lower because our surveying team only surveyed up to 700m from the transformer.

However, WB sites see significantly less construction outside the boundary. This may indicate more stringent adherence to official LMCP rules: this could be viewed as a positive outcome, but does contribute to fewer connections per site. The household survey data indicate similar rates of requests for informal side payments—approximately 8%—inside and outside the 600 meter boundary. While voltage does decrease with distance from the transformer, this decrease is not correlated with funder (Subsection C.9).

To isolate the impact of the WB's unbundling (t) directly, as distinct from its monitoring activities, define $\beta_t = \beta_1 - \beta_3$, estimating the impact of WB contracting without the audit treatment component. This indicates that unbundling per se decreased the number of poles by 18.5 (*p-val* = 0.06) and the number of connections by 22 (*p-val* = 0.04). However, we interpret these numbers with caution, as the WB inspection reports differed from the audit treatment in some important but nuanced way (see the analysis on construction quality in Subsection 6.4 below).

Among both WB and AfDB sites, 22% of households who did not get connected reported the key barrier to be up-front costs. These costs consisted primarily of internal wiring (16%) or fees required by Kenya Power or the contractor: among connected households, 9% report having been asked to pay a bribe. This is noteworthy because, according to LMCP information campaigns, there was not supposed to be any up-front cost (Kenya Power 2016a): ready boards were supposed to have been made available for households who were unable to pay the upfront wiring costs. 30% of unconnected households noted that they were absent on the day on which Kenya Power enrolled households or when construction happened and thus they were unable to get connected.

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

6.3 Power quality

The GridWatch devices recorded an average of 61 minutes of power outage per day across the 150 sites where this was measured. Users also experience poor voltage quality: Kenya's nominal voltage is 240V, but voltage in the control group is on average only 233V.[18] This could affect day-to-day appliance use and damage appliances in the long run.

Were the delays at WB sites associated with an improvement in power quality? Table 4 suggests that WB procedures do not cause statistically or economically meaningful reductions in outages or improvements in voltage quality over the time period we study. The results are similar when estimating daily or monthly coefficients (Figure A8).

The audit treatment has no clear pattern of statistically significant impacts on power outages or voltage at WB sites. However, it had a consistent statistically and economically meaningful effect on voltage quality at AfDB sites. AfDB sites that received the audit treatment experienced average

[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.

Table 4: Donor and audit impacts on power and voltage

	Hours of power		Average voltage	
	(1)	(2)	(3)	(4)
World Bank (=1)	-0.19	-0.31	1.72	2.87
	(0.21)	(0.22)	(2.34)	(2.72)
Treatment for WB Sites	-0.00	0.33*	3.45	1.39
	(0.24)	(0.17)	(2.22)	(1.77)
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). Power quality is measured using GridWatch devices. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

voltage of 238V, significantly closer to nominal voltage of 240V than the control mean of 233V. This again speaks to the substitutability of unbundling and monitoring effort, as per empirical implication 4.

6.4 Engineering assessment and survey results

Despite the lack of impacts on electricity quality, WB procedures could still have improved construction quality in ways that generate long term benefits. Table 5 presents results using primary outcome indices of the engineering measurements and socioeconomic outcome surveys.[19] All indices are standardized to have a mean of zero and a standard deviation of one. Outcomes 1–3, measuring construction quality, network configuration, and construction timing, use site level observations. Outcomes 4–11 use respondent level observations.

Construction quality (Outcome 1) is on average 0.64 standard deviations higher at WB sites. This is primarily driven by increased presence of pole caps, struts, and stays on poles at WB sites (Table A4). While Subsection 6.3 shows that these features had limited impacts on power quality over the five years we observe, they can reasonably be expected to increase the lifetime of the poles over the long-term. 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). We discuss the intertemporal implications of this result in Section 7.

Columns (2) and (3) of Table 5 estimate the audit treatment effect among WB and AfDB sites, respectively. The estimate in Column (3) (denoted β_3) corresponds to the impact of monitoring effort e among a bundled contract as shown in Figure 4. Additional audits did not affect outcomes at WB sites, but did increase household installation quality among AfDB sites (Outcome 4). These results are driven by earlier meter activation, higher likelihood of having a working meter, and increased use of lighting, appliances, and purchases of electricity tokens at treatment sites (Table A7, Table A11).

[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, bribery index	0.13	0.05	0.11	944
	(0.12)	(0.11)	(0.10)	
Outcome 6: Reliability and safety index	-0.11	0.03	-0.01	944
	(0.13)	(0.14)	(0.11)	
Outcome 7: Knowledge index	0.14	-0.00	0.07	944
	(0.10)	(0.09)	(0.10)	
Outcome 8: Electricity Usage index	0.12	0.11	0.28**	944
	(0.13)	(0.10)	(0.13)	
Outcome 9: Household socioeconomic outcomes index	0.24*	-0.00	0.20	944
	(0.12)	(0.13)	(0.13)	
Outcome 10: Firm Performance Index	0.29	-0.11	0.12	373
	(0.19)	(0.21)	(0.17)	
Outcome 11: Political and Social Beliefs index	0.03	0.01	0.03	944
	(0.08)	(0.07)	(0.09)	

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. Column (1) displays the impact of WB funding relative to AfDB funding. Columns (2) and (3) display the treatment randomized audit treatment among WB sites and among AfDB sites, respectively. In rows 1–3, observations are transformer sites; standard errors are shown in parentheses. For rows 4 through 8, observations are occupants of connected compounds. All regressions control for site land gradient and public facility type. Standard errors are clustered by transformer site and shown in parentheses. We interpret the difference between columns (2) and (3) with caution since the interaction between WB status and audit treatment directly, while economically meaningful, is not statistically significant (Table A3). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$. The sub-components for each index are presented in Table A4, Table A5, Table A6, Table A7, Table A8, Table A9, Table A10, Table A11, Table A12, Table A13, and Table A14.

This is in line with the extensive margin increased discussed in Subsection 6.2 and the positive impact on voltage quality discussed in Subsection 5.3. The joint impact on household installation quality and voltage quality could explain the increase in household electricity access and usage (Outcome 8). These benefits came at the cost of a small delay (Outcome 3), albeit one that is 70% smaller in magnitude than the delay caused by WB contracting (Table A6, Figure A9). Outcomes 5, 6, and 7 show little difference in household experiences (Table A8, Table A9, Table A10).

To isolate the impact of unbundling (t), define $\beta_t = \beta_1 - \beta_3$, estimating the impact of WB contracting without the audit treatment component. This yields an estimate of 0.67 (p-val = 0.001) on the construction quality index and –0.61 (p-val = 0.000) on the timing index. However, we interpret this result with caution, as the audit treatment differed from the WB inspection reports in some ways. For example, one reason why the WB procedures affect the technical engineering components included in Outcome 1 (Table A4) whereas the audit treatment at AfDB sites affected household installation quality components included in Outcome 4 (Table A7), is that the inspection reports discussed in Subsection 3.3 investigated more technical components whereas the audit treatment described in Subsection 4.2 emphasized the quality of household connections. This can also explain why the WB did not have an impact on voltage quality while the audit treatment did improve voltage quality at AfDB sites, as discussed in Subsection 6.3.

6.5 Robustness

We conduct numerous robustness tests to confirm the results above (Subsection C.7). All results in Table 5 control for land gradient facility type and facility type, but these do not qualitatively affect the results. There appears to be limited scope for selection in the donor assignment mechanism by land gradient (Table A15 and Figure A10) and by the facility type that each transformer was originally built to connect (Table A1, Table A16, and Table A15). We also explore heterogeneity in the time between construction and power measurement (Figure A1), omit a complex and ambiguous readyboard question (Table A7), exclude one particular contractor that experienced unusual financial circumstances (Table A17), and drop sites that are less than 1,200 meters of another site (Table A18). None of these adjustments qualitatively affect results.

7 Cost effectiveness

The improvement in construction quality at WB sites is an important finding, however, WB procedures may not be worth it if these improvements come at a substantial financial cost. One argument given by WB officials for favoring unbundled contracting in this context is that pooling nationwide materials procurement would generate market power that would lead to cost savings. Subsection 7.1 therefore investigates program costs, investigating whether unbundling was indeed able to decrease costs, as per empirical implication 6. Subsection 7.2 then investigates the trade-off presented in Equation 2, between short-term construction delays and long-term infrastructure resilience.

7.1 Cost analysis

Kenya Power awarded \$154mn in AfDB contracts, and \$133mn in WB contracts.[20] Table 6 presents costs by donor. The original rollout planned to maximize 5,320 AfDB sites and 3,200 WB sites, but only 71% of LMCP sites actually saw construction, according to Figure 7 and our conversations with Kenya Power personnel. Our 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

[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 20.9% more new household connections.

for AfDB contracts while it is $728 for WB contracts: 30% higher.[21] Taken together, unbundling does not appear to have reduced costs in this context, contrary to empirical implication 6.

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 that occurred between 2014–2018. These cost estimates exclude any additional labor associated with the WB's administrative and monitoring effort costs, which could exacerbate this difference. In sum, it does not appear that the WB was able to secure lower-cost contracts. In line with Lee et al. (2020), these connection costs exceed the value of rural electrification as measured through both stated willingness-to-pay ($293) and revealed willingness-to-pay ($147).[22]

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 WB and AfDB funding tranches.

The cost per pole enumerated in rows (6) and (7) of Table 6 would suggest that WB contracts were able to secure poles more cheaply.[23] However, the contract amounts listed in bundled contracts may not reflect true procurement costs: anecdotally, contractors sometimes shift costs onto materials as these invoices are paid sooner, providing them with much needed liquidity. However, these practices are undocumented and therefore unobservable to the principal. This is in contrast to unbundled contracting, where the principal has perfect insight into the cost of each procurement component. This is an example of the opacity that bundled contracting can create, discussed in Section 2.

Finally, there appear to be disparities between the contract amounts and the actual built amounts. For example, according to the procurement contracts, 18% of WB poles and 50% of contracted AfDB poles were concrete—however, according to our on-the-ground surveys, only 3%

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

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

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

of poles at WB sites and 25% of poles at AfDB sites were concrete. However, we cannot distinguish pre-existing poles from poles that were newly constructed during LMCP, so if pre-existing poles were disproportionately wood poles then this could explain this discrepancy. For these reasons, we refrain from over-interpreting this result.

7.2 Cost-benefit analysis

The 30% higher cost per connection for WB contracts might be worth it if the gains in construction quality documented in Subsection 6.4 are sufficiently large. We therefore evaluate the costs and benefits associated with potential gains in quality, as well as the costs of delays, reflecting the key trade-off presented in Equation 2.

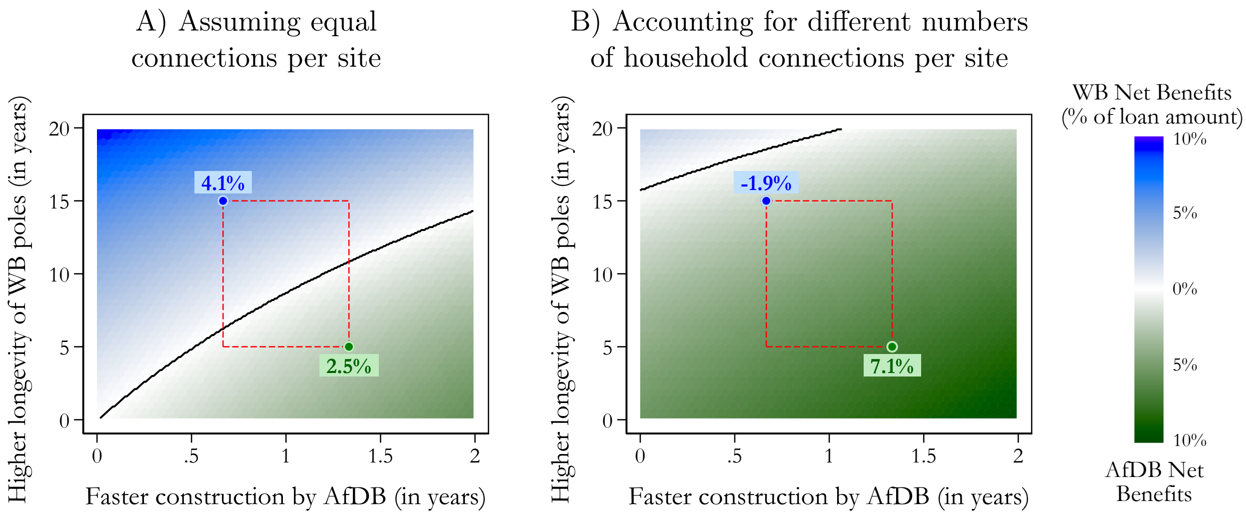
AfDB sites reached construction milestones 8 to 16 months faster than WB sites on average, increasing the net present value of new connections. WB sites saw improved pole and pole installation quality, likely to reduce long-term repair and replacement costs for Kenya Power (UPRC 2018). The aggregate calculations factor in that only 71% of sites were completed. We assume that households discount delayed provision of electricity services at a 10% annual discount rate, and that planners discount future maintenance costs at 5% per year. We focus this analysis on audit control sites, to avoid confounding the different funder's costs with the audit treatment impacts. We assess the costs and benefits of the audit treatment below.

Figure 8 presents the results, emphasizing one key factor that strongly influences the net benefits calculations. Panel A assumes that 80 new household connections are constructed at both WB and AfDB sites, as had been planned by the agencies. Panel B reflects our count of 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 range of the vertical axis corresponds to an up to 20 year improvement in a pole's service life (Muthike and Ali 2021), while the red box illustrates a region between 8 to 16 months faster construction and between 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 policies are ambiguous, ranging anywhere from a net benefit worth 4% of project costs at WB sites to a net benefit worth 7% at AfDB sites (Figure A12 displays results under additional assumptions).

Under a lower discount rate the relative benefits of WB contracting would be more pronounced, up to 5% of the total. Conversely, 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. However, in the aggregate, it appears unlikely that WB procedures would have generated the 30% improvement required to make up for the increased costs per connection.[24]

[24] 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, allowing households to experience benefits sooner. The vertical exist represents potential gains in grid longevity due to grid quality, assumed to accrue to the expected service life of poles with a constant annual probability of pole failure. The 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 at both WB and AfDB sites, as had been planned by the agencies. Panel B reflects our count of LMCP household connections on the ground, which average 72 at AfDB sites and 58 at WB sites. Figure A12 explores additional assumptions.

While this exercise focuses on electrification in Kenya, these calculations illustrate the trade-offs that may influence the contracting approaches best suited to large-scale development projects more generally. If the planner discounts future costs and benefits more severely, if household benefits are larger, or if a more stringent contracting approach is likely to produce greater delays, then bundling contracts may be more worthwhile. 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 may be better suited.

The audits improved outcomes at AfDB sites, but at a cost of around $500 per site.[25] While Column (4) of Table 3 suggests that the audit treatment did not increase the number of connections as measured by drop-down cables, Column (3) of Table 5 (and in particular the household installation quality index, detailed in Table A7) suggests 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 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 audit treatment included household and firm surveys far exceeding the intensity of the inspection reports (IRs). While we do not have cost estimates of the IRs per se, the exercise above suggests that they could pay for themselves in reduced long-term repair and maintenance

[25] The research team spent $125,000 on data collection at 250 sites. $500 per site is approximately 1.2% of average per-site LMCP expenditures.

expenditures.

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

8 Empirical implications

This section combines the quantitative results discussed in sections Section 6 and Section 7 with qualitative data gathered during informational interviews with Kenya Power, the WB, and the AfDB to evaluate the empirical implications discussed in Section 2 in this context.[26]

Empirical implication 1: Bundling affects provider selection, with ambiguous effects on quality. The WB and the AfDB both stipulated that Kenya Power run a competitive auction when awarding contracts, with bidders subject to specific eligibility criteria and donor approval. However, AfDB contractors could use subcontractors at their discretion, with significantly less oversight. We investigate whether this led to differences in provider selection, focusing on suppliers of key goods where subcontracting was standard practice: poles, cables, and conductors. Provider selection does not appear to differ substantially across the two contracting structures.

28 companies were directly awarded at least one supplier contract by the WB and 38 companies were listed as a subcontractor for an AfDB implementer.[27] To start, there was significant overlap: seven of the 59 companies appear on both lists. And while information about subcontractors is limited, there are similarities even among firms that only contracted or subcontracted with either the AfDB or the WB. For both funders, approximately two-thirds of (sub)contractors were from Kenya, 10% were from China, and 10% were from India (Figure A11). 48% of WB contractors and 22% of AfDB subcontractors had been awarded at least one other WB procurement contract prior to the start of the LMCP.

This suggests that provider selection was not an important channel for quality in this context.

Empirical implication 2: Bundling lowers administrative costs: $A(1) < A(t_u)$. Kenya Power's administrative burden under the WB scheme was significantly higher than under the AfDB

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

[27] 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.

scheme. The large 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 between the implementer and the components for those same goods and services. Despite these substantial differences in labor requirements, Kenya Power employed one staff member to manage the WB contracting procedures and one staff member to manage the AfDB contracting procedures: we confirmed in our interviews that total Kenya Power staff time availability was equal across the WB and AfDB components. The employees who held these positions were all certified electrical engineers with similar skill and education levels—at least a bachelor's degree in electrical engineering. Given the absence of additional staffing, these increased upfront administrative requirements are likely a key driver of the 10.2 month delay to the start of construction at WB sites (Subsection 6.1).

The WB's unbundled contracting furthermore generated substantial coordination costs. Given constrained staff availability, the imperfect handling of coordination tasks further exacerbated WB costs and delays. The lack of coordination between the design and installation contracts furthermore meant that the designs were often out of date by the time construction began, requiring costly adjustments to the as-built designs or a change in the required materials. Similarly, a lack of coordination between materials and installation contracts meant that materials were often physically transported into Kenya Power custody before installation contractors were ready to begin work, requiring expensive temporary storage facilities.

This suggests that administrative costs from unbundling are large, and this may be exacerbated in contexts where institutional capacity is constrained.

Empirical implication 3: marginal increases in either t or e should increase quality. Subsection 6.2, Subsection 6.3, and Subsection 6.4 all indicate that WB-funded sites saw higher construction quality than AfDB-funded sites, and that the experimental audits had a positive impact on construction quality among AfDB sites. While empirical evidence on bundling is limited, the audit results build on a large literature in development economics documenting the impact of increased audits on public sector outcomes (Olken 2007; Ferraz and Finan 2008; Finan et al. 2017; Duflo et al. 2018).

This indicates that unbundling and monitoring effort are potentially powerful policy levers to improve project outcomes.

Empirical implication 4: t and e may be substitutes.

The experimental audits had limited impacts at WB sites. This could be due to diminishing returns of monitoring effort e: the AfDB required fewer ex-post audits, such that additional audits would generate an important benefit at those sites, whereas the audit treatment had limited effects at WB sites as these already required an additional layer of inspections. Alternatively, it could be because t and e are substitutes and WB had higher t. While we cannot distinguish between these scenarios, increased monitoring does in any case generate higher quality among bundled contracts. In Section 7 we discuss monitoring costs and weigh these costs against the measured benefits.

This suggests that monitoring could offset some reductions in quality caused by the unobservability of bundled contracts.

Empirical implication 5: marginal increases in t should increase delays, but the effect of e is ambiguous. The WB's administrative costs and the enhanced inspections caused a combined average delay of 16 months between when connected AfDB households received a working meter and when connected WB households received a working meter (Table A6). At AfDB sites, the audit treatment caused a metering delay of 5 months. This suggests that the upfront delay caused by unbundling contracts accounted for approximately 70% of the total delay.

Given that the randomized audits improved quality at a significantly smaller delay than unbundled contracting, the optimal contracting structure in this context may be a combination of bundled contracts but enhanced ex post monitoring. Section 7 discusses this trade-off in more detail.

Empirical implication 6: Bundling may increase contract costs: $\bar{C}_b > \bar{C}_u$. One of the WB's reasons for opting to award unbundled contracts was its belief that having coordinated nationwide contracts for major materials would enable them to secure lower prices through auction. This turns out to have been true on paper: at first glance, the cost per wooden and per concrete pole was 38% and 17% lower, respectively, in the WB subcontracts when compared with the AfDB contracts. However, the aggregate costs per site are in fact *lower* at AfDB sites. Anecdotal evidence suggests that the reported per-pole costs may have been intentionally distorted by the implementers, perhaps facilitated by the fact that the principal has less insight into true the component costs of bundled contracts. Subsection 7.1 discusses this further.

9 Conclusion

Public procurement regulations can have enormous implications on the costs, timeliness, and quality of infrastructure construction, a major source of spending for governments and international organizations. However, causal inference is 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 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.

WB sites experience significant delays in implementation, with households receiving electricity on average 16 months later than households in AfDB-funded sites. We can rule out that the conditions causing these delays generated statistically or economically meaningful improvements in power outages or voltage quality in the short term. However, we find a 0.6 standard deviation improvement in construction quality at WB 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 infrastructure network. To disentangle the difference between bundling and monitoring we implement a randomized audit treatment. 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 fewer delays.

We use a stylized model to shed light on the mechanisms through which contract bundling and monitoring may operate. First, monitoring can be an effective substitute for contract bundling, achieving significant improvements in construction quality. Second, contract unbundling increases the principal's administrative burden, which—in contexts where human capital is constrained—can generate sizeable delays. Taken together, these results suggest that combining bundled contracting with more rigorous ex post audits could reduce delays without necessarily compromising construction quality.

Holding constant WB and AfDB procedures we highlight a key intertemporal trade-off, in which the principal must weigh short-term benefits of earlier access to electricity with the long-term benefit of lower maintenance and upgrading expenditures, according to their time preferences. Even a modest range of assumptions could imply anywhere from a net benefit of AfDB procedures worth 7% of project value, to a net benefit at WB sites worth 4$ of project value.

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

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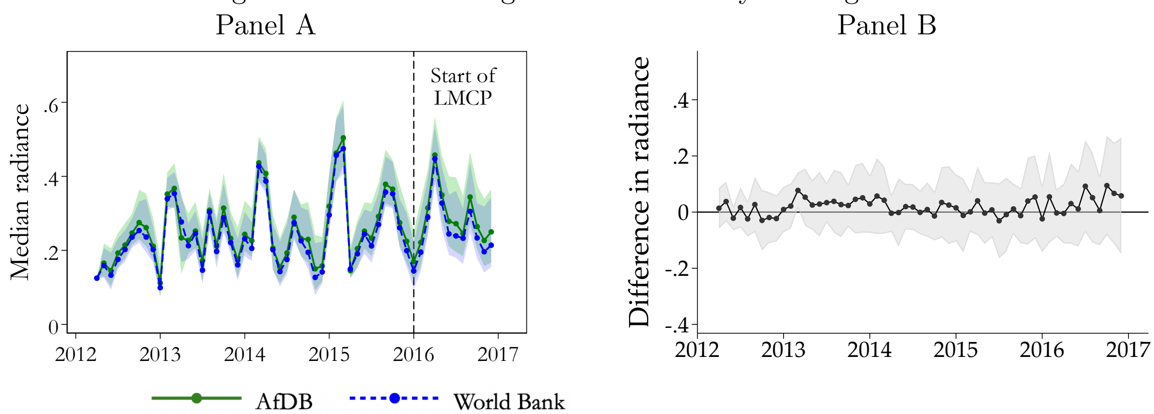
A Appendix Figures

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 site-month, with bands showing the 25th to 75th percentile. Panel B confirms that radiance is statistically indistinguishable across World Bank and African Development Bank-funded sites (estimates include constituency FE). Table 1 confirms baseline balance using a pooled regression of these data.

Figure A2: Monitoring Intervention

THE WORLD BANK
IBRD • IDA

Kenya Power

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

June 2017

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

Dear Sir/Madame:

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

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

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

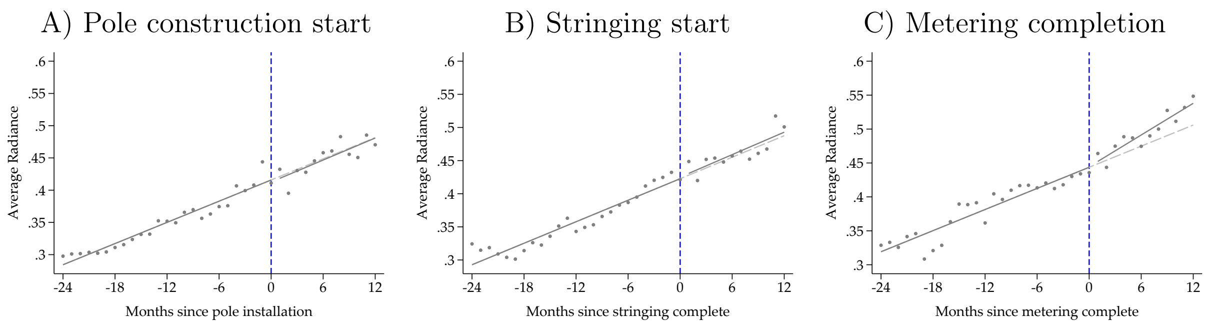
We wish to inform you of the sites that have been awarded to you that have been selected for the EMP. Please find attached a list of these sites.

Sincerely yours,

[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

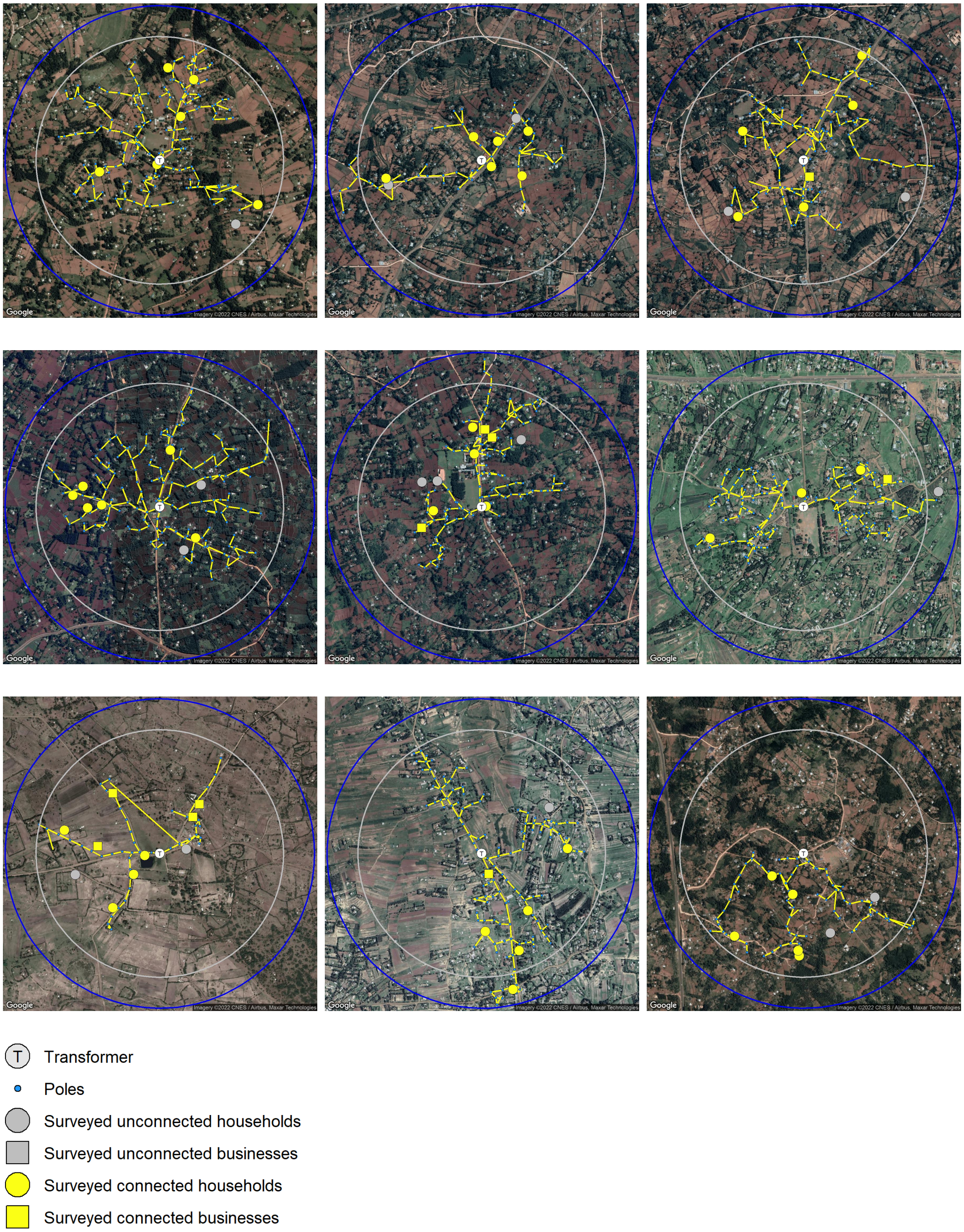
This figure displays the monitoring intervention sent to contractors. All letters were signed by relevant representatives from Kenya Power, the World Bank, and the AfDB, with their names and positions listed below. Each letter specified the contractor's name and contact information. The letters were 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 A3: Event study: nightlights after construction progress



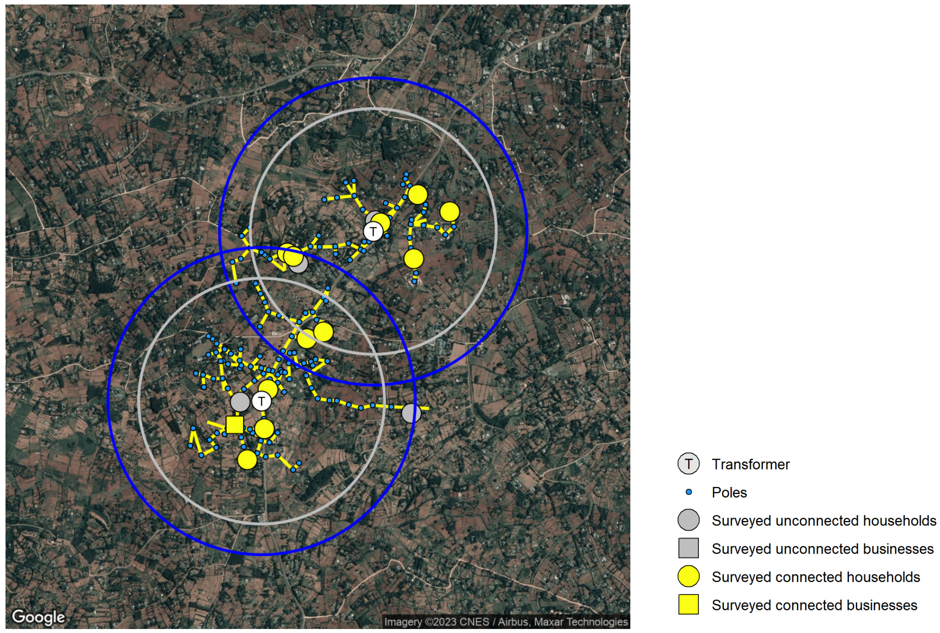
Data on construction progress for the 135 AfDB sites and 121 WB sites located in the five study counties collected through phone surveys with local village representatives. As expected, nighttime radiance data (VIIRS) increases after metering completion (when the electricity connection is activated)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

Figure A4: Engineering data collected (additional example sites)



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

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

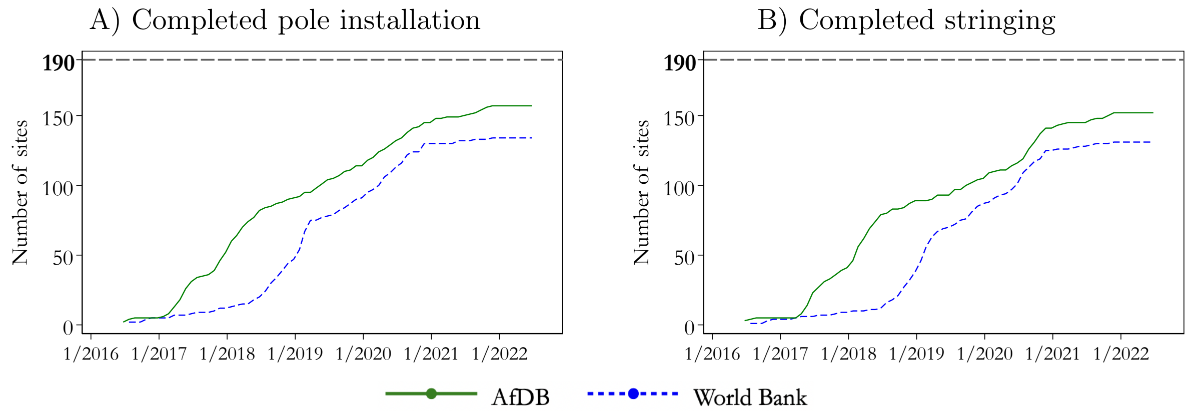


This map displays two sites whose transformers are located 990 meters apart, such that the 600 and 700 meter radius eligibility areas overlap. See Subsection 5.1 for a discussion on this issue. To preserve anonymity random spatial noise has been added to household and business locations.

Figure A6: A PowerWatch device

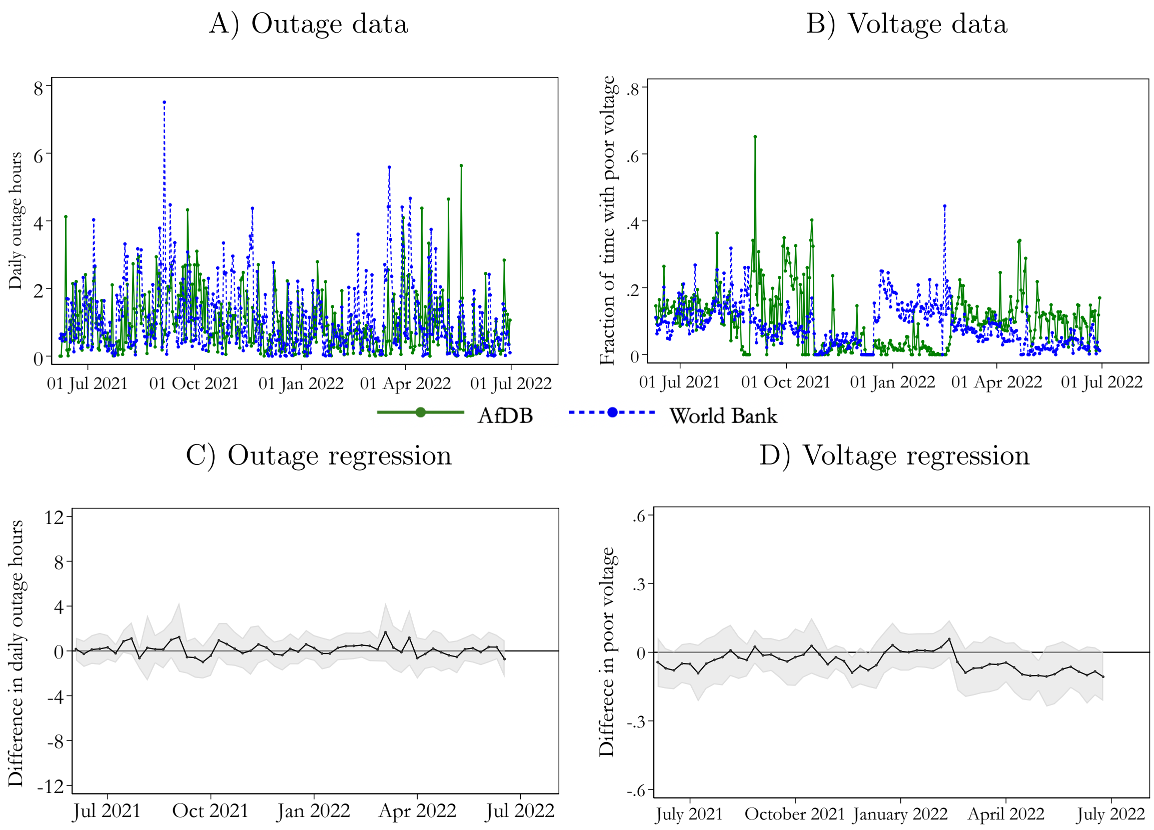
A PowerWatch device, part of nLine's GridWatch technologies used to measure household-level power outages and voltage.

Figure A7: Construction progress by funding source



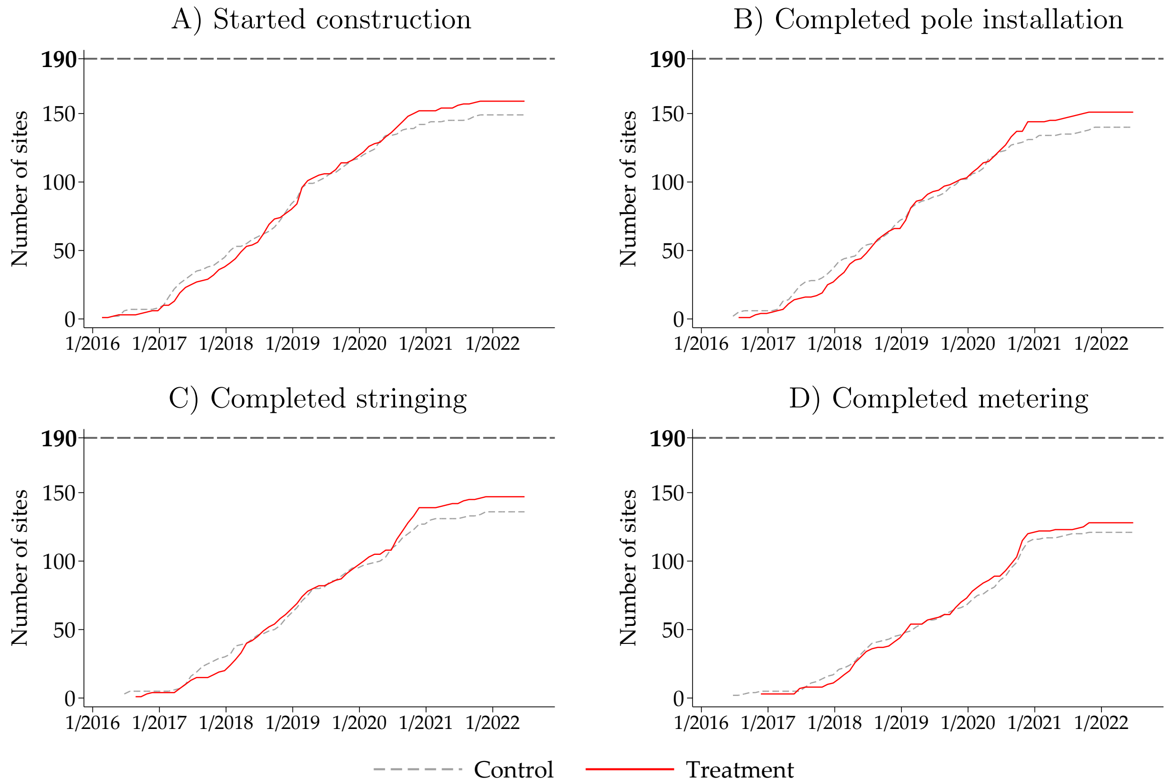
Data for 190 AfDB sites and 190 WB sites located in the five study counties collected through phone surveys with village representatives.

Figure A8: Reliability and voltage quality by funding source



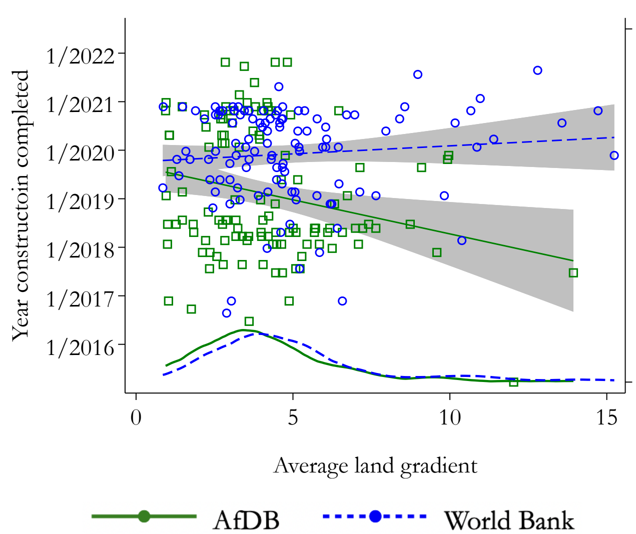
Panels A and B present the hours of outage per day and fraction of time experiencing poor voltage quality, respectively, for WB and AfDB sites. Panels C and D estimate a separate coefficient for each week of the sample, with constituency fixed effects and standard errors clustered by site. In the voltage 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



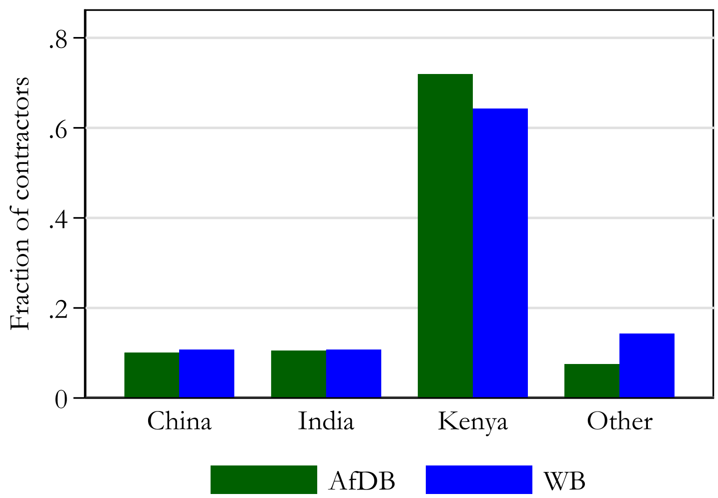
Data for 190 control sites and 190 treatment sites located in the five study counties collected through phone surveys with village representatives.

Figure A10: Construction delays and land gradient



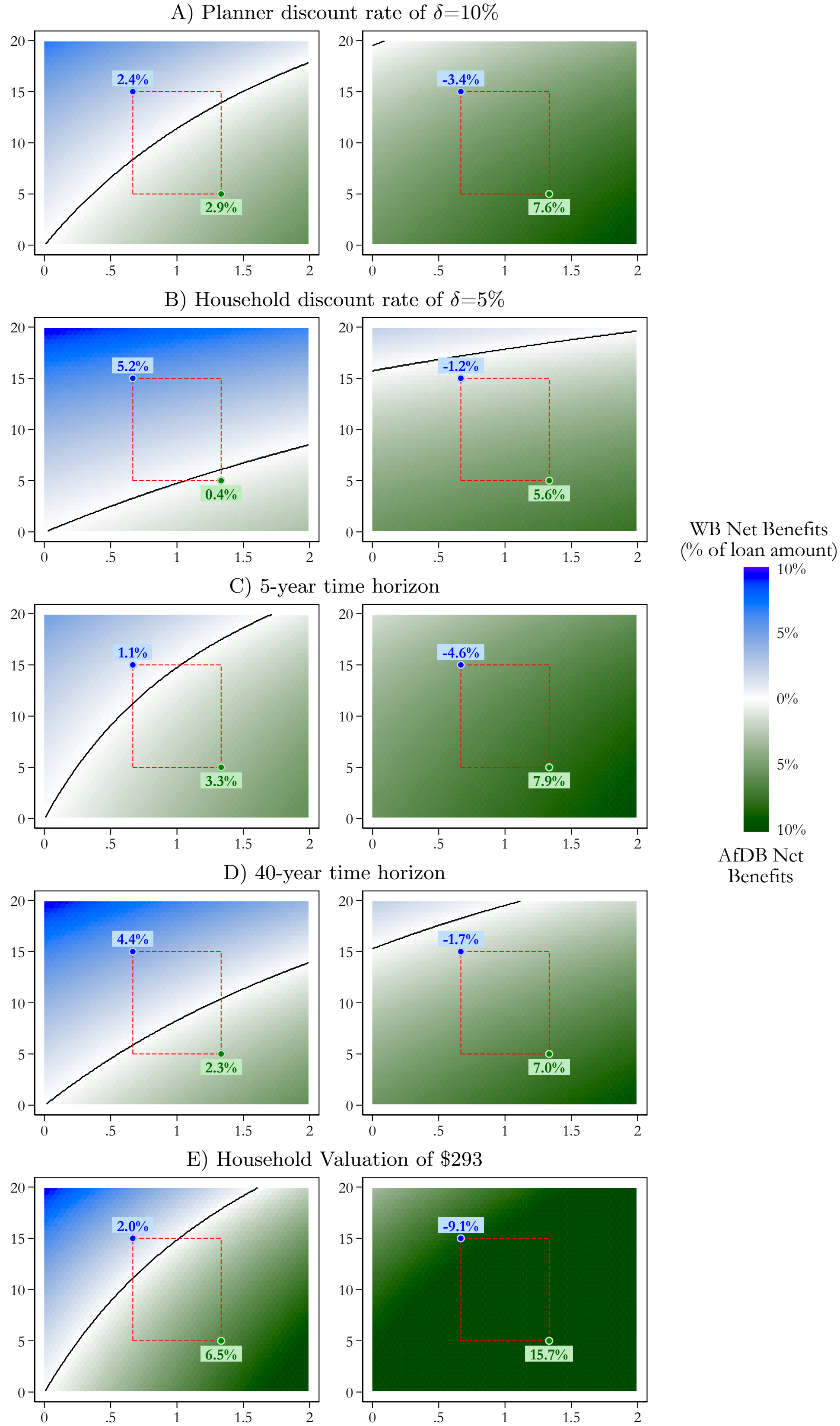
Average land gradient is calculated for each site over the 600 meter radius around its transformer. Land gradient is uncorrelated with construction delays, both unconditionally and conditional on funder. The lag between WB and AfDB is approximately constant across the entire land gradient support. Data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



59 companies were either awarded WB contracts, awarded AfDB contracts, or approved to subcontract with one of the AfDB contractors. 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 FE.

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.

Table A3: 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 9: Household socioeconomic outcomes index	0.24*	0.20	-0.21	944
	(0.12)	(0.13)	(0.18)	
Outcome 10: Firm Performance Index	0.29	0.12	-0.23	373
	(0.19)	(0.17)	(0.28)	
Outcome 11: Political and Social Beliefs index	0.03	0.03	-0.02	944
	(0.08)	(0.09)	(0.12)	

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

Table A4: Construction quality

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 1: Construction quality index	-0.00	0.64***	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. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A5: Network configuration

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 2: Network size and configuration	-0.00	0.00	0.27	0.02	244
index	[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	0.89	-0.02	0.04	-0.01	244
LV line, electrified	[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 A6: Construction timing

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 3: Construction timing index	0.00	-0.90***	-0.07	-0.29*	250
	[1.00]	(0.17)	(0.16)	(0.17)	
LMCP construction start date (months since	37.22	10.18***	1.66	4.00**	250
Jan 2015)	[11.38]	(1.90)	(1.72)	(1.93)	
Pole erection completion date (months since	45.20	9.90***	1.85	3.52	249
Jan 2015)	[15.17]	(2.67)	(2.49)	(2.59)	
Stringing completion date (months since Jan	46.91	9.47***	1.33	2.70	247
2015)	[15.48]	(2.76)	(2.52)	(2.56)	
Metering completion date (months since Jan	47.73	15.67***	-1.23	4.71*	226
2015)	[14.56]	(2.48)	(2.17)	(2.65)	
months between construction start and pole	7.83	-0.06	0.18	-0.32	249
erection complete	[10.19]	(1.81)	(1.63)	(1.52)	
months between pole erection complete and	1.90	-0.73	-0.48	-0.53	246
stringing complete	[4.41]	(0.80)	(0.64)	(0.68)	
months between stringing complete and	0.95	6.25***	-2.01*	0.37	224
metering complete	[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 A7: Household installation quality

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

The household installation quality index (shown here in rows 1 and 2) is a standardized average of subcomponents shown in the remaining rows. Row 2 omits the readyboard question as it is the presence or absence of a readyboard is not strictly an indication of quality. All outcomes are measured at the household level and collected in the household and firm survey data (described in Section 5.2). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A8: Household cost, experience, and bribery

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

The household cost, experience, and bribery index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section 5.2). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A9: Household and firm reliability and safety

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

The household reliability and safety index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section 5.2). For outcomes marked with a (-), a higher value indicates a lower quality. For all other outcomes, a higher value indicates higher quality. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$.

Table A10: Knowledge

	(1) AfDB Mean	(2) World Bank Effect Estimate	(3) Audit Treatment Effect, WB Sites	(4) Audit Treatment Effect, AfDB Sites	(5) N
Outcome 7: Knowledge index	0.01	0.13	-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 A11: Electricity Usage

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

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 A12: Household Socioeconomic Outcomes

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

The household socioeconomic outcomes index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section 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 A13: Firm Performance

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

The firm performance index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the firm level and collected in the household and firm survey data (described in Section 5.2). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A14: Household Political and Social Beliefs

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

The household political and social beliefs index (shown here in row 1) is a standardized average of sub-components shown in the remaining rows. All outcomes are measured at the household or firm level and collected in the household and firm survey data (described in Section 5.2). $^{*} \leq 0.10,^{**} \leq .05,^{***} \leq .01$.

Table A15: 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 A16: 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.

Table A17: Primary engineering and socioeconomic outcomes excluding Lots 3 and 5

	(1) WB Effect Estimate	(2) Audit Treatment Effect, WB Sites	(3) Audit Treatment Effect, AfDB Sites	(4) N
Outcome 1: Construction quality index	0.57	0.13	0.05	161
	(0.50)	(0.49)	(0.19)	
Outcome 2: Network size and configuration index	0.69*	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 6.5 provides more detail. $^{*} \leq 0.10$, $^{**} \leq .05$, $^{***} \leq .01$.

Table A18: 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)
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)	
Treatment (WB sites)		-2.4		8.6		-0.6		-0.4
		(9.2)		(9.9)		(1.0)		(0.8)
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 FE. 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).[28] 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)[29] to connect all public facilities—such as markets, schools, health centers, and water points—to electricity (REA 2008, Berkouwer et al. 2018).

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

C.1 Upfront connection costs

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

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

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

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

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% of households do not recall ever having been told that they would have to pay Kenya Power for the connection.

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

C.2 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 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.[30] 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

[30]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.

respondents still report having been unable to pay, often because they were not able to afford the internal wiring required by Kenya Power to be connected: 16% of unconnected households report this to be the reason. This suggests that despite efforts to provide free readyboards to low-income households, the cost of household wiring remained a barrier that prevented some households from getting connected.

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

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

C.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 USD 5 to USD 50. Tragically, a small number of households report having paid an individual claiming to be a contractor, only to never hear from them again and to remain unconnected. 5% of unconnected households report not wanting a connection, for example because they are simply not interested in having electricity or because they think electricity is unsafe (this is similar to the rate reported in Lee et al. (2020) noted above).

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

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 A15). 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 A16), and the gap in timing between WB and AfDB sites persists when controlling for facility type (Table A15). 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 A1 confirms that voltage quality is constant over time, and that the lack of difference in voltage quality between the WB and the AfDB persists even among sites where the time since stringing completion was approximately equal.

For Outcome 4 measuring household installation quality (Table A7) we replicate the index omitting the question asking the respondent whether they have a readyboard, since it is not obvious whether the presence of a readyboard is a positive or negative component. Its presence simultaneously indicates Kenya Power provisions and a lack of household preparedness (see Subsection 3.5 for more detail).

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 A18 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[31] 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 A17).

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 USD 100 per pole (for materials alone), consistent with contract amounts and discussion in (Muthike and Ali 2021). While the procurement cost per pole was different for AfDB and WB contracts during the LMCP, Kenya Power, not the multilateral donor, is responsible for long-term maintenance and repair and would thus procure these items independently. We assume that about half of total replacement costs is for materials alone, which is roughly consistent with contract

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

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.[32] 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 A19 shows no difference between funders in distance resilience.

Table A19: Resilience of voltage to distance from transformer

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

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

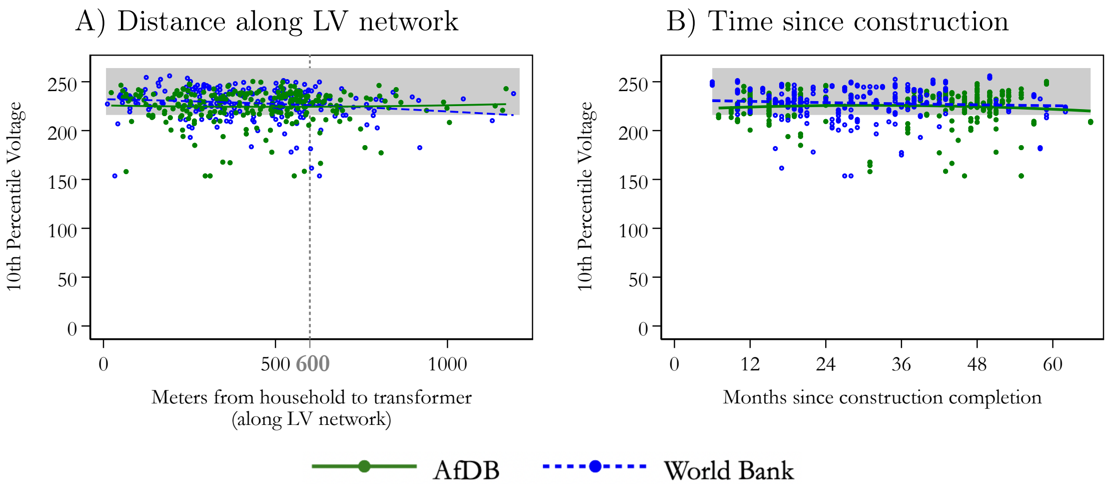
Panel A of Figure A1 explores the correlation between 10th percentage of voltage quality and distance to the transformer along the LV network.[33] There does not appear to be a significant or discontinuous decline after 600 meters, the eligibility cutoff for a subsidized LMCP household connection, suggesting greater returns to scale might have been achieved under a higher distance eligibility cutoff.

Second, voltage quality could worsen with the passage of time, as infrastructure ages. Higher quality construction might make infrastructure more resilient and slow any associated decay. The time since construction varies across our sample since stringing was completed between June 2017 and January 2021, while GridWatch devices recorded data between June 2021 and June 2022. Panel B of Figure A1 examines the correlation between voltage quality and time since construction. At both AfDB and WB sites, the grid appears resilient to aging for the first five years after the completion of stringing.

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

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

Figure A1: Voltage quality resilience to distance and infrastructure aging



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

D List of individuals engaged in qualitative informational interviews

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

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